Wage Bargaining with On-the-job Search: Theory and Evidence

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Abstract

Most applications of Nash bargaining over wages ignore between-employer competition for labor services and attribute all of the workers’ rent to their bargaining power. In this paper, we write and estimate an equilibrium model with strategic wage bargaining and on-the-job search and use it to take another look at the determinants of wages in France. There are three essential determinants of wages in our model: productivity, competition between employers resulting from on-the-job search, and the workers’ bargaining power. We find that between-firm competition matters a lot in the determination of wages, as it is quantitatively more important than wage bargaining à la Nash in raising wages above the workers’ “reservation wages”, defined as out-of-work income. In particular, we detect no significant bargaining power for intermediate- and low-skilled workers, and a modestly positive bargaining power for high-skilled workers.

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1 Introduction

When between-employer competition for labor services is not perfect, firm-worker matches are associated with a positive rent, defined as the expected value of future match output flows net of the worker’s and firm’s outside options. Understanding how these rents are shared between workers and employers necessitates a complete characterization of the determinants of those outside options. Labor market competition is crucial in this respect: even in an imperfectly competitive labor market, it is in the workers’ interest to prompt inter-firm competition through on-the-job search. Yet the existing literature on labor market rent-sharing generally understates the role of inter-firm competition for two main reasons. First, the vast majority of contributions to this literature ignores on-the-job search altogether. Second, in cases where on-the-job search is permitted, incumbent employers are not allowed to counter outside offers.

In this paper, we propose an equilibrium model with strategic wage bargaining, on-the-job search and counter-offers. The model builds on Postel-Vinay and Robin (2002), which is a competitive model with search frictions. In the extension that we consider here, unemployed workers negotiate with a single employer in a conventional way, but when an employed worker receives an outside job offer, a three-player bargaining process is started between the worker, her/his initial employer and the employer which made the outside offer. We explicitly model this bargaining process using a version of the Rubinstein (1982) infinite-horizon, alternating-offers bargaining game. This allows us to relate workers’ market power, i.e. the share of the match surplus that they obtain from the negotiation, to other structural search friction parameters.

Related work includes Dey and Flinn (2003) who consider a rent-sharing model featuring the same wage-productivity relationship as in our paper, yet without providing a rigorous non cooperative game-theoretic foundation for that relationship.\footnote{Moreover, Dey and Flinn focus on the issue of renegotiation within a more complex framework with multidimensional employment contracts stipulating wages and health insurance provisions. Due to this added complexity, they are unable to come up with closed-form expression for wages and wage distributions.} Mortensen (2003) develops a search-matching model with on-the-job search and examines a variety of ad hoc wage setting mechanisms, covering the whole spectrum from the monopoly union case through Nash bargaining, all the way to monopsony wage setting. Shimer (2005)
studies wage bargaining in a simple economy with on-the-job search and compares the
equilibrium wage distribution with the one predicted by Burdett and Mortensen (1998).
He does not allow employers to counter outside offers and thus does not extend Rubinstein’s setup to a three-player game. Lastly, Eckstein and Wolpin (1990) was the first paper to estimate a search-matching model, albeit without on-the-job search, on micro data.

We estimate our structural model on a 1993-2000 panel of matched employer-employee French administrative data. This data contains firm-level information on value added, wages and hours worked by labor category (based on occupation). One of the important empirical novelties of this paper is that we are able to use wage data on one side and productivity data on the other and see whether our wage equation correctly captures the link between the two. To our knowledge, this is the first estimation of an equilibrium search model which uses actual productivity data instead of predicting the distribution of productivity that best matches the distribution of wages. Our estimated model is found to correctly replicate the empirical wage-productivity relationship. In particular, we find that firm-level mean wages are below labor productivity, with a mark-up increasing from zero at low-productivity firms to about 100% at high-productivity firms.

We estimate a very low bargaining power for “unskilled” workers (workers with no managerial tasks), between 0 and 20%, depending on the particular industry considered, and a somewhat higher value for “skilled” workers (supervisors of all ranks and engineers), between 20% and 40%. Most existing studies find higher values for workers’ bargaining power.² If we end up estimating a much lower bargaining power coefficient than in the literature, although match productivity and worker wages follow the same definition, this is because our definition of the match rent is different. Allowing for on-the-job search and employers’ counteroffers raises workers’ outside options significantly. Now, using a more conventional definition of a match quasi-rent, namely, match output minus minimum wage, our model suggests the following decomposition of the share of the quasi-

²A far from exhaustive list of which includes Abowd and Lemieux (1993), Blanchflower, Oswald and Sanfey (1996), Van Reenen (1996), Margolis and Salvanès (2001), Kramarz (2002). These studies are based on static models where some bargaining process leads to splitting the job surplus, typically defined as the difference between productivity and some outside wage that depends on worker characteristics and selected labor market variables such as the (local) unemployment rate and the industry- or economy-wide mean wage.
rent that goes to the worker into two components: first, the contribution of between-firm competition for labor services and second, the outcome of the negotiation with the employer. Overall we find the former source of worker rent acquisition to be quantitatively much more important than the latter, in that if we shut down wage bargaining in our model, competition alone is still typically found to explain more than a half (and up to 100% in the case of low-skill workers) of the workers’ quasi-rent share.

Our model thus offers an encompassing structural view of wage determination. By explicitly accounting for on-the-job search, we leave ample scope for labor market competition to affect wages. By reducing the role of bargaining, we make wage determination less dependent on exogenous “black-box” parameters such as preferences or bargaining power. This is important for understanding the effect on wages of policy interventions. For example, our model suggests that sources of upward pressure on unskilled wages are mostly external to wage setting procedures and should rather be sought among parameters affecting the general competitive environment in which wages are determined (such as out-of-work income or payroll taxes).

That labor market competition is found to matter a lot in wage determination in France can sound somewhat surprising. First, the reputed “sclerosis” of the French labor market, where worker and firm unions negotiate wages at the industry level for all low- and medium-skill occupations, may have lead to the presumption that negotiation should play a major role in determining wages in France. Second, high institutional wage floors in France possibly weaken the correlation between wages and productivity (especially for unskilled workers), and could potentially drive our finding of unskilled workers having very little bargaining power. However, the explicit incorporation of a minimum wage in our framework suggests that this is not the case: we find that low-skill labor categories do get a share of the job surplus over and above what would be implied by the sole presence of the minimum wage, and that this extra bit of worker rent can be attributed to between-firm competition.

