Heterogeneity in Firms' Wages and Mobility Policies

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Abstract: We study the simultaneous determination of worker mobility and wage rates using a model that allows for both individual and firm-level heterogeneity. The model is estimated using longitudinally linked employer-employee data from France. The structural results for mobility and wages show remarkable heterogeneity. For instance, the average structural returns to seniority are essentially zero but, again, this masks enormous heterogeneity with positive seniority returns found in low starting-wage firms. A factor analysis of the firm-specific wage and mobility parameters estimates the strongest association as the contrast between high-turnover, low-wage, and high return-to-seniority firms with low-turnover, high-wage, low return-to-seniority firms. This result is strongly reminiscent of Job Search models à la Mortensen, that are structured along such lines.

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1 Introduction

We study the connections between firm-level compensation, promotion, and retention policies in a model with firm heterogeneity in each of these policies. We relate a worker's inter-firm mobility to firm-specific compensation policies. Then, in our empirical analysis we use newly developed econometric methods and fully-integrated French employer-employee data to estimate some of the firm-specific parameters of the model. As others have noted, particularly for France and the United States, the results tend to show enormous individual- and firm-level heterogeneity in compensation, promotion, and retention policies. We characterize this heterogeneity by modeling its joint distribution in the populations of individuals and firms. Finally, we recover some of the structural parameters of the firm-level policies such as "returns to seniority" parameter.

The labor economics literature has attempted to measure the average return to seniority in models with limited heterogeneity. Abraham and Farber ([3]) were the first to demonstrate that heterogeneity in the model for employment duration induced an upward bias in the measured average return to seniority, specifically, jobs with a longer expected duration were likely to be better-paying jobs and, therefore, longer seniority would be associated with higher pay but the return to an additional year of seniority, holding constant the expected duration of the job, was much smaller than the measured average return to seniority, ignoring expected job duration. Brown ([9]) showed that the return to seniority is not constant; rather, it is higher during the first years of a job and diminishes to zero at the end of the employee's self-declared "training period." In a series of articles, Altonji and co-authors, [4], [5], [6] applied various econometric techniques that attempted to remove the bias in the average return to seniority due to unobserved heterogeneity in individual job durations. These estimates, very much in the spirit of Abraham and Farber, also indicated that the measured average return was upward biased and that the true return was closer to zero. In contrast, Topel ([26]) used a model that included the possibility of bias arising from individual job search. This bias goes in the opposite direction of the job-duration heterogeneity bias leading Topel to entertain both upward and downward biases. He concluded that the bias was downward in the uncorrected average return to seniority. More complete models of the sources of heterogeneity in the return to seniority lead to distributions of estimates that display individual, firm and within-firm heterogeneity as in, for example, Abowd, Kramarz, and Margolis, ([2], AKM hereafter), who find substantial heterogeneity in the returns to seniority in France (all of the previously cited papers used American data) with an average return of zero for men and women. More recent work by Margolis ([21]) and Dostie ([14]), using French data, confirm that simultaneous modeling of individual- and firm-level heterogeneity produces estimates of the average return to seniority that are lower than the uncorrected estimates.

We begin by laying out a very simple theory in section 2 that relates individual and firm heterogeneity in wages, productivity and mobility. This theory translates directly into estimating equations laid out in section 3. Section 4 describes our data. Section 5 presents statistical results on compensation and mobility parameters that take account of potential mobility and heterogeneity biases that have plagued other analyses. This first set of results, which properly accounts for each of the heterogeneity biases, delivers estimates of the central tendency of compensation parameters, such as the return to seniority and the structural job duration, that may be interpreted as structural in the same sense as those given in the studies cited above. The second set of results summarizes all the above informations into four factors. They show that the main factor appears to order firms very similarly to the equilibrium distribution of wages in a Job Search equilibrium model à la Mortensen.

2 A Simple Theory of Wages, Productivity, and Mobility

This "theoretical" section presented here attempts to give a rationale to the estimating equations presented in the next section and is to be considered as a departure point for interpretations of the estimates proposed at the end of the paper. Although very simple –and because of this– this theory does not allow us to identify among the large number of competing theories that relate the wage and the mobility processes. The approach adopted in this paper is mostly descriptive and atheoretical.

In this section, we try to explicit the relation between a worker's wage, worker's productivity, and mobility decisions. Our model is relatively straightforward. We assume that there exist firms that do not make use of technologies that have firm-specific components. These firms are homogeneous and any worker can find a job in such a firm at any period. These firms, that will be thereafter be denoted as "simple", pay market wages. Their profits are zero.[1]

All other firms have heterogeneous technologies that make use of firm-specific and worker-specific components. These technologies are known to workers and firms who agree at all times on the value of a given worker-firm match. These firms consider market wages as exogenous and given.

When entering a firm, a worker contributes to the value of the match by bringing the following productivity sequence $(p_{ij0}, ..., p_{ijS})$, p_{ij0} being the productivity of the worker i at the beginning of her job spell within firm j, and p_{ijS} being her productivity at the end of the job spell. Once again, we assume for simplicity, that wages in "simple" firms equal their productivity. In these firms, productivity of individuals only depend on their innate, fixed, abilities θ_i and on their labor market experience Exp_{it}. Thus, basic wages or productivities can be written as:

$$p_{it}^B = w_{it}^B = \exp\left(\theta_i + \beta Exp_{it}\right) \tag{1}$$

where β is the return to experience. The dependence of basic productivity with respect to experience may be non-linear : it has a quartic form in the empirical section. In simple firms, productivity and wage increase as experience

[1] Other specifications specifying market wages are possible. The simplest assumption, selected here, is to assume that market wages are given.

increases : $Exp_{it+1} = Exp_{it} + 1$. These productivity or wage terms are not firm-specific, since all simple firms are endowed with the same technology and wage policies.[2] Since productivity equals wage, there is no mobility issue within these firms. With this specification, w_{it}^B can be viewed as the reservation wage of all workers.[3] Finally, notice that in these firms, the value of a match equals zero.

In non-simple firms (complex, hereafter), technology is firm-specific and productivity paths may differ accross firms. Overall, individual productivity may depend on worker's seniority in the firm j.[4] In addition, as in simple firms, worker's productivity will depend on innate abilities θ_i, on experience as follows:

$$p_{ijt}^{NB} = \exp\left(\theta_i + \beta Exp_{it} + \beta_j Sen_{ijt} + \nu_{ijt}\right) = p_{it}^{B} \exp\left(\beta_j Sen_{ijt} + \nu_{ijt}\right) \quad (2)$$

where Sen_{ijt} denotes the seniority of worker i in firm j at time t. Hence worker i entered into the firm at time $t_0 = t - Sen_{ijt}$.

The expected value of the match at time t is the actualized sum of the difference between worker's productivity and reservation wage as long as the job continues:

$$V_{ijt} = E_t\left(\sum_{s=0}^{\infty} \delta^s \left(p_{ijt+s}^{NB} - w_{it+s}^{B}\right) R_{ijt+s}\right) \quad (3)$$

where δ is the discount rate and R_{ijt} is a variable that indicates whether worker i works in firm j at time t, in which case it is equal to 1 (and 0 otherwise). Obviously, R_{ijt} is a decision variable. It may result from optimal decisions from both the worker and the firm. But, R_{ijt} may also be affected by some worker or firm's features. For instance, some workers may have a large specific propensity to move from firm to firm. In this case, this would result in a relatively high probability for R_{ijt} to be equal to 0, with some potentially inefficient separations. Moreover, we assume that, once a worker has left the firm, she cannot come back (with the same match value). Should she come back, she is endowed with a new match value, a new productivity corresponding to this new spell. Thus, if $t > t_0$, where t_0 is the job starting date, the relation

$$R_{ijt} = \prod_{s=0}^{t-t_0} R_{ijt_0+s} \quad (4)$$

[2] Once again, we could dispense with this assumption. Papers such as Burdett and Mortensen[12], Robin and Roux [25], Burdett and Coles[11] show that ex-ante identical firms may have very different wage policies. Integration of such theories is beyond the scope of this paper.

[3] We do not account for other job opportunities that may affect this value of the reservation wage as in on-the-job search theory. We assume that these aspects are contained in the individual heterogeneity parameter θ_i.

[4] We astract from match-specific learning, but see Woodcock ([28]) for a full treatment, and from optimal sorting, but see Mortensen (([23]) for a full treatment.

holds. The value of the match is equal to zero when the jobspell is over. As mentioned just above, when a worker reenters a firm, she is considered to be a new individual.

The relation (3) corresponds to the expected realized value of the match V_{ijt}, for the sequence of mobility decisions $(R_{ijt}, ..., R_{ijt+s})$. Using (4), this value can also be written in an intertemporal way :

$$V_{ijt} = R_{ijt}E_t\left(p_{ijt}^{NB} - w_{it}^{B} + \delta V_{ijt+1}\middle| R_{ijt} = 1\right) = R_{ijt}\widetilde{V}_{ijt} \tag{5}$$

where $\widetilde{V}_{ijt}$ is the expected continuation value of the match at time t, that is V_{ijt} conditional on $R_{ijt} = 1$. Thus, *should* the choice of R_{ijt} be efficient (not imposed here), we would have the following continuation rule:

$$\begin{aligned} R_{ijt} &= 1 \text{ if } \widetilde{V}_{ijt} = E_t\left(p_{ijt}^{NB} - w_{it}^{B} + \delta V_{ijt+1}\middle| R_{ijt} = 1\right) \geq 0 \\ &= 0 \text{ if } \widetilde{V}_{ijt} = E_t\left(p_{ijt}^{NB} - w_{it}^{B} + \delta V_{ijt+1}\middle| R_{ijt} = 1\right) < 0 \end{aligned} \tag{6}$$

As explained above, this rule can be perturbed by worker's or firm's actions, potentially unrelated to the maximization of the match value. However, we believe that most of the time, as this rule exemplifies, worker's mobility decisions are affected by shocks on her current or expected productivity.