The plan of the paper is as follows. In section 2, we develop the theory. In section

\(^3\)The high coverage rate of collective bargaining (about 95%) may indeed suggest that wages are primarily influenced by collective agreements. However, analyses of French wage data in the light of French wage setting institutions have shown that individual and match-specific heterogeneity in productivity explain a remarkably high share of wage differentials (Goux and Maurin, 1999, Abowd et al., 2005).

\(^4\)The minimum wage covers about 15% of the employed workforce in France.
3 we use the theoretical model of section 2 to estimate the influence of productivity, 
between-firm competition and the bargaining power of workers on wages. In section 4 we 
use our model to assess the relative quantitative importance of those wage determinants  
and conclude that labor market competition plays a primary part. Section 5 concludes.

2 Theory

We first describe the characteristics and objectives of workers and firms. The matching 
process and the negotiation game that workers and firms play to determine wages is then 
explained. In the last subsection, the steady-state equilibrium of this labor market is 
characterized.

2.1 Workers and firms

We consider a labor market in which a measure $M$ of atomistic workers face a continuum 
of competitive firms, with a mass normalized to 1, that produce one unique multi-purpose 
good. Time is continuous, workers and firms live forever. The market unemployment 
rate is denoted by $u$. The pool of unemployed workers is steadily replenished by layoffs 
that occur at the exogenous Poisson rate $\delta$.

Workers have different skills. A given worker’s ability is measured by the amount $\varepsilon$ 
of efficiency units of labor s/he supplies per unit time. The distribution of ability in the 
population of workers is exogenous, with cdf $H$ over the interval $[\varepsilon_{\min}, \varepsilon_{\max}]$. We only 
consider continuous ability distributions and designate the corresponding density by $h$.

Summation of ability values over all employees in a given firm defines efficient firm 
size. Firms differ in the technologies that they operate: marginal productivity of efficient 
labor (denoted as $p$) is firm-specific and is distributed across firms with a cdf $\Gamma$ over the 
support $[p_{\min}, p_{\max}]$. This latter distribution is assumed continuous with density $\gamma$. The 
marginal productivity of a match $(\varepsilon, p)$ between a worker with ability $\varepsilon$ and a firm with 
technology $p$ is $\varepsilon p$.

A type-$\varepsilon$ unemployed worker receives an income flow of $\varepsilon b$, with $b$ a positive constant, 
which s/he has to forgo upon finding a job. Being unemployed is thus equivalent to 
working at a “virtual” firm with labor productivity equal to $b$ that would operate in a
Walrasian labor market, therefore paying each employee their marginal productivity, εb.\(^5\)

Workers discount the future at an exogenous and constant rate \(\rho > 0\) and seek to maximize the expected discounted sum of future utility flows. For simplicity, we assume that the instantaneous utility flow enjoyed from a flow of income \(x\) is \(U(x) = x\). Firms maximize profits.

### 2.2 Matching and wage bargaining

Firms and workers are brought together pairwise through a sequential, random and time consuming search process. Specifically, unemployed workers sample job offers sequentially at Poisson rate \(\lambda_0\). Employees may also search for a better job while employed and the arrival rate of offers to on-the-job searchers is \(\lambda_1\). We treat \(\lambda_1\) as an exogenous parameter.\(^6\)

The type \(p\) of the firm from which a given offer originates is assumed to be randomly selected from \([p_{\min}, p_{\max}]\) according to a *sampling distribution* with cdf \(F\) (and \(F^{-1}\)) and density \(f\). The sampling distribution is the same for all workers irrespective of their ability or employment status. When a match is formed, the wage contract is negotiated between the different parties following a set of rules that we now explain.

Wages are bargained over by workers and employers in a complete information context. In particular, all agents that are brought to interact by the random matching process are perfectly aware of one another’s types. All wage and job offers are also perfectly observed and verifiable. Wage contracts stipulate a fixed wage that can be renegotiated by mutual agreement only: renegotiations thus occur only if one party can credibly threaten the other to leave the match for good if the latter refuses to renegotiate. There are no renegotiation costs.

**Bargaining with unemployed workers.** When an unemployed worker meets a firm, the wage is determined as the outcome of a Rubinstein (1982) infinite horizon game

\(^5\)We assume that the flow opportunity cost of employment is proportional to individual ability essentially because this is the most tractable form. As is explained in Postel-Vinay and Robin (2002), and as will become clear from the analysis below, the substantive consequence of this (admittedly disputable) assumption is to rule out sorting: first, the distribution of ability is the same in the population of employees as in the population as a whole, second, it is independent of the employer’s type.

\(^6\)Endogenizing \(\lambda_1\) at the macro level using a matching function à la Diamond-Mortensen-Pissarides, as in Mortensen (2000), is not attractive given the paper’s main objective. Endogenizing \(\lambda_1\) at a more micro level by allowing for endogenous worker search effort, as in Christensen, Lentz, Mortensen, Neumann and Werwatz (2005), may be of greater importance for our purposes. We leave this extension to further research as Christensen et al.’s paper show that this is by no means a trivial one.
of alternating offers, the precise structure and solution of which are characterized in Appendix A. This game delivers the generalized Nash bargaining solution, where the worker receives a constant share $\beta$ of the match rent. This latter parameter $\beta$ is referred to as the worker's bargaining power.

Formally, let $V_0(\varepsilon)$ denote the lifetime utility of an unemployed worker of type $\varepsilon$ and $V(\varepsilon, w, p)$ that of the same worker when employed at a firm of type $p$ and paid a wage $w$. When the worker is paid her/his marginal productivity $\varepsilon p$, the employer makes zero marginal profit on this worker who therefore receives the entire match value, $V(\varepsilon, \varepsilon p, p)$. Further assuming that a vacant job has zero value to the employer, the difference between the match value $V(\varepsilon, \varepsilon p, p)$ and the unemployment value defines the match surplus: $V(\varepsilon, \varepsilon p, p) - V_0(\varepsilon)$. The bargained wage on a match between a type-$\varepsilon$ unemployed worker and a type-$p$ firm, denoted as $\phi_0(\varepsilon, p)$, solves:

$$V(\varepsilon, \phi_0(\varepsilon, p), p) = V_0(\varepsilon) + \beta [V(\varepsilon, \varepsilon p, p) - V_0(\varepsilon)].$$  \hspace{1cm} (1)

This equation merely states that a type-$\varepsilon$ unemployed worker matched with a type-$p$ firm obtains her/his reservation utility, $V_0(\varepsilon)$, plus a share $\beta$ of the match surplus.

**Bargaining with employed workers.** When an employed worker contacts an outside firm, the situation becomes more favorable to the worker because s/he can now force the incumbent and poaching employers to compete.\(^7\) A formal presentation of the relevant strategic bargaining game is given in Appendix A, and we use here a simple heuristic argument to derive the sharing rule.

Let there be a worker of ability $\varepsilon$ and two would-be employers of productivity levels $p$ and $p' > p$. Competition between the two employers over the worker’s services can be seen as an auction where the bidder with the higher valuation wins and pays the

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\(^7\)Whenever the worker receives an outside offer, the pre-existing contract with the incumbent employer prevails if no agreement is reached. This is an important difference with the negotiation on new matches—between unemployed workers and firms—that are dissolved in case of disagreement. We view this assumption as more in accordance with actual labor market institutions than the usual one according to which matches always break up in case of renegotiation failure (Pissarides, 2000, Mortensen and Pissarides, 1999). It is indeed legally considered in most OECD countries, and especially in France, that an offer to modify the terms of a contract does not constitute a repudiation. Accordingly, a rejection of the offer by either party leaves the pre-existing terms in place, which means that the job continues under those terms if the renegotiation fails (Malcomson, 1999, p. 2321). This also suggests that the assumption of renegotiation by mutual agreement captures an important and often neglected feature of employment contracts (again, see the enlightening survey by Malcomson, 1999).
second price. As obviously no employer will pay more than match productivity, the type-$p'$ firm eventually hires the worker. Moreover, the auction forces firm $p$ to place a bid equal to marginal productivity $\varepsilon p$, which the worker values at $V(\varepsilon, \varepsilon p, p)$. Accepting this contract is always an option for the worker and constitutes the new fallback position for the standard negotiation game that the worker and firm $p'$ subsequently play. The outcome of this game is the wage $\phi(\varepsilon, p, p')$ in firm $p'$ that leaves the worker with a value of $V(\varepsilon, \varepsilon p, p)$—her/his outside option—plus a share $\beta$ or the match surplus $V(\varepsilon, \varepsilon p', p') - V(\varepsilon, \varepsilon p, p)$, i.e. $\phi(\varepsilon, p, p')$ solves the equation:

$$V(\varepsilon, \phi(\varepsilon, p, p'), p') = V(\varepsilon, \varepsilon p, p) + \beta [V(\varepsilon, \varepsilon p', p') - V(\varepsilon, \varepsilon p, p)], \quad p' > p. \quad (2)$$

Of course, renegotiation takes place only if it is in the worker’s interest. Assume that the worker is currently employed at firm $p$ with wage $w$ and that s/he is contacted by firm $p'$. If $p' > p$, then the workers moves to firm $p'$ for a wage $\phi(\varepsilon, p, p')$ that is necessarily acceptable because it has more value than the highest wage firm $p$ can offer, i.e. marginal productivity $\varepsilon p$. If $p' < p$, however, then the worker decides to trigger the renegotiation game only if $\phi(\varepsilon, p, p') > w$. It is shown in Appendix B that $\phi(\varepsilon, p, p')$ solution to equation (2) is increasing in $\varepsilon$ and $p$ (but not necessarily in $p'$; see below). So, there exists a threshold $q(\varepsilon, w, p)$ (formally defined by $\phi(\varepsilon, q, p) = w$), such that:

(i) if $p' \leq q(\varepsilon, w, p)$, then the workers keeps the current wage contract $w$ in firm $p$;

(ii) if $p \geq p' > q(\varepsilon, w, p)$, the worker obtains a wage raise $\phi(\varepsilon, p', p) - w > 0$ from her/his current employer.

(iii) if $p' > p$, the worker moves to firm $p'$ for a wage $\phi(\varepsilon, p, p')$.

Note that whenever $p' > p$, the wage $\phi(\varepsilon, p, p')$ obtained in the new firm can be smaller than the wage $w$ paid in the previous job, because the worker expects larger wage rises in firms with higher productivity. This option value effect implies that workers may be willing to take wage cuts just to move from a low- to a high-productivity firm.

Finally, since the workers’ bargaining power $\beta$ is a focal point of this paper, we definitely need to explain where it comes from. The kind of alternating-offer, infinite-horizon bargaining games à la Rubinstein that we are invoking as a foundation for our wage equations (1) and (2) predict that the bargaining power potentially depends on
other structural parameters, namely the discount rates of each party, their response time (i.e. the amount of time it takes to each party to formulate an offer), and also on the flow probability of match breakup during the bargaining rounds (see Osborne and Rubinstein, 1990). In our framework this implies that $\beta$ potentially depends on the discount rate ($\rho$), on the arrival rate of job offers ($\lambda_0$ or $\lambda_1$), on the time it takes to each party to formulate an offer at each negotiation round—i.e. the players’ response times, and finally on the breakdown rate of the ongoing negotiation. However, we show in Appendix A that as this breakdown rate becomes large compared to the transition rates and the players’ discount rates, the bargaining power is reduced to a function of the parties’ relative response times only. Specifically, $\beta$ is an increasing function of worker’s ability to formulate offers quickly (relative to the employer) and is otherwise independent of the arrival rate of job offers or any other structural parameter. So $\beta$ can indeed be considered a separate structural parameter which specifically reflects the workers’ ability to voice claims during bilateral negotiations with employers.

2.3 The wage equation

The precise form of wages can be obtained from the expressions of lifetime utilities (see Appendix B for the corresponding algebra). The wage $\phi(\varepsilon, p', p)$ of a type-$\varepsilon$ worker, currently working at a type-$p$ firm and whose last job offer emanated from a type-$p'$ firm, is defined by:

$$\phi(\varepsilon, p', p) = \varepsilon \cdot \left( p - (1 - \beta) \int_{p'}^p \frac{\rho + \delta + \lambda_1 \bar{F}(x)}{\rho + \delta + \lambda_1 \beta \bar{F}(x)} dx \right), \quad p' < p. \quad (3)$$

This expression shows that the returns to on-the-job search depend on the bargaining power parameter $\beta$. It can be seen that outside offers cause wage increases within the firm only if employers have some bargaining power. In the limiting case where $\beta = 1$, the worker appropriates all the surplus up-front and gets a wage equal to $\varepsilon p$, whether or not s/he searches on the job. In the opposite extreme case, where $\beta = 0$, the wage increases as outside offers come since all offers from firms of type $p' \in (q(\varepsilon, w, p), p]$ cause within-firm wage raises.