The continuation expected value $\widetilde{V}_{ijt}$ in equation (5) has two components. The first component, $E_t\left(p_{ijt}^{NB} - w_{it}^{B}/R_{ijt} = 1\right) = p_{ijt}^{NB} - w_{it}^{B}$, reflects the flow value of firm-specific productivity in excess of the market value generated by the match at time t. The second component captures the expected value of the match $E_t\left(\delta V_{ijt+1}/R_{ijt} = 1\right)$ after time t. Assume, for the sake of discussion, that firm-specific productivity can be decomposed into $p_{ijt}^{NB} = f_{ijt} + \varsigma_{ijt}$ where the first term is the known productivity of the match and the second term is an independent (over i, j, t) random shock with zero mean. Similarly, assume that the external wage rate in a firm with no firm-specific productivity is $w_{it}^{B} = g_{it} + \eta_{it}$ where the first component reflects the known market value of the worker and the second is another random shock (independent over i, t) with zero mean. Finally, assume that both f_{ijt} and g_{it} are (weakly) increasing and concave functions of time in the match, $s = t - t_0$ where t_0 is the starting date of the job. Many theories, for example Jovanovic's learning model of firm-specific capital ([18]), predict that productivity in the early years of a match is lower than worker's productivity in alternative firms where productivity has no firm-specific component. To summarize these effects consider two seniority values s_- and s_+ with $0 < s_- < s_+$. Let us suppose that $E(p_{ijt_0+s}) = f_{ijt_0+s}$ is smaller than $E(w_{it_0+s}^{B}) = g_{ijt_0+s}$ for $s < s_-$. Expected returns to the match are positive after s_- until seniority s_+ when worker's productivity stops increasing. For $s > s_+$ expected outside productivity can, again, exceed worker's firm-specific productivity so that at least one of the partners will terminate the match. In addition to these systematic elements, the random shocks ς_{ijt_0+s}.and η_{it_0+s} will also affect the separation decisions. To summarize, the worker remains at firm j as long as the expected value $E_t\left(V_{ijt+1}\right)$ is large enough to exceed any current productivity disadvantage captured in $\left(p_{ijt}^{NB} - w_{it}^{B}\right)$. This part of the value function reflects the technology of the firm, promotion practices, human resource management and other firm-specific factors.

This reasoning applies also at the beginning of the job. Before the beginning of the job at time t_0, both firm and workers who meet consider the non-optimized expected value of the match $\widetilde{V}_{ijt_0}$. If $\widetilde{V}_{ijt}$ is positive the worker will be hired, which would have for consequence $R_{ijt_0} = 1$. If not, the worker is not hired.

Until now, nothing has been said about wages in complex firms. Let us consider the wage sequence $(w_{ijt_0}, ...w_{ijt_0+s}, ...)$. These wages reflect a breadkdown of the match value between the value accruing to worker i if employed in firm j, V^W and the value accruing to the firm, when j employs worker i, V^F.

$$V_{ijt}^{W} = E_t\left(\sum_{s=0}^{\infty}\delta^s\left(w_{ijt+s} - w_{it+s}^{B}\right)R_{ijt+s}\right) \tag{7}$$

$$V_{ijt}^{F} = E_t\left(\sum_{s=0}^{\infty}\delta^s\left(p_{ijt+s}^{NP} - w_{ijt+s}\right)R_{ijt+s}\right) \tag{8}$$

A large number of theories explain wage formation. The most simple states that wages always equal productivity, in which case accumulation of specific capital leads to a direct relationship between wages and seniority. At the opposite, firms could always pay workers' reservation wages. On-the-job equilibrium search models provide a rationale for wages being higher than reservation wages (Burdett and Mortensen [12]) and possibly dependent on seniority (Burdett and Coles [11]) even without accumulation of specific capital in worker's productivity. Nash bargaining or personnel economics (Lazear [19]) provide other rationales for wages being higher than reservation wages and possibly dependent on productivity. The point here is clearly not to choose among all these theories or even to test them. The previous representation of the mobility process is flexible enough to be consistent with all these theories. We now want to write a flexible description of the wage formation process consistent with as many theories as possible as well as with the separation rule described above.

The optimal continuation rule discussed above tells us nothing about the optimal compensation system for the employing firm. Therefore, we use a simple flexible sharing rule that can reflect the details of many pay systems in a matching or firm-specific capital environment:[5]

$$\ln w_{ijt} = \ln w_{it}^{B} + \gamma_{ijt}\left(\ln p_{ijt}^{NB} - \ln w_{it}^{B}\right) \tag{9}$$

With this sharing rule, the sharing parameter γ_{ijt} has many potential interpretations. Using our above specification of the productivity in complex firms (2), we get

$$\begin{aligned} \ln w_{ijt} &= \theta_i + \beta Exp_{it} + \gamma_{ijt}\beta_j Sen_{ijt} + \gamma_{ijt}\nu_{ijt} \\ &= \theta_i + \beta Exp_{it} + \widetilde{\gamma}_{ijt} Sen_{ijt} + \widetilde{\nu}_{ijt} \end{aligned} \tag{10}$$

[5] The log sharing rule specification is choosen mainly for practical empirical reasons.

Hence, $\widetilde{\gamma}_{ijt}$ now corresponds to i's specific returns to seniority in firm j at time t. $\widetilde{\nu}_{ijt}$ is a firm and individual specific shock that affect wages. As it is written, the model cannot be identified. One way to add some structure is to eliminate the individual heterogeneity in the components $\widetilde{\nu}_{ijt}$ and $\widetilde{\gamma}_{ijt}$. Instead of being directly indexed by i, these components will depend on observable caracteristics X_{it} of i: so $\widetilde{\gamma}_{ijt} = \widetilde{\gamma}_{jt}(X_{it})$ and $\widetilde{\nu}_{ijt} = \widetilde{\nu}_{jt}(X_{it}) + \varepsilon_{ijt}$ where ε_{ijt} is a shock on productivity or on the sharing rule Therefore, unobserved individual heterogeneity will affect wages only through θ_i, transferable from firm to firm.

The dependance of $\widetilde{\gamma}_{jt}$ and $\widetilde{\nu}_{jt}$ on t potentially reflects the dependance of the sharing rule with seniority (as in personnal ecomomics theories), even in absence of pure seniority effects on workers' productivity. We will assume that these functions are firm-specific. They are to be estimated in what follows.

Even though no assumption is made about the choice of a compensation system in our modelling strategy, we will use the term "firm-specific wage policies" in our estimation section. These policies will reflect both the sharing rule and the technologies prevailing in each firm. To allow for a more flexible specification, the wage equation adopted in the following is:

$$\ln w_{ijt} = \theta_i + \beta Exp_{it} + \widetilde{\gamma}_j (Sen_{ijt}, X_{it}) Sen_{ijt} + \widetilde{\nu}_j (X_{it}, Sen_{ijt}) + \varepsilon_{ijt} \quad (11)$$

From (10), the starting wage equation can be written as:

$$\begin{aligned} \ln w_{ijt_0} &= \theta_i + \beta Exp_{it_0} + \widetilde{\nu}_{ijt_0} \\ &= \theta_i + \beta Exp_{it_0} + \widetilde{\nu}_j (X_{it_0}, 0) + \varepsilon_{ijt_0} \end{aligned} \quad (12)$$

Until now, nothing has been said about the relationship between mobility and wages. The link goes through productivity. A shock on productivity clearly affects the probability that a worker stays in a firm through the continuation rule (6). It also affects wages, hence inducing a potential correlation between the decision to continue in a firm and wages. Consider continuation rule (6) which states that the differential between productivity and the reservation wage must be greater than a function representing the future matched value, estimated using information available at time t. This condition can be written as:

$$\ln \left(p_{ijt}^{NB}\right) - \ln \left(w_{it}^{B}\right) \geq f_j (Z_{ijt}) \quad (13)$$

where Z_{ijt} are all characteristics, firm-level or worker-level, that may enter the continuation rule. Notice that the condition may differ from firm to firm. Using complex firms' productivity equation (2) and reservation wages (1), this condition turns to

$$\beta_j Sen_{ijt} + \nu_{ijt} \geq f_j (Z_{ijt}) \quad (14)$$

Thus, in this specification, a positive shock on the inobservable component of productivity increases the probability to stay in the firm. But, using equation (10), this component also affects wages. Obviously, there is endogenous selection. Moreover, because seniority depends on past immobility decisions, it is endogenous in the wage equation. These effects may be different from firm to firm because productivity shocks are likely to have differential effects on wages, depending on the firm-specific sharing rule and technologies in use in the firm.

This simple framework provides us with a framework for thinking about a representation of firm-specific wage and retention policies. The wage policy correspond to functions $\widetilde{\gamma}_j$ and $\widetilde{\nu}_j$, possibly depending on individual characteristics and seniority. The retention policy is also captured by firm-specific parameters and functions $(f_j \ )$, also depending on individual characteristics and seniority. The next Section presents a methodology to estimate these two policies.

3 A General Set of Wage and Mobility Equations

Based on the above model, we first estimate the reservation wage equation (1). Then, we estimate the firm-specific wage and retention policies. Because market wages cannot directly be observed, simple and complex firms are essentially identical at entry. Hence, the reservation wages estimates come from estimating a starting wage equation. In addition, once again because we cannot separate simple and complex firms, the estimation of the firm-specific wage and retention policies will be restricted to large firms (i.e those for which enough observations are available in our data sources) assuming therefore that all such firms are complex w.l.o.g..

3.1 Starting Wage equation

Based on the above model, consider a wage equation in which there are two main components:

- an opportunity wage which reflects the time-varying market value of the workers–value that they keep when moving from firm to firm. This corresponds in the previous section to the wage w_{it}^{B} that workers get in simple firms. This opportunity wage may depend on some characteristics that may change with time, $X_{it}^{(1)}$, such as the experience, as in the theoretical section, and on a fixed individual term that reflects all observed and unobserved time-invariant heterogeneity. Thus,

$$\log w_{it}^{B} = X_{it}^{(1)}\beta + \theta_i \tag{15}$$

  β includes all person characteristics that may affect the market wage, including temporal indicators. The variables entering this equation are described in section 5.

- firm specific parameters which capture the firm's compensation policy, in particular the role of seniority Sen_{ijt}, education, and other characteristics $X_{it}^{(2)}$, some possibly interacted with seniority (for instance education and gender) in the firm's productive activities. These components are lost when leaving firm j. Using above notations, this leads to the following specification

$$\widetilde{\gamma}_j \left(Sen_{ijt}, X_{it}^{(2)}\right) Sen_{ijt} + \widetilde{\nu}_j \left(X_{it}^{(2)}, Sen_{ijt}\right) = \psi_j + \varphi_j X_{it}^{(2)} \left(Sen_{ijt}\right) + g_j \left(Sen_{ijt}\right) \quad (16)$$

where g_j is a non-linear function, introduced to account either for a possible non-linear dependance between productivity and seniority and/or of the sharing rule.

Slightly departing from equation (11) but using this extended specification, we obtain:

$$\begin{aligned}\log w_{ijt} &= \log w_{it}^B + \widetilde{\gamma}_j \left(Sen_{ijt}, X_{it}\right) Sen_{ijt} + \widetilde{\nu}_j \left(X_{it}, Sen_{ijt}\right) + \varepsilon_{ijt} \\ &= X_{it}^{(1)}\beta + \theta_i + \psi_j + \varphi_j X_{it}^{(2)} \left(Sen_{ijt}\right) + g_j \left(Sen_{ijt}\right) + \varepsilon_{ijt} \quad (17)\end{aligned}$$

Hence, for each employment spell, wage equation (17) generates a starting-wage equation at date t_0, when worker i enters firm j, given by

$$\begin{aligned}\log w_{ijt_0} &= X_{it_0}^{(1)}\beta + \theta_i + \psi_j + \varphi_j X_{it}^{(2)} (0) + g_j (0) + \varepsilon_{ijt_0} \\ &= X_{it_0}^{(1)}\beta + \theta_i + \psi_j + \varepsilon_{ijt_0} \quad (18)\end{aligned}$$

under the assumption that the initial component of the firm-specific compensation policy can be summarized by ψ_j, a constant irrespective of workers' characteristics.