The wage $\phi_0(\varepsilon, p)$, obtained by a type-$\varepsilon$ unemployed workers when matched with a
type-$p$ firm, writes as:

$$\phi_0(\varepsilon, p) = \varepsilon \cdot \left( \inf_p - (1 - \beta) \int_{\inf_p}^p \frac{\rho + \delta + \lambda_1 F(x)}{\rho + \delta + \lambda_1 \beta F(x)} dx \right) = \phi(\varepsilon, \inf_p, p), \tag{4}$$

where $\inf_p$ is the lowest viable marginal productivity of labor. The latter is defined as the productivity value that is just sufficient to compensate an unemployed worker for her/his forgone value of unemployment, given that s/he would be paid her/his marginal productivity, thus letting the firm with zero profits. Analytically:

$$V(\varepsilon, \inf_p, \inf_p) = V_0(\varepsilon) \Leftrightarrow \inf_p = b + \beta(\lambda_0 - \lambda_1) \int_{\inf_p}^{\max_p} \frac{F(x)}{\rho + \delta + \lambda_1 \beta F(x)} dx. \tag{5}$$

It is worth noting that the lower support of observed marginal productivity levels, that we denote by $p_{\min}$, can be strictly above the lower support of viable productivity levels $\inf_p$, for instance if free entry is not guaranteed on the search market.

The definition (4) of $\phi_0(\varepsilon, p)$ together with the definition (5) of $\inf_p$ shows that entry wages, received by individuals who exit from unemployment, are not necessarily higher than unemployment income. It actually appears that those wages are always smaller than unemployment income if workers have no bargaining power, because accepting a job is a means to obtain future wage raises. Entry wages obviously increase with the bargaining power parameter $\beta$.

We conclude this section by commenting on comparative statics. The wage function $\phi(\varepsilon, p, p')$ decreases with $\lambda_1$ and $\bar{F}$ (in the sense of first-order stochastic ordering), and increases with $\delta$. These properties reflect an option value effect: workers are willing to pay today for higher future earnings prospects. Of course $\phi(\varepsilon, p, p')$ increases with the bargaining power, $\beta$. It also increases with worker ability $\varepsilon$ and the type $p$ of the less competitive employer, as both Bertrand competition and Nash-bargaining work in tandem to push wages up. However, we note an ambiguous effect of the type $p'$ of the employer winning the auction: $\phi(\varepsilon, p, p')$ decreases with $p'$ if $\beta$ is small enough for the option value effect to dominate. A high $p'$ means that the upper bound put on future renegotiated wages is more remote (as it is equal to $p'$) and the worker is thus willing to trade lower present wages for a promise of higher future wages. Yet $\phi(\varepsilon, p, p')$ increases with $p'$ if $\beta$ is large enough for the bargaining power effect on rent sharing to take over the option value effect.
2.4 Steady-state equilibrium

We know from what precedes that a type-$\varepsilon$ employee of a type-$p$ firm is currently paid a wage $w$ that is either equal to $\phi_0(\varepsilon, p) = \phi(\varepsilon, p_{inf}, p)$ if $w$ is the first wage after unemployment, or is equal to $\phi(\varepsilon, q, p)$, with $p_{inf} \leq p_{min} < q \leq p$, if the last wage mobility is the outcome of a bargain between the worker, the incumbent employer and another firm of type $q$. The cross-sectional distribution of wages therefore has three components: a worker fixed effect ($\varepsilon$), an employer fixed effect ($p$) and a random effect ($q$) that characterizes the most recent wage mobility. In this section we determine the joint distribution of these three components.

In a steady state a fraction $u$ of workers is unemployed and a density $\ell(\varepsilon, p)$ of type-$\varepsilon$ workers is employed at type-$p$ firms. Let $\ell(p) = \int_{\varepsilon_{min}}^{\varepsilon_{max}} \ell(\varepsilon, p) d\varepsilon$ be the density of employees working at type-$p$ firms. The average size of a firm of type $p$ is then equal to $\bar{M}\ell(p)/\gamma(p)$. We designate the corresponding cdfs with capital letters $L(\varepsilon, p)$ and $L(p)$, and we let $G(w|\varepsilon, p)$ represent the cdf of the (not absolutely continuous, as we shall see) conditional distribution of wages within the set of workers of ability $\varepsilon$ within type-$p$ firms.

The steady state assumption implies that inflows must balance outflows for all stocks of workers defined by a status (unemployed or employed), a personal type $\varepsilon$, a wage $w$, an employer type $p$. The relevant flow-balance equations are spelled out in Appendix C. They lead to the following series of definitions/results:

- **Unemployment rate:**
  
  $u = \frac{\delta}{\delta + \lambda_0}$. \hfill (6)

- **Distribution of firm types across employed workers:** The fraction of workers employed at a firm with npl less than $p$ is
  
  $L(p) = \frac{F(p)}{1 + \kappa_1 F(p)}$, \hfill (7)

  with $\kappa_1 = \frac{\lambda_1}{\gamma}$, and the density of workers in firms of type $p$ follows from differentiation as
  
  $\ell(p) = \frac{1 + \kappa_1}{[1 + \kappa_1 F(p)]^2} f(p)$. \hfill (8)

- **Distribution of matches:** The density of matches $(\varepsilon, p)$ is
  
  $\ell(\varepsilon, p) = h(\varepsilon)\ell(p)$. \hfill (9)
• **Within-firm distribution of wages:** The fraction of employees of ability \( \varepsilon \) in firms with \( \text{mpl} \) \( p \) is

\[
G(w|\varepsilon, p) = \left( \frac{1 + \kappa_1 F(p)}{1 + \kappa_1 \overline{F}(p)} \right)^2 = \left( \frac{1 + \kappa_1 L[q(\varepsilon, w, p)]}{1 + \kappa_1 L(p)} \right)^2.
\]

Equation (6) is standard in equilibrium search models (see Burdett and Mortensen, 1998) and merely relates the unemployment rate to unemployment in- and outflows. Equation (7) is a particularly important empirical relationship as it will allow us to back out the sampling distribution \( F \) from its empirical counterpart \( L \).

Equation (9) implies that, under the model’s assumptions, the within-firm distribution of individual heterogeneity is independent of firm types. Nothing thus prevents the formation of highly dissimilar pairs (low \( \varepsilon \), high \( p \), or low \( p \), high \( \varepsilon \)) if profitable to both the firm and the worker. This results from the assumptions of constant returns to worker ability \( \varepsilon \), both in and out of employment, scalar heterogeneity and undirected search.