As in Topel [26], the returns to experience are directly estimated from this equation. Hence, $X_{it_0}^{(1)}$ include experience variables (see section 5 for a full description of the explanatory variables) as well as other individual characteristics. Because some workers have one job over the period whereas others have many more, we introduce the number of previous jobs as an additional explanatory variable.[6]

The starting-wage equation is estimated by full least squares based on the technique described in [1]. The observations included are those for which seniority s is equal to zero. Hence, the coefficients $\hat{\beta}$, $\hat{\theta}_i$, $\hat{\psi}_j$ are known parameters for the following steps where the firm-specific compensation policy as described by equation (17) is examined.

The identification of these parameters requires supplementary assumptions that we explicit now. $\hat{\theta}_i$ is the estimation of the individual transferable productivity. It can be identified only for the individuals who had at least two different jobs in at least two different firms during the observation period. These individuals correspond to 60% of the whole sample. There is clearly an identification problem for the others. For those ones, we consider $\hat{\theta}_i = \log w_{ijt_0} - X_{it_0}\hat{\beta} - \hat{\psi}_j$, which corresponds to the assumption that $\varepsilon_{ijt_0} = 0$. There exists a similar problem for some firms whose number of sampled workers is very low: only

[6] For instance, Dustmann and Meghir [15] restrict their estimation of such an equation to displaced workers.

44% have more than one observation. For the firms for which only one observation is present, we set $\hat{\psi}_j = 0$. As for the other parameters to estimate, $\hat{\beta}$, there is no identification problem since the number of degrees of freedom is very large (around 2.5 millions), even accounting for the estimation of individual and firm fixed effects. Obviously, our estimated individual fixed effects $\hat{\theta}_i$ will be affected by some measurement error. Therefore, we will restrict its use as much as possible in what follows.

3.2 The firm-specific model for wages and mobility

After entry into firm j, and at each date t, the worker and firm jointly decide to separate or to continue the match. In our approach, and given the available data, quits and layoffs are empirically identical. The worker's wage is observed after entry if and only if the worker-firm pair jointly decide to continue the match. This process is very much in the spirit of work by Jovanovic [18], Flinn [16], Topel and Ward [27], Bushinsky et al. [10] for micro-matching models or earlier work by Lillard and Willis [20] or Mincer and Jovanovic [22] for the whole economy.

At date t for a worker with seniority s, after substracting the effect of the market variables as measured by $X_{it}\hat{\beta}+\hat{\theta}_i$, the mobility process can be expressed using the following equations, that correspond to the firm-specific continuation rule (13) and wage equation (11):

$$\begin{aligned} R^*_{ijt} &= \beta_j Sen_{ijt} - f_j\left(Z_{ijt}\right) + \nu_{ijt} \\ \log w_{ijt} - X^{(1)}_{it}\hat{\beta} - \hat{\theta}_i &= \psi_j + \varphi_j X^{(2)}_{it}\left(Sen_{ijt}\right) + g_j\left(Sen_{ijt}\right) + \varepsilon_{ijt} \end{aligned} \tag{19}$$

where R^*_{itj} is a latent variable expressing staying in the firm j at date t. These equations can be rewritten:

$$\begin{aligned} R^*_{ijt} &= \alpha^R_j Z^R_{ijt} + \nu_{ijt} \\ \log w_{ijt} - X^{(1)}_{it}\hat{\beta} - \hat{\theta}_i &= \alpha^W_j X^W_{ijt} + \varepsilon_{ijt} \end{aligned} \tag{20}$$

where, Z^R_{ijt} is a vector of (possibly) seniority-dependent variables that affect the continuation decision, α^R_j is the firm-specific parameter vector describing the dependence of the separation decision on Z^R_{ijt}, and ν_{ijt} is the productivity shock from the theoretical model. α^R_j describe the whole firm-specific retention policy. X^W_{ijt} is a vector of (possibly) seniority-dependent variables that affect the difference between wage and market wage. α^W_j is the firm-specific parameter vector describing the dependence of firm-specific wage on X^R_{ijt}. α^W_j describes the firm-specific wage policy. For example, a worker hired at date t_0, who stays for two periods then separates, has mobility and log wage equations given by:

$$\begin{aligned} R^*_{ijt_0+1} &= \alpha^R_j Z^R_{ijt_0+1} + \nu_{ijt_0+1} > 0 \qquad (21) \\ \log w_{ijt_0+1} - X_{it_0+1}\hat{\beta} - \hat{\theta}_i &= \alpha^W_j X^W_{ijt_0+1} + \varepsilon_{ijt_0+1} \\ R^*_{ijt_0+2} &= \alpha^R_j Z^R_{ijt_0+2} + \nu_{ijt_0+2} > 0 \\ \log w_{ijt_0+2} - X_{it_0+2}\hat{\beta} - \hat{\theta}_i &= \alpha^W_j X^W_{ijt_0+2} + \varepsilon_{ijt_0+2} \\ R^*_{ijt_0+3} &= \alpha^R_j Z^R_{ijt_0+3} + \nu_{ijt_0+3} < 0 \end{aligned}$$

The indexation of explanatory variables X^W_{ijt} and Z^R_{ijt} means that their seniority dependent components increase with time as long as the job continues. In order to model the statistical relations between past wages and mobility or, similarly, future wages and mobility, we assume that the following correlation structure holds:

$$\begin{matrix} \nu_{ijt_0+1} \\ \varepsilon_{ijt_0+1} \\ \nu_{ijt_0+2} \\ \varepsilon_{ijt_0+2} \\ \nu_{ijt_0+3} \end{matrix} \rightsquigarrow N\left(0, \begin{bmatrix} 1 & \rho_{1j} & 0 & 0 & 0 \\ \rho_{1j} & \sigma^2_j & \rho_{2j} & 0 & 0 \\ 0 & \rho_{2j} & 1 & \rho_{1j} & 0 \\ 0 & 0 & \rho_{1j} & \sigma^2_j & \rho_{2j} \\ 0 & 0 & 0 & \rho_{2j} & 1 \end{bmatrix}\right) \qquad (22)$$

A simple rewriting of the correlation matrix based on the normality assumption is useful for estimation since the likelihood does not involve multiple integration of the normal distribution. Actually, the true correlation matrix that would support the process described above should not be limited by the absence of the individual into the firm. In the example above, the continuation rule at date $t_0 + 3$ should be affected by the wage anticipation at date $t_0 + 3$. What is described here is how we deal with the censorship induced by the job separation. Since the wage at date $t_0 + 3$ is not observed, it has to be taken account for this.

This correlation structure assumes the absence of correlation with the starting wage. It would have been more correct to allow the residual at entry ε_{ijt_0} to be correlated with ν_{ijt_0+1}. We did not include this supplementary information to simplify the estimation method. To account for it, we should have considered as supplementary variable in the continuation equation an estimation of the residual ε_{ijt_0}. Since this residual is assumed equal to zero for more than 40% of workers, this possibility has been ruled out.

The crucial point in our approach should now be clear: all parameters of the wage and mobility equation, apart from the starting-wage equation, are firm-specific. The estimation method is maximum likelihood. For instance, in the wage equation, there are returns-to-seniority parameters that are similar for all workers employed in the firm and may differ from returns estimated in other firms. In addition, these firm-specific returns to seniority are allowed to vary with the sex and education of the workers in that firm. More generally, since the estimation is done firm-by-firm, the estimated parameters can be used to characterize the hiring, promotion, and retention policies of the firm.

The estimation of this process does not rely on the parametric assumptions on the residuals. We introduce also two types of instrumental variables or exclusion restrictions that are supposed to affect continuation probability and not wages. The first type captures individual propensity to change job: these are the duration of the previous jobs and the number of previous jobs. The second type is firm-specific, it is the position of the worker at entry in the firm-specific distribution of ages. This variable is assumed to give some evidence on the existence of internal labor markets (Doeringer and Piore[13]). These instrumental variables are detailed in the section 5, devoted to the results' presentation.

4 Data Description

We use data from the Déclarations annuelles des donnés sociales (DADS), a 1/25th sample of the French work force with information from 1976-1996 on the matched worker-firm side and data from the BRN on the performance of the firm side. We describe these data in turn.

The DADS

The "Déclarations Annuelles des Salaires" are a large collection of matched employer-employee information collected by INSEE (Institut National de la Statistique et des Etudes Economiques). The data are based on a mandatory employer report of the gross earnings of each employee subject to French payroll taxes. The universe includes all employed persons. Our analysis sample covers all individuals employed in French enterprises who were born in October of even-numbered years, with civil servants excluded. Our extract runs from 1976 through 1996, with 1981, 1983 and 1990 excluded because the extracts were not built for those years. The initial data set contained 16 millions observations. Each observation corresponds to a unique enterprise-individual-year combination. The observation includes an identifier that corresponds to the employee (called NNI below) and an identifier that corresponds to the enterprise (SIREN). For each observation, we have information on the number of days during the calendar year the individual worked in the establishment, as well as the full-time/part-time/intermittent/at home work-status of the employee. Each observation also includes, in addition to the variables listed above, the sex, month year and place of birth, occupation, total net nominal earnings during the year and annualized gross nominal earnings during the year for the individual, as well as the location and industry of the employing establishment.

Having done various selections and imputations similar to those described in Abowd et al. [2], the final data set that we use contains 13,770,082 observations, corresponding to 1,682,080 individuals and 515,557 firms.

The estimation of the firm-specific mobility and wage process requires enough observations for each firm. Thus, we had to restrict the estimation to the firms with 200 observations at least. This leaves only 5000 firms that can be used in this purpose. These are the biggest firms and cover around 1/3 of all workers in the private sector.

To estimate the starting wage equation, i.e. a wage equation for all observations with zero seniority, we concentrate on all observations at entry in a new firm. This leaves us with 4,616,093 observations which corresponds to 1,535,758 individuals (some persons are only employed by their 1976 employer and never leave it). and 480,360 firms.

5 Estimation Results

This section is devoted to the presentation of the results. As stated in the section (3), the estimation is two-stage, a first stage estimating a starting wage equation and then the firm-specific model for wages and mobility. The presentation of this section thus begins with the starting wage equation, then goes to the firm-specific model. Different results are presented. Distribution of parameters for mobility and wage equations are presented, then the parameters reflection at the firm-level relationship between wages and mobility. Finally, this section presents a synthesis of all these results using principal component analysis.

5.1 Starting wages

The explanatory variables in equation (18) are experience (up to a quartic), an Ile de France region indicator, a full-time vs part-time indicator, and year indicators. These variables are all full interacted with sex. To control for the endogenous number of starting-wage observations (some workers churn more and therefore have more entry jobs), we control for the past number of jobs in the equation (using indicator functions). In addition, we control for both a person and a firm effect using the Abowd-Creecy-Kramarz, [1], estimation technique. Notice, however, that for firms with only have one observation (one worker in an entry job) we replace the firm identifier with the 2-digit (NAP 100) industrial classification. Starting wage results are presented in Appendix B. This equation captures initial heterogeneity, at entry in the firm, in the spirit of Heckman ([17]).

5.2 The firm-specific wage and mobility equations

For the approximately 5,000 firms in the sample for which there are enough individual observations to perform a firm-by-firm estimation (at least 200 person-year observations) we estimate by maximum likelihood the set of equations similar to those described in equation (21). Convergence occurs for 3,951 firms using the automated maximization programs. We did not try to reestimate models for those firms in which the algorithm did not converge[7]. Since we want to correct the principal component analysis correlation matrix for the estimated nature of the parameters, we also lose some firms because their parameters were too imprecisely estimated.

[7] In previous versions of this research, we succeeded in obtaining convergence for 95% of firms after multiple attempts but none of the subsequent results were changed by inclusion of these firms. In addition, we were less confident in some of the coefficients obtained for those firms where convergence was obtained in the supplementary searches. For these reasons, in this article, we decided to restrict attention to firms for which the maximum likelihood procedure converged immediately using a grid search for the starting values of the correlation coefficients ρ_{1j} and ρ_{2j}.

The distributions of estimated parameters for the mobility equation and the wage equation are given in Tables 1 and 2. Most parameters are easy to interpret. Notice though that the parameters for seniority in the mobility equation and in the wage equation are estimated as splines. For the mobility equation, these parameters induce the following functional form for the probability of moving from the firm:

$$\begin{aligned}\Pr(\text{Staying}\,|sen) &= F\{a_1 sen \times \mathbf{1}\,(0 \leq sen < 2) + [2a_1 + a_2\,(sen-2)] \times \mathbf{1}\,(2 \leq sen < 5) \\ &+ [2a_1 + 3a_2 + a_3\,(sen-5)] \times \mathbf{1}\,(5 \leq sen < 10) \\ &+ [2a_1 + 3a_2 + 5a_3 + a_4\,(sen-10)] \times \mathbf{1}\,(10 \leq sen)\ \}\end{aligned}$$

where $\mathbf{1}(.)$ denotes an indicator function and *sen* denotes seniority. These spline functions are set up so that the function is linear, continuous everywhere, with changing slopes at 2, 5, and 10 years of seniority. For instance, a positive coefficient for a_1 means that workers are more likely to stay after 1 year than after the initial year. Then, coefficient a_2 applies and measures a difference (either increasing or decreasing depending on its sign) from coefficient a_1. For instance if a_2 is not significantly different from zero, it means that workers with three to five years of seniority have the same continuation probability as workers with two years of seniority.

Similarly, we implement spline functions of seniority for the wage equation.To assess the significance of these parameters, we also present the corresponding distributions of Student statistics for these two equations in Tables 3 and 4. The results are striking. The amount of dispersion across firms is daunting. Most models that only incorporate a minimum amount of heterogeneity are way off the mark. This heterogeneity can not be considered as a result of noisy estimations. Should it be the case, the distribution of Students would reflect this. It appears that, for a large number of variables, the distribution of coefficients is far more dispersed than would allow a normal distribution assumption.

The continuation equation:

The continuation equation is the probability that the job continues, hence a positive coefficient corresponds to a larger propensity to stay. Starting from the Student statistics in Table 3, we see that some variables almost never matter in the continuation outcome. As our model shows, this outcome results from the interaction of workers' behavior and firms' policies. These are equilibrium behavior and it is often difficult to disentangle the firm behavior from the workers' decision.

Examining the results, we start with the best summary of a firm retention policy: its propensity to keep or to separate workers. This policy is measured by the three period indicators (there is no constant in our model). These three indicators are very highly correlated within firms (not shown in table) and therefore reflect a long-term component of the firm mobility policy. A large negative indicator means that the firm has many separations or, equivalently, that it is a high-turnover firm. Interestingly, results in Table 3 show that more firms (around 35%) are low-turnover firms whereas 10 to 20% of firms are high-turnover firms. The retention policy of firms may well depend on workers' types. For instance, we see that the worker's sex appears to matter for less than 30% of firms. For more than 90% of firms, workers with long tenure in their previous job stay longer in their current job. Tenure in the current firm often has the opposite consequences for mobility; that is, our results show negative duration dependence for job seniority but with substantial heterogeneity.

Focusing on variables that reflect potential human resource policies of the firm, we consider first the relation between the continuation probability and the individual effect from the starting-wage equation. For 30% to 40% of the firms there is a strong positive relation between the starting-wage person effect and the continuation probability, as indicated by the distribution of Student statistics in the row labelled "person effect" in Table 3. Hence, firms keep the best workers, as measured by their value on the market.

An alternative measure of the heterogeneity of human resource policies comes from examining the evidence for internal labor markets (Doeringer and Piore, 1976 [13]). In this view, firms can create labor markets within their own organization. There are privileged ports of entry and the whole career takes places within the firm through moves between jobs. To assess this theory, we have created for each firm a distribution of ages at entry. In Tables 1 and 3, this firm-specific distribution of age at entry is summarized by the variables labelled "Entry in Q_n of the age at entry distribution," where n is the first, second or third quartile, respectively (with $n = 4$ as the reference group). If entry at a young age is associated with a career within the organization, we should see a negative relation between mobility and workers who enter in Q_1 or Q_2 of this age-at-entry. For instance if a firm hires workers for some jobs on a short-term basis and other workers for core jobs on a long-term basis at a specific age (mostly young), then one expects to see that entry in the first or the second quartile of the age-at-entry distribution is associated with lower separation probabilities. Direct examination of the relevant rows of Tables 1 and 3 shows that there is not much evidence for this interpretation. There is actually a strong negative relation between entry in the first quartile of the age-at-entry distribution and the continuation probability for about 50% of the firms and a strong positive relation (as predicted by internal labor markets) for less than 5%.

By contrast, when firms hire workers at various ages and when the worker-firm pair is concerned about the quality of the match, then one expects to see more separations for workers entering in the bottom of the age distribution. As noted above, this is precisely the case. In more than 30% of firms, workers entering in the first three quartiles of the firm-specific age-at-entry distribution move more often than workers entering in the last quartile of the age distribution (unreported results show that these three coefficients are highly positively correlated). Virtually no firm (less than 5%) keeps workers entering in the bottom of the age distribution. These results are largely inconsistent with most versions of the internal labor market theory. Notice that these variables are included in the continuation equation and excluded from the wage equation, hence they are one of our exclusion restrictions granting non-parametric identification of the model.

Finally, it is interesting to note that some firms, approximately 30%, try to keep workers with technical degrees (as opposed to workers with general education, either low or high), as can be seen from the rows labelled "low general education" and "high general education" in Tables 1 and 3 since "technical degrees" is the omitted category. Workers with general education (the coefficient for low and for high are very strongly positively correlated) separate from those firms more often than those with technical degrees.

The wage equation:

At this stage, it is important to recall that we have jointly estimated firm-specific wage and mobility equations (19). The dependent variable in the firm-specific wage equation is the actual log wage rate less the effects that depend upon coefficients estimated from the starting-wage equation (18). This difference captures the firm-specific log wage less the opportunity wage that a worker would receive, in expectation, on the market at an employer with no firm-specific compensation component at hire. Furthermore, since we substract $\hat{\theta}_i$ from the wage, problems of unobserved person heterogeneity are controlled. Notice also that some variables that were present in the mobility equation are not included in the wage equation. These exclusions serve as identification restrictions. In particular, the position of the entrant within the firm-specific distribution of age-at-entry is excluded from the wage equation since most theories would predict that all effects of this variable work through the propensity to stay in the firm. Similarly, the seniority with the previous employer is excluded from the wage equation since the returns to experience capture this effect.

Results for the firm-specific wage equation are presented in Table 2 (for the coefficient distribution) and Table 4 (for the Student statistic distribution). Many variables have more than half of the coefficients that are statistically significant at the 5% level. Only tenure in its various guises (as a spline or interacted with education and sex) displays 40% or less of the estimated coefficients that are significant at the same level. Even more striking is the almost completely symmetric (around zero) distribution of many wage coefficients. As before, the best summary of the compensation policy of the firm is captured by the period indicators (there is no constant in the wage equation).[8] A positive coefficient corresponds to a high-wage firm and a negative coefficient to a low-wage firm. Roughly 20% of the firms are low-wage firms (at the 5% level) and 30 to 40% of the firms are high-wage firms (again, at the 5% level).

Studying the rest of the Table 2, some results deserve further comment. That the coefficient for full-time compensation is negative may appear surprising. However, one must remember that this variable is present in the starting wage equation. Hence, what is estimated here is the difference between part-time compensation on the market (included in the opportunity cost of time) and the firm-specific policy vis-à-vis part-time. Hence, a positive coefficient means that the firm pays a larger differential to full-time workers than the market rate and

[8] As before, unreported computations show that these indicators are highly positively correlated.

conversely a negative coefficient means that the firm pays its part-time workers better than the market rate.

Returning to the symmetry around zero of most coefficients, it is striking to see that returns to seniority in the first two years of a job–to take a question that has attracted a lot of attention–are significantly negative for 15% to 20% of the firms whereas they are positive for 20% of the firms. These negative returns are still present at higher tenure levels. Furthermore, the estimated seniority coefficients are strongly positively correlated. Hence, around 20% of French firms have negative returns to seniority; 20% have positive returns to seniority, and 60% of French firms have returns to seniority that are virtually zero (not significantly different from zero at the 5% level). This result confirms previous findings of AKM [2] or, more recently of Dostie [14] using a similar data set but completely different estimation techniques. Notice also that comparing the 5th percentile with the 95th percentile for the male-specific returns to tenure we see that 20% of firms provide higher returns to tenure to women and 10% to 15% reward male tenure more than female tenure. Results are roughly similar for returns to tenure for our different levels of education. In general, some firms appear to favor low-education workers, other firms appear to favor technical education (the omitted category), and finally some firms focus on the high-education group. The correlations in Table 6 show that those firms that pay low-education workers high wages also pay their high-education workers high wages.