### 3 Estimation

The estimation of the structural model goes through the following simple steps. Firm-level labor productivity identifies firm type \( p \). We use worker data on jobs and employment durations to draw inference on the job offer arrival rate \( \lambda_1 \) and the job destruction rate \( \delta \). The empirical distribution of firm-level labor productivity among workers identifies the distribution of firm types \( p \) across employees, \( L(p) \). The intercept and slope parameters of the regressions of log wages on log productivity by occupation and industry identify mean worker ability \( \varepsilon \) and the bargaining power \( \beta \).

We describe the data before explaining the estimation procedure in greater detail. Then, we discuss the results.

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8It is exactly the same equilibrium relationship as between the distribution of wage offers and the distribution of earnings in the Burdett and Mortensen model.
3.1 Data

We use a matched employer-employee panel of French data collected by the French National Statistical Institute (INSEE) and covering the period 1993-2000. This panel contains standard accounting information extracted from the BRN (“Bénéfices Réels Normaux”) firm data source: total compensation costs, value added, current operating surplus, gross productive assets, etc. The BRN data are supposedly exhaustive of all private companies (not establishments) with a sales turnover of more than 3.5 million FRF (about 530,000 Euros) and liable to corporate taxes. In addition, we use the DADS (“Déclarations Annuelles de Données Sociales”) worker data source to compute labor costs and employment at the company level for various worker (skill) categories. The DADS data are based on mandatory employer (establishments) reports of the earnings of each salaried employee of the private sector subject to French payroll taxes over one given year. This is a very large dataset, which we “collapse” by firm and worker category and then merge with the BRN dataset to obtain our base sample.

Our base sample thus essentially contains firm-level data on value added, capital, and employment and labor costs by labor category over the period 1993-2000. Regarding labor categories, we have sorted workers into the following four distinct cells, based on occupation:

- Category #1: Executives, managers and engineers;
- Category #2: Technicians, foremen, supervisors of all kinds;
- Category #3: Clerical employees, skilled production workers;
- Category #4: Sales workers, unskilled production and service employees.

In the sequel, we shall refer to “workers of observed skill level $s$”, for $s = 1, \ldots, 4$, where our prior is that a worker’s observed “skill level” (loosely defined though this latter term may be) is a decreasing function of the worker’s category index, $s$.

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9 The BRN is a subset of a larger firm sample, the BIC, “Bénéfices Industriels et Commerciaux”.
10 For more information on these datasets, we refer to Crépon and Desplat (2002) who were the first to construct a similar matched panel covering the period 1993-97. See also Abowd, Kramarz and Margolis (1999) for another very precise description of the same data sources and others.
11 Apart from age, gender and place of birth, occupation is the only personal characteristic that is available in our worker panel.
Given this classification of workers, we then split our base panel into four panels of firm data on value-added, employment and average labor costs by skill category covering the period 1993-2000 and corresponding to four distinct industries: Manufacturing, Construction, Trade and Services. Finally, these four panels were balanced and firms with strictly less than 10 employees in total were removed. This final trimming leaves us with four seven-year panels, involving an approximate total of just under 3 million workers distributed into 50,000 firms each year.

Table 1 contains some descriptive statistics for selected variables. From that table, we see that our four industries are somewhat different in size (as measured by the total number of either firms or workers), and in the structure of their workforce. In this latter respect, the Construction sector stands out in that it seems to employ an especially large share of medium-skilled production workers \((s = 3)\), and very few of the extreme categories \((s = 1 \text{ or } 4)\) within relatively small firms. In spite of these differences, the skill category \(s = 3\) is by a substantial amount the most numerous—and therefore presumably the most heterogeneous—in all four industries. A last feature of Table 1 that may be worth mentioning at this point is the numbers in parentheses in the rightmost column. Those are the relative mean wages of labor categories 1, 2 and 3 to category 4. We see that the wage hierarchy follows our prior about the ranking of the observed skill levels. There are interindustry differences in those wage ratios, with the Construction sector once more being remarkable in that it is the sector where cross-occupational wage inequality is most important.

Finally, estimating the model requires data on worker mobility. We use the French Labor Force Survey (“Enquête Emploi”) which is a three-year rotating panel of individual professional trajectories similar to the American CPS (“Current Population Survey”). We prefer to use the LFS panel instead of the larger DADS panel as the latter is known to be affected by large attrition biases. Moreover, the LFS is precisely designed to study unemployment and worker mobility.
3.2 Productivity

The production data (the BRN firm accounting data) is a set of $NT$ observations of value-added ($Y_{jt}$), the book value of capital ($K_{jt}$) and the number of working hours (divided by $2028 = 52 \times 39$) of skill category $s = 1, ..., 4$ used by firm $j$ in year $t$ ($M_{sjt}$), where $j = 1, ..., N$ is the firm index and $t = 1, .., T$ the time index.

We assume, as in the theory laid out in the preceding section, that the distribution of abilities in the $s$th skill category within each firm fluctuates around some fixed density, say $h_s(\varepsilon)$. Assuming further that workers are perfectly substitutable between skill categories as well as within, we define the total amount of efficient labor employed at firm $j$ at time $t$ as

$$L_{jt} = \sum_{s=1}^{4} \alpha_s M_{sjt},$$  \hspace{1cm} (11)

where $\alpha_s = \int \varepsilon h_s(\varepsilon) \, d\varepsilon$ is the steady-state mean ability in category $s$.

We then specify firm $j$’s total per-period output (value-added) as the following constant-return, Cobb-Douglas function of capital and efficient labor:

$$Y_{jt} = \theta_j K_{jt}^\chi L_{jt}^\xi \exp(\eta_{jt}),$$  \hspace{1cm} (12)

where $\theta_j$ is a firm-specific productivity parameter and $\eta_{jt}$ is a zero-mean, stationary productivity shock independent of the fixed effect $\theta_j$. Elasticities $\xi$ and $\chi$ are between 0 and 1 and are common to all firms within a given industry. We normalize $\alpha_4$ to one and leave $\theta_j$ free.

Using the panel of firm data on value-added, employment and capital, we estimate equation (13) in log form by iterated GMM using lagged first-differences of the production function gradient as instruments,$^{12}$ i.e.

$$\Delta \ln \left( \sum_{s=1}^{4} \alpha_s^0 M_{sj,t-\tau} \right), \quad \left\{ \Delta \left( \frac{M_{sj,t-\tau}}{M_{jt-\tau}} \right), s = 1, 2, 3 \right\}, \quad \Delta \ln K_{j,t-\tau}, \quad \tau \geq 3,$$

where we set $\alpha_s^0$ equal to cross-category mean wage ratios. The estimates are thus consistent if $\eta_{jt}$ is MA(2).$^{13}$ Confidence intervals are obtained by boostrapping (with

\footnote{The model being nonlinear, it is well known since Chamberlain (1992) that the optimal vector of instruments is equal to the conditional expectation of the gradient of the production function (with respect to the parameters) given all instruments.}

\footnote{We use instruments lagged three times based on the Sargan overidentification test. The Sargan test statistic drops sharply between $\tau \geq 2$ and $\tau \geq 3$ in all industries save for the puzzling case of Construction. Three is also the minimum number of lags for which the $p$-value is nonzero at computer precision in all industries.}
the necessary re-centering for bootstrap to work in case of overidentification).\textsuperscript{14}

**Results.** Estimates of $\chi, \xi$ and $\alpha = (\alpha_1, \alpha_2, \alpha_3, \alpha_4)$, are displayed in Table 2. These bring about two comments. First, it turns out that in spite of the large number of firms that we have in our sample, the precision of the production function parameter estimates obtained by direct GMM estimation is poor. This will induce us to design an alternative estimation procedure for that set of parameters and to check our results’ robustness (see below subsection 3.4). Second, the estimated returns to capital are very low (between 0.04 and 0.08, depending on the industry and estimator considered). Zero returns to capital cannot even be rejected in Construction or Trade. Conversely, the estimated returns to labor are high (between 0.91 and 0.96 with 1 often being comprised in the confidence interval). As a result, the constancy of returns to scale is rejected in none of our four sectors, and we can thus apply the theory laid out in the previous section.

Assuming that firm $j$’s capital stock continuously adjusts to equate the marginal productivity of capital to its user cost, $r$, so that $rK_{jt} = (1 - \xi)Y_{jt}$ for all $(j, t)$; and replacing $K_{jt}$ with its optimal value into (12), one easily obtains the following expression for firm $j$’s mean labor product:

$$p_{jt} = \frac{Y_{jt}}{L_{jt}} = \left[\left(\frac{1 - \xi}{r}\right) \theta_j \exp\left(\eta_jt\right)\right]^{1/\xi},$$

and, although our theory does not allow for productivity shocks, we nevertheless define $\ln p_{jt} = \mathbb{E}(\ln p_{jt})$ as the expectation of $\ln p_{jt}$ with respect to transitory shocks $\eta_{jt}$.\textsuperscript{15}

< Table 2 (production function parameter estimates) about here. >

### 3.3 Worker mobility

In this Section we are interested in the distribution of job spell durations, using a sample drawn from the French Labor Force Survey data. As all job transition processes are

\textsuperscript{14}See Freedman (1984), Hall and Horowitz (1996) and Horowitz (1998).

\textsuperscript{15}The rent that is shared between the entrepreneur $j$ and one single type-$s$ worker with ability value $\varepsilon$ should be this worker’s marginal contribution to firm $j$’s output net of capital costs. From the assumptions spelled out earlier in this paragraph, the latter is $Y_{jt} - rK_{jt} = \xi Y_{jt} = \xi p_{jt} L_{jt}$. Hence, given (13), bargaining takes place over the following marginal rent:

$$\frac{d[Y_{jt} - rK_{jt}]}{d[h_s(\varepsilon) M_{sjt}]} = \xi \varepsilon p_{jt}.$$  

The marginal productivity of the match thus multiplicatively depends on the worker’s ability $\varepsilon$ and the firm’s mean labor product $p_{jt}$.  

15
Poisson, all corresponding durations are exponentially distributed. The distribution of job spell durations $t$ has the following density, conditional on $p$:

$$L(t|p) = \left[\delta + \lambda_1 F(p)\right] \cdot e^{-[\delta + \lambda_1 F(p)]t}, \quad (14)$$

where we know from equation (8) that $p$ is distributed in the population of employed workers according to the density $\ell(p) = (1 + \kappa_1) f(p) / [1 + \kappa_1 F(p)]^2$.

Because it is impossible to match the LFS worker data with the BRN firm data (which is the only source of information on $p$), we treat $p$ as unobserved heterogeneity and integrate it out from the joint likelihood of $p$ and $t$, $\ell(p) L(t|p)$. In order to obtain estimates of $\delta$ and $\kappa_1$, we thus maximize the unconditional likelihood of job spell durations, $L(t) = \int_{p_{\text{min}}}^{p_{\text{max}}} \ell(p) L(t|p) \, dp$, which turns out to have a simple enough expression:

$$L(t) = \frac{\delta(1 + \kappa_1)}{\kappa_1} \left[ E_1(\delta t) - E_1(\delta t (1 + \kappa_1)) \right], \quad (15)$$

where $E_1(t) = \int_1^\infty \frac{e^{-x} - e^{-tx}}{x} \, dx$ is the exponential integral function.$^{16}$ Note in particular that $L(t)$ only depends on parameters $\delta$ and $\lambda_1$. Integrating unobserved productivity $p$ out of the conditional likelihood $L(t|p)$ not only takes $p$ out but also all reference to the sampling distribution $F$, irrespective of its exact, unknown shape.

This method of unconditional inference was first explored by van den Berg and Ridder (2003). It is robust to any modelling error in the way wages are negotiated. The only property of the theoretical model that is used is that there exists a scalar firm index $p$—we do not need to define it precisely—that is such that a worker employed at a firm $p$ moves to a firm $p'$ if and only if $p' > p$. Then stationarity implies that the steady-state distribution of $p$ is $\ell(p)$. The source of identification in the unconditional inference approach is state dependence: unobserved heterogeneity makes the hazard rate a decreasing function of job spell duration, the slope of which identifies $\lambda_1$.$^{17}$

**Results.** The unconditional ML estimates of $\delta$, $\lambda_1$ and, most importantly, $\kappa_1$ are reported in Table 3. In terms of $\kappa_1$, i.e. the average number of outside contacts that an

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16See Abramowitz and Stegun (1972). The exact likelihood that we maximize does take into account the fact that the panel covers a fixed number of periods so that some job durations are censored. However, it is straightforward to apply this integration methodology to likelihoods over both uncensored and censored spells. The algebra is just a bit more tedious.

17For a graphical illustration of this state dependence, see Jolivet, Postel-Vinay and Robin (2005).
employed worker can expect before the next unemployment period, higher skill categories tend to be more mobile than lower skilled ones (with the remarkable exception of the Construction sector, where category 1 turns out to have the lowest value of $\kappa_1$). Now looking at the frequency of such contacts, which is measured by $\lambda_1$, we find a similar pattern, in which workers with higher observed skill levels tend to get more frequent outside offers than less skilled workers. Finally, the rate of job termination $\delta$ is everywhere a decreasing function of the skill index $s$ (except again for Construction where categories 1, 2 and 3 exhibit values of $\delta$ that are roughly equal).