Relation between pay and mobility:

In Tables 2 and 4, we present the estimated coefficients and estimated Student statistics for the correlation between the mobility error term with the wage error term (future, ρ_1 and past, ρ_2). Here again, the heterogeneity is daunting: 20% of firms have a significant (at the 5% level) positive ρ_1 whereas slightly less than 20% of firms have a significant negative ρ_1. Similarly, more than 30% of firms have a significant positive ρ_2 whereas 15% have a significant negative ρ_2. A low ρ_1 means that workers who face a positive shock to mobility, which decreases their probability to stay, also face a positive shock to their future wage. This is a potential reflection of firms trying to counteract workers' decisions to accept outside offers. Alternatively, the result may mean that workers who have a tendency to move face very good prospects in their origin firm. Conversely a high ρ_1 means that workers who face a negative shock to their mobility also face a positive shock to their future wage. Once again, the mobility decision is an equilibrium outcome in which workers who will not get promoted may decide to move. The question of who initiates the potential separation is virtually impossible to solve. Now, ρ_2 captures the correlation between the past shock on wages and the continuation decision. When negative, workers move after an unexpected wage increase. Apparently, this move is induced by the workers' decision. When positive, workers stay after an unexpected wage increase, resulting from a joint decision. As already mentioned, the latter case (joint optimization) is much more common: an unexpected wage hike is associated workers staying in most firms.

Correlation analysis:

To gain a better understanding of potential relations among these various parameters, we performed a principal component analysis of all these estimated coefficients, *i.e.* those that characterize the mobility policy, those that characterize the pay policy, and those that characterize their relations. Estimates, using the covariance matrix that has been corrected for the fact that all within-firm parameters were estimated (see Appendix C), are presented in Tables 5 and 6. Table 5 shows the eigenvalues whereas Table 6 shows the factor loadings for the first four axes. The results can be summarized as follows. The first four axes capture 61% of the variance. These four dimensions are built on the following linear combinations.

The first axis contrasts high-wage and low-mobility firms with those that pay low wages and are high-mobility firms. It captures 24% of the total variance. The following factor captures only 13% of the variance. These high-wage firms also hire relatively older workers whereas the high-mobility firms mostly hire workers at younger ages, as measured by the firm-specific age-at-entry coefficients. This is clearly consistent with the existence of many short-term formal contracts. Among high-mobility firms, because workers increasingly move with seniority, returns to seniority are high in the first five years. This axis is consistent with some of the theoretical predictions of on-the-job equilibrium search models. For instance, Postel-Vinay and Robin [24] exhibit an on-the-job-equilibrium search model in which employers can respond to outside job offers received by their employees. Some predictions of this model are consistent with firm heterogeneity as structured in our first axis. Firms with low wages have a high turnover rate because workers employed in low-wage firms receive better offers more often than workers employed in high wage firms. Because wage increases within each firm depend on the number of job offers received by its employees, low-wage firms should exhibit higher returns to seniority, exactly what is observed here. At the opposite extreme, high-wage firms do not offer returns to tenure because no firms can compete away their workers. Another explanation for these facts is also found in Burdett and Coles [11]. They present a model with no *ex-ante* heterogeneity in firms in which firms offer wage tenure contracts. In this model, under the assumption that workers are risk-averse, the distribution of contract offers is non-degenerate and the equilibrium is characterized by a baseline scalary scale, which corresponds to the wage/tenure profile of a firm offering the lowest starting wage. Predictions of this model are also consistent with our characterization of the first axis. Low-wage firms offer a wage/tenure profile that begins at low-starting wages. They are the ones that experiment the most important quits of workers who receive better job offers. Since the baseline salary scale is concave, the wage tenure profile of the workers who stay in these firms exhibit higher returns to seniority. These theories may also help resolve a puzzle in our estimates : the existence of negative returns to seniority in some firms. They can be understood in the presence of market failures such as search frictions. Notice that returns to tenure are estimated on top of the returns to experience that reflect potential gains due to better offers when employed. Negative returns to seniority appear to often exist in high wage firms, the ones for which expected gains of receiving higher offers are clearly weaker.

The second factor loading axis combines experience and education. The contrast is between firms in which mobility is increasing with experience and where workers with technical education are better paid with firms in which stability is decreasing with experience and where workers with general education are better paid.

The third axis contrasts low-paying firms that are high-wage firms for workers with a general education with those that are high-wage firms except for workers with a technical education. Interestingly, the fourth axis also revolves around pay choices for the different education types. It contrasts high-wage firms with relatively low wages for the technically educated and low returns to seniority with low-wage firms with high wages for the technically educated and large returns to seniority. Such firms are neither low- or high-turnover.

6 Conclusion

In this paper,we have used a simple descriptive theoretical framework to help us think about the relation between mobility and wage for an individual, both from the worker's own perspective as well as from the employer's perspective. This framework helped us to set up the estimating equations. The data sources were based on a very large, longitudinal employer-employee data set for France, the DADS. The system of equations was estimated firm by firm, very much relying upon the perspective adopted by authors such as Baker, Gibbs, and Holmstrom, [7] and [8], with the distinctive feature that we capture elements of the outside labor market, at entry through an entry wage equation with both person and firm effects as well as at exit by explicitly modelling the joint mobility and wage processes, whereas these authors could not. The results are destructive of the homogeneous view of the labor market in which firms adopt very similar strategies. In fact, the amount of heterogeneity in the policies adopted by the firms is daunting. After documenting this heterogeneity, we tried to characterize what compensation and retention strategies could be in such a world. To do so, we used a simple factor analysis that was able to guide us and show that four factors gave a useful summary view of the heterogeneity. We focus here on the first factor, which appears to give a very simple and clearcut overview of our results. The main contrast between high-wage, low-mobility firms where returns to seniority are low (even negative) and low-wage, high-mobility firms where returns to seniority are relatively high (in a country where the average returns to seniority are lower than in the United States, even compared with Altonji's results) gives a good first-order approximation of the French landscape. Recent job search and matching models (Postel-Vinay and Robin [24], Burdett and Coles [11] and Woodcock [28]) with person or/and firm heterogeneity appear to be able to generate exactly this type of effect. Other dimensions contrast firms that favor general education with firms that favor more technical education.

On the methodology side, this paper uses some newer, recently developed, techniques for analyzing the matched employer-employee data. It also contains a non trivial number of methodological firsts. To name but a few, the firm-by-firm (maximum likelihood) estimation strategy, the correction for the estimated nature of the parameters characterizing the firm policies, the joint modelling of wages and mobility at the firm level, and the identification strategy relying on exclusion restrictions based on variables that can only be constructed using the matched worker-firm aspect of the data (for instance the age at entry within the firm-specific age distribution).

We believe that the analysis presented here opens more avenues of research than it closes doors and solves problems. But, we see it as a first step in our understanding the substance as well as the methods to use when analyzing firms' hiring, retention, compensation, or more generally human resource management policies. New methods should also be developed that would allow us to perform an analysis of workers' firm to firm movements.

References

[1] Abowd J. M., Creecy R., and F. Kramarz (2003), "Computing Person and Firm Effects Using Linked Longitudinal Employer-Employee Data," Cornell University working paper, revised.

[2] Abowd J. M., Kramarz F. and D. N. Margolis (1999), "High Wage Workers and High Wage Firms," *Econometrica*, 67, 251-334.

[3] Abraham, K.J. and H.S. Farber (1987), "Job Duration, Seniority and Earnings," *American Economic Review*, 77, 278-97.

[4] Altonji J. G. and R. A. Shakotko (1987), "Do Wages Rise With Job Seniority?," *Review of Economic Studies*, LIV, 437-459.

[5] Altonji J. G. and N. Williams (1992), "The Effects of Labor Market Experience, Job Seniority and Job Mobility on Wage Growth," NBER Working Paper Series 4133.

[6] Altonji J. G. and N. Williams (1997), "Do Wages Rise With Job Seniority ? A Reassessment," NBER Working Paper Series 6010.

[7] Baker G., Gibbs M., and B. Holmstrom (1994), "The Internal Economics of the Firm: Evidence from Personnel Data," *Quarterly Journal of Economics*,.CIX, November 1994.

[8] Baker G., Gibbs M., and B. Holmstrom (1994), "The Wage Policy of a Firm," *Quarterly Journal of Economics*,.CIX, November 1994.

[9] Brown, J.M. (1989) "Why Do Wages Increase with Tenure? On-the-job Training and Life-cycle Wage Growth Observed within Firms," *American Economic Review*, 79, 971-91.

[10] Buchinsky M., Fougère D., Kramarz F. and R. Tchernis (2002), "Interfirm Mobility, Wages, and the Returns to Seniority and Experience in the U.S.," CREST Working Paper 2002-29, Paris.

[11] Burdett, K and M. Coles (2003), "Equilibrium Wage-Tenure Contracts", *Econometrica*, 71(5), 1377-1404.

[12] Burdett, K and D.T. Mortensen (1998), "Wage Differentials, Employer Size and Unemployment", *International Economic Review*, 39, p. 257-273.

[13] Doeringer, Peter B. and Michael J. Piore. 1976. *Internal Labor Markets and Manpower Analysis*. Lexington: CD Health.

[14] Dostie, B. (2005) "Job Turnover and the Returns to Seniority," *Journal of Business and Economic Statistics* (forthcoming).

[15] Dustman, C. and C. Meghir (2003) "Wages, Experience and Seniority." Unpublished paper, Institute for fiscal studies.

[16] Flinn C. J. (1986), "Wages and Job Mobility of Young Workers," *Journal of Political Economy*, 94, S88-S110.

[17] Heckman J. J. (1981), "Heterogeneity and State Dependence," in *Studies in Labor Market*, Rosen S. ed., University of Chicago Press.

[18] Jovanovic B. (1979), "Job Matching and the Theory of Turnover," *Journal of Political Economy*, 87, 972-990.

[19] Lazear, E.P. (1995) *Personnel Economics*, Cambridge, MA: MIT Press.

[20] Lillard L. A. and R. J. Willis (1978), "Dynamic Aspects of Earnings Mobility," *Econometrica*, 46, 985-1012.

[21] Margolis, D.N. (1996) "Cohort Effects and the Return to Seniority in France," *Annales d'Economie et Statistique*, 41/42, 443-464.

[22] Mincer J. and B. Jovanovic (1981), "Labor Mobility and Wages," "Heterogeneity and State Dependence," in *Studies in Labor Market*, Rosen S. ed., University of Chicago Press.

[23] Mortensen D. T. (2003), *Wage Dispersion*, MIT press, Cambridge, Ma.

[24] Postel-Vinay, F. and J-M. Robin (2002), "Equilibrium Wage Dispersion with Worker and Employer Heterogeneity," *Econometrica*, 70, 2295-350.

[25] Robin J-M. and S. Roux (2002), "An equilibrium model of the labour market with endogeneous capital" *Annales d'Economie et de Statistique*, 67-68, p.257-297.