< Table 3 (transition parameter estimates) about here. >

The average duration of an employment spell (i.e. the average duration between two unemployment spells), $1/\delta$, ranges from 10 to 35 years, while the average waiting time between two outside offers, $1/\lambda_1$, lies between 3.5 and 19 years. The average number of outside contacts, $\kappa_1$, that results from these estimates is never very large (between 1 and 6.4) which confirms the relatively low degree of worker mobility in the French labor market. Workers are relatively less mobile in Manufacturing than elsewhere, where they tend to have both lower job separation and job-switching rates.

These values are in the same order of magnitude as those found by earlier studies using different datasets (see for instance Jolivet, Postel-Vinay and Robin, 2005, where the source is the European Community Household Panel). To get a sense of how reasonable they are, one can compute the average length of a job spell implied by the model. Straightforward algebra shows that this average is defined by $\int_0^\infty tL(t)\,dt = \frac{1}{\delta} + \frac{1}{\delta + \lambda_1}$. Taking the largest worker category as an example (clerical employees and skilled manual workers), we find the following values: 8.1, 6.9, 6.4 and 7.1 years for Manufacturing, Construction, Trade and Services respectively. Our estimated values of $\delta$ and $\lambda_1$ thus yield reasonable predictions of mean employment duration and can be considered adequate calibrations for the upcoming counterfactual analysis.

We end this section by a short discussion of the effect of a low contact rate $\lambda_1$ on wage dynamics. The arrival of job offers to employees clearly matters in determining the frequency of wage increases within a job spell, i.e. the returns to seniority: a straightforward prediction of our model is that lower values of $\lambda_1$ are associated with lower average
returns to seniority. Yet, we have used no data on wage dynamics to identify and estimate the contact rate. We still have to ask whether the estimated value of $\lambda_1$ is consistent with the returns to seniority in France.

There is little work on wage dynamics within and between firms for France, in sharp contrast with the abundant, yet polemical, literature on the returns to seniority and experience in the U.S. The recent contribution by Beffy, Buchinsky, Fougère, Kamionka and Kramarz (2005) fills this gap. They estimate a joint model of participation, mobility, and wages for France, allowing for unobserved individual heterogeneity and state-dependence. Their results suggest that returns to seniority are small in France, even close to zero for some education groups. In a companion study using the same specification, Buchinsky, Fougère, Kramarz and Tchernis (2002) had found much larger returns to seniority in the US. Beffy et al. also find a similar discrepancy when they use the model of Altonji and Williams (1998). They attribute the bulk of that discrepancy to interfirm mobility: in fact they specifically analyze their empirical findings through the lens of a job search model (Burdett and Coles, 2003) closely related to the one we use in this paper, and show that the France-US gap in returns to tenure is explained by differences in firm-worker contact rates—i.e., $\lambda_1$—within a model where the returns on seniority are the consequence of labor market competition caused by employed job search.

### 3.4 The wage equation

Consider again a market segment consisting of workers all in the same skill category. For each firm $j$ in the sample and each period $t$, we compute the average wage of labor category $s$, say $\overline{w}_{sjt}$ or $\overline{w}_{jt}$, omitting the $s$ index for notational simplicity. Under the steady-state assumption and using the theory of wage determination and equilibrium wage distributions presented in section 2, $\overline{w}_{jt}$ exhibits stationary fluctuations around the steady-state mean wage paid by firm $j$, with mean labor productivity $p_j$. Using the steady-state distributions derived in Section 2.4, Appendix D establishes that:

$$\mathbb{E}(\overline{w}_{jt}|p_j) = \xi \alpha \left( p_j - \frac{1 - \beta}{1 + \kappa_1 L(p_j)} \int_{p_{\min}}^{p_j} \frac{[1 + \kappa_1 (1 - \sigma) + \sigma \kappa_1 L(q)] [1 + \kappa_1 L(q)]^2}{1 + \beta \kappa_1 (1 - \sigma) + (1 - \beta + \beta \sigma) \kappa_1 L(q)} dq \right),$$

(16)

where $\alpha = \mathbb{E}\varepsilon$ is the mean efficiency of workers in that market and $\sigma = \frac{\rho}{\rho + \tau}$, and where $L(\cdot)$ is the steady-state distribution of employers’ productivity across employees in that
The previous estimation steps yield consistent and fairly precise estimates of $\kappa_1$ and $\xi$ but very imprecise estimates of parameter $\alpha$. For that reason we estimate $\beta$, $\xi$ and $\alpha$ simultaneously (the normalization $\alpha_4 = 1$ allows identification of $\xi$) by iterating the following estimation procedure. For starting values $\xi^0, \alpha^0 = (\alpha_1^0, \alpha_2^0, \alpha_3^0, \alpha_4^0 = 1)$,

1. Estimate $p_j$ as

$$\hat{p}_j(\alpha^0) = \exp \left[ \frac{1}{T} \sum_t \ln \left( \frac{Y_{jt}}{\sum_{s=1}^4 \alpha_s^0 M_{sjt}} \right) \right]$$

and estimate the steady-state distribution $L_s$ of workers of skill category $s = 1, \ldots, 4$ at firms of any productivity $p$, by the empirical distribution of $\hat{p}_j$, weighting each firm in the sample by the average amount of type $s$ labor in that firm over the $T$ observations periods ($\hat{M}_{sj} = \frac{1}{T} \sum_t M_{sjt}$):

$$\hat{L}_s(p_j; \alpha^0) = \frac{\sum_{j=1}^N \hat{M}_{sj} \mathbf{1} \{ \hat{p}_j(\alpha^0) \leq p \}}{\sum_{j=1}^N \hat{M}_{sj}}.$$

2. Estimate $\xi \alpha_1, \ldots, \xi \alpha_4 = \xi$ and $\beta_1, \ldots, \beta_4$ by applying Nonlinear Least Squares to the system of 4 seemingly unrelated regressions: for $s = 1, \ldots, 4$,

$$\ln \overline{w}_{sqt} = \ln(\xi \alpha_s) + \ln \left[ \hat{p}_j(\alpha^0) - \frac{1 - \beta}{1 + \kappa_1 \hat{L}_s(\hat{p}_j; \alpha^0)} \right]^2 + \int_{\min(\hat{p}_j(\alpha^0))}^{\hat{p}_j(\alpha^0)} \frac{1 + \kappa_1 (1 - \sigma) + \sigma \kappa_1 \hat{L}_s(q; \alpha^0) \left[ 1 + \kappa_1 \hat{L}_s(q; \alpha^0) \right]^2}{1 + \beta \kappa_1 (1 - \sigma) + (1 - \beta + \beta \sigma) \kappa_1 \hat{L}_s(q; \alpha^0)} dq + u_{sjt},$$

imposing the normalization $\alpha_4 = 1$ and where $u_{sjt} = (u_{1jt}, \ldots, u_{4jt})$ is a vector of transitory shocks due to worker inflows and outflows, of unrestricted variance. (We set the discount factor $\rho$ to an annual value of 5% for everyone, i.e. $e^{\rho} = 0.95$.)