[26] Topel R. H. (1991), "Specific Capital, Mobility, and Wages: Wages Rise with Job Seniority," *Journal of Political Economy*, 99, 145-175.

[27] Topel R. H. and M. P. Ward (1992), "Job Mobility and the Careers of Young Men," *The Quarterly Journal of Economics*, 439-479.

[28] Woodcock S. D. (2003), "Agent Heterogeneity and Learning: An Application to Labor Markets," Chapter 1 of Ph.D thesis, Cornell University.

Appendix A: The Likelihood Function for the Firm-specific Model of Wages and Mobility

Consider the log wage equation (17), the starting-wage equation (18) and the firm-specific wage and mobility equations (19) in the text. With all definitions associated with those equations. We derive the likelihood for the firm-specific model of wages and mobility in this appendix. After entry in firm j, and at each value of seniority $s(i,t)$, the worker and firm mutually decide to continue or terminate the employment relation. The latent variable $R^*_{ijt} = \alpha^R_j Z^R_{ijt} + \nu_{ijt}$ operationalizes the condition given by the value function in equation (14). Let t_0 be the starting year of the job, a wage rate is observed for $s = t - t_0 > 0$ if and only if the employment relation continues. At date t for a worker with seniority s, (after substracting the effect of the market variables as measured by $X_{it}\hat{\beta} + \hat{\theta}_i$), the mobility process can be expressed by the equations (19) in the text. Consider the $s = 2$ example from equations (21) From this structure of correlation, multivariate normality implies that:

$$\begin{matrix} \eta^R_{ijt_0+1} \\ \eta^W_{ijt_0+1} \\ \eta^R_{ijt_0+2} \\ \eta^W_{ijt_0+2} \\ \eta^R_{ijt_0+3} \end{matrix} = \begin{matrix} \nu_{ijt_0+1} - \frac{\rho_{1j}}{\sigma^2_j}\varepsilon_{it_0+1} \\ \varepsilon_{ijt_0+1} \\ \nu_{ijt_0+2} - \frac{\rho_{2}j}{\sigma^2_j}\varepsilon_{ijt_0+1} - \frac{\rho_{1j}}{\sigma^2_j}\varepsilon_{ijt_0+2} \\ \varepsilon_{ijt_0+2} \\ \nu_{ijt_0+3} - \frac{\rho_{2j}}{\sigma^2_j}\varepsilon_{ijt_0+2} \end{matrix} \rightsquigarrow N\left(0, \begin{bmatrix} 1-\frac{\rho^2_{1j}}{\sigma^2_j} & 0 & 0 & 0 & 0 \\ 0 & \sigma^2_j & 0 & 0 & 0 \\ 0 & 0 & 1-\frac{\rho^2_{2j}}{\sigma^2_j}-\frac{\rho^2_{1j}}{\sigma^2_j} & 0 & 0 \\ 0 & 0 & 0 & \sigma^2_j & 0 \\ 0 & 0 & 0 & 0 & 1-\frac{\rho^2_{2j}}{\sigma^2_j} \end{bmatrix}\right)$$

where the vector η has components with subscripts ijt denoting the individual-employer match and superscripts R or W denoting the equation number (R for the continuation equation; W for the wage equation). This last result is useful for estimation since the likelihood does not involve multiple integration of the normal distribution as shown by

$$\begin{aligned} R^*_{ijt_0+1} &= \alpha^R_j Z^R_{ijt_0+1} + \frac{\rho_{1j}}{\sigma^2_j}\varepsilon_{ijt_0+1} + \eta^R_{ijt_0+1} > 0 \\ \log w_{ijt_0+1} - X_{it_0+1}\hat{\beta} - \hat{\theta}_i &= \alpha^W_j X^W_{ijt_0+1} + \varepsilon_{ijt_0+1} \\ R^*_{ijt_0+2} &= \alpha^R_j Z^R_{ijt_0+2} + \frac{\rho_{2j}}{\sigma^2_j}\varepsilon_{ijt_0+1} + \frac{\rho_{1j}}{\sigma^2_j}\varepsilon_{ijt_0+2} + \eta^R_{ijt_0+2} > 0 \\ \log w_{ijt_0+2} - X_{it_0+2}\hat{\beta} - \hat{\theta}_i &= \alpha^W_j X^W_{ijt_0+2} + \varepsilon_{ijt_0+2} \\ R^*_{ijt_0+3} &= \alpha^R_j Z^W_{ijt_0+3} + \frac{\rho_{2j}}{\sigma^2_j}\varepsilon_{ijt_0+2} + \eta^R_{ijt_0+3} < 0 \end{aligned}$$

or

$$R^*_{ijt_0+1} = \alpha_j^R Z^R_{ijt_0+1} + \frac{\rho_{1j}}{\sigma_j^2}\left[\log w_{ijt_0+1} - X_{it_0+1}\hat{\beta} - \hat{\theta}_i - \alpha_j^W X^W_{ijt_0+1}\right] + \eta^R_{ijt_0+1} > 0$$
$$\log w_{ijt_0+1} - X_{it_0+1}\hat{\beta} - \hat{\theta}_i = \alpha_j^W X^W_{ijt_0+1} + \eta^W_{ijt_0+1}$$
$$R^*_{ijt_0+2} = \alpha_j^R Z^R_{ijt_0+2} + \frac{\rho_{2j}}{\sigma_j^2}\left[\log w_{ijt_0+1} - X_{it_0+1}\hat{\beta} - \hat{\theta}_i - \alpha_j^W X^W_{ijt_0+1}\right]$$
$$+\frac{\rho_{1j}}{\sigma_j^2}\left[\log w_{ijt_0+2} - X_{it_0+2}\hat{\beta} - \hat{\theta}_i - \alpha_j^W X^W_{ijt_0+2}\right] + \eta^R_{ijt_0+2} > 0$$
$$\log w_{ijt_0+2} - X_{it_0+2}\hat{\beta} - \hat{\theta}_i = \alpha_j^W X^W_{ijt_0+2} + \eta^W_{ijt_0+2}$$
$$R^*_{ijt_0+3} = \alpha_j^R Z^W_{ijt_0+3} + \frac{\rho_{2j}}{\sigma_j^2}\left[\log w_{ijt_0+2} - X_{it_0+2}\hat{\beta} - \hat{\theta}_i - \alpha_j^W X^W_{ijt_0+2}\right] + \eta^R_{ijt_0+3} < 0$$

The contribution to the log likelihood of this sequence of observations is

$$\begin{gathered}
\log L\left(R_{ijt_0+1} = 1, w_{ijt_0+1}, R_{ijt_0+2} = 1, w_{ijt_0+2}, R_{ijt_0+3} = 0\right) = \\
\log\Phi\left(\alpha_j^R Z^R_{ijt_0+1} + \frac{\rho_{1j}}{\sigma_j^2}\left[\log w_{ijt_0+1} - X_{it_0+1}\hat{\beta} - \hat{\theta}_i - \alpha_j^W X^W_{ijt_0+1}\right]\right) \\
+\log\varphi\left(\frac{\log w_{ijt_0+1} - X_{it_0+1}\hat{\beta} - \hat{\theta}_i - \alpha_j^W X^W_{ijt_0+1}}{\sigma_j}\right) \\
+\log\Phi\left(\begin{array}{c} \alpha_j^R Z^R_{ijt_0+2} + \frac{\rho_{2j}}{\sigma_j^2}\left[\log w_{ijt_0+1} - X_{it_0+1}\hat{\beta} - \hat{\theta}_i - \alpha_j^W X^W_{ijt_0+1}\right] \\ +\frac{\rho_{1j}}{\sigma_j^2}\left[\log w_{ijt_0+2} - X_{it_0+2}\hat{\beta} - \hat{\theta}_i - \alpha_j^W X^W_{ijt_0+2}\right] \end{array}\right) \\
+\log\varphi\left(\frac{\log w_{ijt_0+2} - X_{it_0+1}\hat{\beta} - \hat{\theta}_i - \alpha_j^W X^W_{ijt_0+2}}{\sigma_j}\right) \\
+\log\left[1 - \Phi\left(\alpha_j^R Z^R_{ijt_0+3} + \frac{\rho_{2j}}{\sigma_j^2}\left[\log w_{ijt_0+2} - X_{it_0+2}\hat{\beta} - \hat{\theta}_i - \alpha_j^W X^W_{ijt_0+2}\right]\right)\right]
\end{gathered}$$

where $R_{ijt_0+s} = 1$ when $R^*_{ijt_0+s} > 0$. More generally, the log likelihood for person i who arrived at date t_0 in firm j and stayed exactly S periods (*i.e.*, with one entry wage and $S-1$ observed wages in firm j after this initial date) is:

$$\begin{array}{l}
\log L\left(R_{ijt_0+1}=1,w_{ijt_0+1},...,R_{ijt_0+S}=0\right)= \\
R_{ijt_0+1}\log\Phi\left(\alpha_j^R Z_{ijt_0+1}^R+\frac{\rho_{1j}}{\sigma_j^2}\left[\log w_{ijt_0+1}-X_{it_0+1}\hat{\beta}-\hat{\theta}_i-\alpha_j^W X_{ijt_0+1}^W\right]\right) \\
\quad +\sum_{s=1}^{S-1}\left\{\log\varphi\left(\frac{\log w_{ijt_0+s}-X_{it_0+s}\hat{\beta}-\hat{\theta}_i-\alpha_j^W X_{ijt_0+s}^W}{\sigma_j}\right)\right. \\
\left. +R_{ijt_0+s+1}\log\Phi\left(\begin{array}{c}\alpha_j^R Z_{ijt_0+s+1}^R+\frac{\rho_{2j}}{\sigma_j^2}\left[\log w_{ijt_0+s}-X_{it_0+s}\hat{\beta}-\hat{\theta}_i-\alpha_j^W X_{ijt_0+s}^W\right] \\ +\frac{\rho_{1j}}{\sigma_j^2}\left[\log w_{ijt_0+s+1}-X_{it_0+s+1}\hat{\beta}-\hat{\theta}_i-\alpha_j^W X_{ijt_0+s+1}^W\right]\end{array}\right)\right\} \\
+(1-R_{ijt_0+S})\log\overline{\Phi}\left(-\alpha_j^R Z_{ijt_0+S}^R-\frac{\rho_{2j}}{\sigma_j^2}\left[\log w_{ijt_0+S-1}-X_{it_0+S-1}\hat{\beta}-\hat{\theta}_i-\alpha_j^W X_{ijt_0+S-1}^W\right]\right)
\end{array}$$

Appendix B: Starting-wage Equation Estimates

Table B1 presents the results for the starting wage equation. We present only the coefficients and not the standard errors, which are not directly delivered by the Abowd, Creecy, and Kramarz (2003), [1], estimation technique. Standard errors could be obtained by substracting the estimated person and firm effects from the wage and rerunning the regression on the observed characteristics contained in this table.

Appendix C: Estimation of the Corrected Covariance Matrix

The principal composant analysis requires the covariance matrix of the observed variables. The problem here is that these variables are not directly observed but estimated at the firm-level. We thus need to correct the covariance matrix for the measurement errors.

X is a set of parameters that comes from a first step equation and, therefore, is measured with error following

$$\widehat{X}=X+\nu$$

in which $\nu_i \rightarrow N(0,\Sigma_i)$. We know the probability distribution of ν for each observation since the first-step estimation delivered a variance-covariance matrix for each firm (set of parameters).

Furthermore,

$$\begin{aligned}
\widehat{X}_i'\widehat{X}_i &= (X_i+\nu_i)'(X_i+\nu_i) \\
&= X_i'X_i+X_i'\nu_i+\nu_i'X_i+\nu_i'\nu_i
\end{aligned}$$

By taking the average over the observations, the above implies:

$$M_{\widehat{X}\widehat{X}}=\frac{1}{N}\sum\widehat{X}_i'\widehat{X}_i=\frac{1}{N}\sum X_i'X_i+X_i'\nu_i+\nu_i'X_i+\nu_i'\nu_i$$

Then, by noting that X_i and ν_i are uncorrelated among themselves, we see that the second and third components of the above equality tend to zero. An empirical counterpart for the last component is needed. Even though we do not know ν_i, we know its law. We estimate the mean of the variance of the residuals by its empirical counterpart:

$$\frac{1}{N}\sum \nu_i'\nu_i \to \frac{1}{N}\sum \Sigma_i$$

Hence, an estimator of the true covariance matrix Σ is :

$$\widehat{\Sigma}^{(1)} = M_{\widehat{X}\widehat{X}} - \frac{1}{N}\sum \Sigma_i$$

Unfortunately, the above estimators pose practical problems because some estimates of $\widehat{X}$ are too imprecise. Those $\widehat{X}$ that are the least precise make $\widehat{\Sigma}^{(1)}$ not being positive. One way to address this difficulty is by weighting the estimator presented above by the inverse of the variance of the $\widehat{X}_i$. In practice, it is much easier to use the inverse of the trace of the variance covariance matrix estimated at the firm-level as a weight for each observation. Therefore, we have the following estimator for the covariance matrix that will be used for the principal components analysis.

$$\widehat{\Sigma}^{(2)} = \frac{1}{N\frac{1}{\sum \frac{1}{tr\Sigma_i}}}\sum \frac{1}{tr\Sigma_i}\left(\widehat{X}_i'\widehat{X}_i - \Sigma_i\right)$$

Table 1: Distribution of the Estimated Parameters for the Firm-by-Firm Mobility Equation

	Mean	Std Err.	q1	q5	q25	q50	q75	q95	q99
Male	-0.0161	0.3941	-0.8390	-0.4055	-0.1364	-0.0056	0.0912	0.3597	0.7923
Part-time	0.3628	0.6742	-0.8001	-0.2063	0.1141	0.3320	0.5661	1.0100	1.7191
First Period indicator	0.2607	1.2618	-2.9530	-1.5661	-0.3271	0.3854	0.8989	1.9496	3.1858
Second Period indicator	-0.0382	6.3362	-3.5082	-1.9353	-0.8422	0.0323	0.4819	1.3875	2.6178
Third Period indicator	-0.0363	6.4468	-3.2716	-1.7774	-0.8102	-0.0133	0.4572	1.4282	2.9012
Person Effect (from starting wage equation)	0.1035	0.2629	-0.6697	-0.2669	-0.0168	0.0890	0.2221	0.4912	0.8511
Experience	0.0083	1.1331	-0.3339	-0.1644	-0.0478	-0.0005	0.0743	0.2149	0.4069
(Experience/10)**2	-0.0712	2.7688	-4.6965	-2.3532	-0.6320	0.0146	0.6348	1.5255	3.4281
(Experience/100)**3	0.0553	0.7575	-1.3101	-0.5314	-0.2116	0.0039	0.2472	0.9559	2.0674
(Experience/1000)**4	-0.0010	1.6188	-0.2925	-0.1307	-0.0358	-0.0041	0.0199	0.0545	0.1587
Tenure (less than two years)	-0.1796	24.8821	-2.5486	-1.2529	-0.2385	0.0307	0.2315	0.4720	0.8842
Tenure (2 to 5 years)	-0.3839	24.6520	-1.6256	-0.7018	-0.2156	-0.0619	0.0601	0.4240	1.1096
Tenure (5 to 10 years)	-0.1683	19.0219	-1.5974	-0.7267	-0.1687	-0.0035	0.0691	0.2717	0.9527
Tenure (more than 10 years)	-0.1788	4.4410	-1.3999	-0.7433	-0.2716	-0.1266	-0.0374	0.0377	0.4514
Tenure*Male	0.0074	5.0466	-0.4647	-0.1119	-0.0147	0.0007	0.0295	0.1348	0.4469
Tenure*Low general education	-0.1774	31.1999	-1.4458	-0.2843	0.0190	0.0498	0.1318	0.4384	1.1699
Tenure*High general education	-0.1037	17.5362	-1.6970	-0.4159	-0.0409	0.0233	0.0853	0.5356	1.4725
Low general education	-0.2575	1.8298	-2.4651	-1.2942	-0.5095	-0.2116	-0.0170	0.7692	1.8120
High general education	-0.3246	1.4654	-3.3289	-1.5403	-0.6040	-0.2616	0.0095	0.8746	2.2733
Entry in first quartile of the age at entry distribution	-0.4194	0.6432	-2.1209	-1.3098	-0.6852	-0.4609	-0.1124	0.4548	1.2314
Entry in second quartile of the age at entry distribution	-0.3016	0.5181	-1.7105	-1.0220	-0.5058	-0.3016	-0.0824	0.3991	1.1092
Entry in third quartile of the age at entry distribution	-0.1996	0.3867	-1.1937	-0.7134	-0.3659	-0.2111	-0.0384	0.3132	0.8599
Number of previous jobs	-0.0522	1.0663	-0.3287	-0.1646	-0.0565	-0.0277	-0.0102	0.0145	0.1097
Duration of the previous job	0.1936	0.4149	-0.0030	0.0392	0.0670	0.0930	0.1972	0.6890	1.3476

Notes: Between-firms distribution of the estimated parameters for the mobility equation. The model is estimated by maximum likelihood separately firm-by-firm. For each firm in the sample, there is a set of estimated parameters used to compute the distribution. Parameters are only estimated for those firms in which there is enough within-firm variability. Number of observations (firms): 3,951. Sources: DADS.

Table 2: Distribution of the Estimated Parameters for the Firm-by-Firm Wage Equation

	Mean	Std Err.	q1	q5	q25	q50	q75	q95	q99
Part-time	0.0344	0.4644	-0.7983	-0.5281	-0.2270	-0.0583	0.1978	0.9165	1.5304
First Period indicator	0.0138	0.6353	-1.9025	-1.0553	-0.2934	0.1022	0.3829	0.8695	1.2988
Second Period indicator	-0.0151	0.7096	-1.9277	-1.6657	-0.3627	0.1234	0.3943	0.9038	1.2977
Third Period indicator	0.0084	0.7198	-2.2397	-1.3609	-0.3812	0.1683	0.4382	0.9387	1.4081
Tenure (less than two years)	0.0391	1.5918	-0.3602	-0.1425	-0.0243	0.0138	0.0674	0.2227	0.4025
Tenure (2 to 5 years)	0.0014	0.2508	-0.3470	-0.1297	-0.0323	0.0003	0.0318	0.1393	0.3395
Tenure (5 to 10 years)	0.0056	0.2556	-0.2956	-0.0953	-0.0163	0.0032	0.0266	0.1219	0.3143
Tenure (more than 10 years)	0.0189	0.3298	-0.2742	-0.0721	-0.0078	0.0145	0.0338	0.1343	0.4395
Male	0.0212	0.1438	-0.3919	-0.1822	-0.0324	0.0184	0.0771	0.2226	0.4771
Tenure*Male	-0.1544	7.7711	-0.1321	-0.0434	-0.0115	-0.0017	0.0081	0.0448	0.1280
Low general education	-0.0005	0.3524	-0.9861	-0.4865	-0.1353	0.0148	0.1178	0.4481	1.0047
Tenure*Low general education	-0.0211	1.9502	-0.3320	-0.1073	-0.0206	-0.0040	0.0138	0.1113	0.3698
High general education	0.0074	0.4688	-1.4712	-0.6056	-0.1625	0.0059	0.1584	0.6571	1.3720
Tenure*High general education	0.1302	11.9309	-0.4659	-0.1535	-0.0125	0.0082	0.0391	0.1695	0.5464
Correlation between mobility and f	-0.3139	1.2977	-4.8606	-3.6833	-0.0743	0.0048	0.0650	0.3359	2.6381
Correlation between mobility and p	-0.0260	0.1637	-0.5884	-0.2421	-0.0747	-0.0237	0.0315	0.1661	0.3723
Standard error of the wage shock	-0.9099	0.8357	-2.4347	-2.0403	-1.4549	-1.0676	-0.5762	0.9425	1.1945

Notes: Between-firms distribution of the estimated parameters for the wage equation. The model is estimated by maximum likelihood separately firm-by-firm. For each firm in the sample, there is a set of estimated parameters used to compute the distribution. Parameters are only estimated for those firms in which there is enough within-firm variability. Number of observations (firms): 3,951. Sources: DADS.

Table 3: Distribution of the Estimated Student Statistics for the Firm-by-Firm Mobility Equation

	Mean	Std Err.	q1	q5	q25	q50	q75	q95	q99
Male	0.8117	4.6330	-4.5846	-2.6651	-0.9781	-0.0320	1.0997	5.1979	21.0560
Part-time	4.2133	7.7969	-8.2593	-1.4457	0.6292	2.0488	4.6859	18.2803	34.6720
First Period indicator	0.6768	8.3624	-29.2288	-19.7934	-0.5738	0.9161	3.1356	13.2404	22.4660
Second Period indicator	-0.7344	6.4521	-26.3768	-14.7496	-1.4135	0.0497	1.4600	9.2332	10.0240
Third Period indicator	-1.0553	6.1903	-22.0264	-20.1132	-1.5007	-0.0054	1.5153	6.3767	7.7360
Person Effect (from starting wage e	1.7315	3.5785	-7.9233	-2.5961	-0.3158	1.1439	2.9645	9.0843	11.1400
Experience	-0.4688	3.0357	-9.8025	-6.9150	-1.3716	0.0000	1.0995	3.3827	8.7410
(Experience/10)**2	1.0354	4.0817	-4.9620	-2.9832	-1.0722	0.0230	1.2908	11.9717	15.3340
(Experience/100)**3	-1.3839	5.0645	-21.0915	-13.8944	-1.2761	0.0410	1.0507	2.5297	4.3750
(Experience/1000)**4	1.2024	5.2846	-4.7710	-2.9442	-1.2377	-0.1353	1.1844	13.3020	22.1950
Tenure (less than two years)	1.4053	6.9969	-12.9560	-9.3060	-1.2807	0.2008	2.2533	19.3344	25.4720
Tenure (2 to 5 years)	-1.0196	3.9677	-10.8282	-7.2990	-2.5344	-0.6255	0.5190	4.3250	10.1230
Tenure (5 to 10 years)	0.0788	4.3181	-11.9530	-8.5697	-1.5431	-0.0210	1.6305	8.0322	10.5820
Tenure (more than 10 years)	-3.3559	3.4848	-14.2948	-13.0720	-5.1823	-2.3665	-0.9545	0.2945	1.3840
Tenure*Male	-0.0035	1.7796	-5.2250	-2.4542	-0.9155	0.0119	1.0286	2.6630	4.8060
Tenure*Low general education	1.7749	2.3458	-2.1896	-0.9771	0.2316	1.3170	2.7654	7.3194	7.7430
Tenure*High general education	0.6063	1.9080	-2.8912	-1.8786	-0.5306	0.2803	1.3293	3.7927	6.6810
Low general education	-1.3314	2.0393	-8.9120	-4.4944	-2.1132	-0.9830	-0.0397	1.1336	2.3000
High general education	-1.5891	2.7773	-11.3924	-9.7713	-2.5382	-0.9414	0.0076	1.3711	2.3580
Entry in Q1 of the age at entry distri	-3.0635	4.4751	-15.1124	-14.7924	-4.0094	-1.7155	-0.3604	1.5673	3.9560
Entry in Q2 of the age at entry distri	-2.5399	3.3882	-11.6351	-10.8439	-3.3930	-1.5074	-0.3576	0.9300	1.9040
Entry in Q3 of the age at entry distri	-2.6000	4.1588	-16.3312	-14.7258	-2.8080	-1.2474	-0.3372	0.9689	2.0480
Number of previous jobs	-2.4686	2.6466	-10.5123	-6.4336	-3.9635	-1.9461	-0.7086	0.7917	2.9220
Duration of the previous job	23.0341	30.8499	-0.6994	1.8674	5.6677	11.0840	28.7513	70.0884	162.1100

Notes: Between-firms distribution of the estimated Student statistics for the mobility equation. The model is estimated by maximum likelihood separately firm-by-firm. For each firm in the sample, there is a set of estimated parameters used to compute the distribution. Parameters are only estimated for those firms in which there is enough within-firm variability. Number of observations (firms): 3,951. Sources: DADS.

Table 4: Distribution of the Estimated Student Statistics for the Firm-by-Firm Wage Equation

	Mean	Std Err.	q1	q5	q25	q50	q75	q95	q99
Part-time	-1.1127	17.0783	-51.0257	-34.3249	-8.0100	-0.9373	4.7356	24.0932	74.0798
First Period indicator	1.1297	9.4462	-28.1657	-16.3387	-1.6538	1.0256	4.4142	21.0527	23.7489
Second Period indicator	0.1831	13.8692	-59.8403	-19.6869	-1.6918	0.9407	4.4304	23.3272	25.2641
Third Period indicator	1.5633	11.7271	-40.2238	-25.1032	-1.6738	1.0696	5.1741	25.1945	27.3398
Tenure (less than two years)	1.1347	4.7704	-6.1039	-4.8529	-0.8270	0.2309	1.6982	13.4474	21.7162
Tenure (2 to 5 years)	0.1226	2.4116	-7.5739	-3.1071	-1.0027	0.0019	1.1426	4.4182	6.1592
Tenure (5 to 10 years)	0.1058	2.6798	-6.1009	-3.8120	-1.0224	0.1469	1.1765	5.0952	7.6454
Tenure (more than 10 years)	1.5590	3.8481	-3.9260	-2.4861	-0.2296	0.6551	1.9420	13.3941	13.5813
Male	0.5180	2.3120	-4.4312	-2.5663	-0.9346	0.3282	1.5950	4.3710	9.3833
Tenure*Male	-0.7141	3.1378	-11.8777	-5.7531	-1.4278	-0.1832	0.8077	2.8793	6.3390
Low general education	-0.0995	2.5634	-9.1418	-3.6319	-0.9258	0.1302	1.1549	3.0289	5.8824
Tenure*Low general education	-0.4878	2.2550	-9.9137	-4.1598	-1.1489	-0.1639	0.6306	2.1636	4.6151
High general education	0.0618	2.1536	-4.4692	-3.6446	-1.2043	0.0510	1.0697	3.1759	8.1428
Tenure*High general education	0.4587	2.1630	-4.9640	-3.4729	-0.5072	0.3880	1.5273	4.3626	6.0300
Correlation between mobility and future wage	5.2210	22.5500	22.7840	5.9166	1.1875	0.0516	-1.4760	-78.7770	-95.1290
Correlation between mobility and past wage	0.2850	4.8550	13.0730	8.8196	0.7943	-0.5977	-2.2450	-6.4730	-12.0560
Standard error of the wage shock (in log)	-124.7990	207.9740	-957.1740	-561.5850	-142.9060	-48.2124	-15.6818	73.1256	153.5680

Notes: Between-firms distribution of the estimated Student statistics for the wage equation. The model is estimated by maximum likelihood separately firm-by-firm. For each firm in the sample, there is a set of estimated parameters used to compute the distribution. Parameters are only estimated for those firms in which there is enough within-firm variability. Number of observations (firms): 3,951. Sources: DADS.

Table 5: Factor Analysis of the Firm-by-Firm Parameters of the Mobility and Wage Equations; Eigenvalues

	Eigenvalue	Difference	Proportion	Cumulative
1	8.5768	3.8185	0.2382	0.2382
2	4.7583	0.2521	0.1322	0.3704
3	4.5062	0.3948	0.1252	0.4956
4	4.1114	1.4632	0.1142	0.6098
5	2.6482	0.6009	0.0736	0.6834
6	2.0473	0.2041	0.0569	0.7402
7	1.8432	0.1915	0.0512	0.7914
8	1.6517	0.3102	0.0459	0.8373
9	1.3416	0.2582	0.0373	0.8746
10	1.0833	0.1433	0.0301	0.9047

Table 6 : Factor Analysis of the Firm-by-Firm Parameters of the Mobility and Wage Equations; Factor Loadings

		Factor1	Factor2	Factor3	Factor4
Mobility equation	Male	-0.0546	-0.3818	-0.1798	-0.1933
	Full-Time	-0.1944	-0.1237	-0.0593	-0.0606
	First Period indicator	-0.7950	-0.1154	0.1732	-0.0732
	Second Period indicator	-0.7877	-0.1230	0.1547	-0.1381
	Third Period indicator	-0.6613	-0.1476	0.0601	-0.0940
	Person Effect (from starting wage equation)	0.1142	0.1159	0.2308	-0.2744
	Experience	-0.0215	0.6514	0.3178	0.1150
	Experience**2	0.0582	-0.7565	-0.4127	-0.1286
	Experience**3	-0.0371	0.7738	0.4240	0.1725
	Experience**4	0.0739	-0.7764	-0.4373	-0.2043
	Tenure (less than two years)	-0.4400	-0.3540	-0.1326	-0.2981
	Tenure (2 to 5 years)	-0.3606	-0.1688	-0.0463	-0.0662
	Tenure (5 to 10 years)	-0.5099	-0.2869	0.0822	-0.2645
	Tenure (more than 10 years)	-0.2875	-0.5369	-0.0964	-0.1514
	Tenure*Low general education	-0.3427	0.5515	0.3015	-0.1436
	Tenure*High general education	-0.1976	0.4691	0.4085	-0.2759
	Low general education	0.5644	-0.3350	-0.1004	0.2020
	High general education	0.6033	-0.1447	-0.0996	0.4848
	Entered in Q1 of age at entry distribution	0.8451	0.0473	-0.2928	0.2711
	Entered in Q2 of age at entry distribution	0.7938	0.0238	-0.2961	0.3535
	Entered in Q3 of age at entry distribution	0.8217	0.1516	-0.2051	0.4010
	Number of previous jobs	0.0513	-0.2263	-0.1599	-0.2406
	Duration the previous job	0.6476	0.0622	-0.0794	0.3952
Wage equation	Full-Time	0.1383	-0.0747	0.3109	-0.3358
	First Period indicator	-0.5328	0.1030	-0.4236	0.5723
	Second Period indicator	-0.6220	0.0493	-0.3499	0.5999
	Third Period indicator	-0.5988	0.0019	-0.3360	0.5161
	Tenure (less than two years)	0.4467	0.1651	-0.0335	-0.3241
	Tenure (2 to 5 years)	0.3198	0.2129	-0.1430	-0.5459
	Male	-0.1853	-0.0463	0.0622	0.2192
	Low general education	-0.1580	-0.5198	0.8486	0.4522
	High general education	-0.0217	-0.4907	0.8542	0.4446
	Tenure*High general education	0.8412	-0.6744	1.0749	0.0678
	Correlation between mobility and future wage	-0.5646	-0.1012	0.0574	0.6084
	Correlation between mobility and past wage	0.2295	0.0496	0.0356	-0.5463
	Standard error of the wage shock (in log)	0.6217	-0.0305	-0.0993	-0.3681

Table B.1: Entry Wage Equation

	Coefficients Male	Coefficients Female
Experience	0.1024	0.0667
Experience**2	-0.5612	-0.3347
Experience**3	0.1436	0.0891
Experience**4	-0.0138	-0.0090
Year=1977	-0.1545	-0.1381
Year=1978	-0.1293	-0.0976
Year=1979	-0.1454	-0.1201
Year=1980	-0.1742	-0.1670
Year=1982	-0.1987	-0.1693
Year=1984	-0.1658	-0.1476
Year=1985	-0.1823	-0.1668
Year=1986	-0.1915	-0.2040
Year=1987	-0.1967	-0.1989
Year=1988	-0.2230	-0.2296
Year=1989	-0.1955	-0.2135
Year=1991	-0.1581	-0.1952
Year=1992	-0.1715	-0.2175
Year=1993	-0.2309	-0.2543
Year=1994	-0.3225	-0.3222
Year=1995	-0.3448	-0.3404
Year=1996	-0.3691	-0.3859
Region=Ile de France	0.0583	0.0656
Full-time=yes	0.7893	0.7526
First Job	0.0987	0.0780
Second Job	0.1464	0.1268
Third Job	0.1732	0.1619
Fourth Job or More	0.2038	0.2036

Notes: DADS. 4,616,093 observations. The regression also includes a person and a firm effect. Estimated by a conjugate gradient algorithm. See Abowd, Creecy, Kramarz (2003)