We use the estimates of the production function to initiate the procedure.

**Results.** The estimation results are gathered in Table 4. The numbers in parentheses are the bootstrap standard errors based on 1,000 replications of our entire estimation procedure, i.e. including the estimation of the transition parameters, on 1,000 resamples.
with replacement. Thus, the reported standard errors do account for the presence of
nuisance parameters \( \kappa_1 \) and \( L_s \) and for the fact that mean productivity \( \hat{p}_j \) depends on
the production function parameters \( \alpha_s \). We note that despite the number of nuisance
parameters, those estimators are remarkably precise.

The first four columns of Table 4 display the bargaining power estimates and the last
five columns the estimates of the production function parameters. Bargaining power is
found to be an increasing function of observable ability, the least skilled two categories
being endowed with a bargaining power close to zero. There are some small discrepancies
across sectors but the most striking one is the bargaining power of the first category of
workers (managers) in the Construction sector: it is close to one whereas it is never
higher than a third in all other sectors. Also, bargaining power seems to be uniformly
low for all labor categories in the Service sector.

< Table 4 (wage equation estimates) about here. >

Looking at estimates of relative productivity, we find that the less skilled categories 3
and 4 have values of \( \alpha_s \) very close to (yet slightly lower than) the wage ratios displayed in
Table 1. This is not the case for the higher-skill categories 1 and 2 where the ability ratios
\( \alpha_s \) are estimated substantially lower than the corresponding wage ratios. Productivity
differences thus only account for a fraction of inter-occupational wage differentials. Other
nonproductive factors have to be appealed to in order to explain cross-occupation wage
inequality. The Construction sector is again remarkable in this respect as this is the sector
where inter-occupational wage dispersion is highest. Productivity differences across labor
categories also seem larger here than in other sectors, but still the productivity ratio of
managers in the Construction sector is not large enough to explain the relative wage of
that category of workers.

To show how well equation (16) fits the data we have plotted the predicted and ob-
served (log) mean wages against (log) firm productivity levels \( \ln \hat{p}_j \) for our four industries
on Figure 1. Each column pertains to one given industry, and each row to a given skill
level. The solid curves represent the log wages predicted by the structural model. The
dashed curves are nonparametric regressions of log wages on log labor productivity, which
is what the model’s prediction should be compared with. The gray dots correspond to
the scatterplot. Finally, the solid lines represent the log of match productivity, \( \ln(\xi \alpha_s p_j) \).
A glance at the various panels of Figure 1 shows that the model is reasonably good at predicting wages. More specifically, the Figure suggests two remarkable stylized facts. One is that the wage paid by the lowest-\(p\) firms in our four samples and for all categories of workers is always very close to match productivity (solid line) at \(p_{\min}\). The other is that profit rates are strongly increasing with productivity: the gap between wages and productivity—which as we just saw is close to zero at \(p_{\min}\)—becomes substantial at higher values of \(p\). Our structural model correctly captures this phenomenon.

Going back to our bargaining power estimates, one final point is worth mentioning. The point estimates gathered in Table 4 were obtained with a parameterization that constrains \(\beta\) to stay within the unit interval. One can thus worry that the model would in fact best fit the data with negative values of \(\beta\), at least in the cases where the constrained estimates reach the zero lower bound. Estimating \(\beta\) without imposing the constraint \(\beta \in [0, 1]\) yields unconstrained estimates \(\hat{\beta}_u\) significantly negative in two cases only: labor category 4 in Manufacturing (\(\hat{\beta}_u = -0.12\), standard error = 0.023) and labor category 4 in Services (\(\hat{\beta}_u = -0.12\), standard error = 0.046).\(^{18}\) In both cases, the negative point estimates are small in absolute value. And most importantly, the set of other parameters which are estimated jointly with those negative \(\hat{\beta}_u\)’s—the \(\hat{\beta}_u\)’s for other labor categories in the same industry and the production function parameters for this industry—turn out to be only marginally affected by the constraint \(\beta \in [0, 1]\). Overall, we conclude that forcing \(\beta \in [0, 1]\), while needed to make economic sense, only imposes a very mild constraint on the model. The negative estimated values only reflect the poor estimation of \(L_s(p)\) in the lowest tail of the distribution of firm labor productivity.

Lastly, the production function parameters \(\xi, \alpha_1, \alpha_2, \alpha_3\) in Table 4, estimated using the wage equation (16), are well within the 95%-confidence interval obtained by bootstrapping the GMM estimation of the production function. Estimating \(\alpha\) from value-added or from wages yields close estimates. We view this result as strongly supportive of the theory.

\(^{18}\) We also find very slightly negative, nonsignificant point estimates \(\hat{\beta}_u\) for category 4 in Trade and category 3 in Manufacturing.
3.5 A robustness check: legal minimum wage omission biases

So far no mention has been made of an institutionalized wage floor: both our theoretical model and our estimation procedure also ignore the presence of a minimum wage. Yet, the minimum wage is binding for approximately 15% of the employed workforce in France. This observation begs the question of the extent to which our results depend on this omission.\(^\text{19}\) The problem is that introducing a legal minimum wage in the theoretical model complicates the model structure by an order of magnitude. Yet, the critique is a serious one: intuitively, a binding minimum wage should lower the correlation between wage and productivity. Because, as we explained before, our main source of identification for the bargaining power coefficient \(\beta\) is the slope of the wage-productivity relationship, our finding of \(\beta = 0\) for low-skill workers might thus be largely driven by the fact that we ignored the presence of a binding minimum wage.

Part of the difficulty in introducing a minimum wage—say, \(w_{\text{min}}\)—into the theoretical model is that with heterogeneous workers and firms a wage floor generates negative sorting: only matches with productivity such that \(p \epsilon \geq w_{\text{min}}\) are viable. However, assuming homogeneous worker ability \(\epsilon\), sorting is no longer an issue and it becomes possible—however cumbersome—to adapt the estimation procedure to the new theoretical equations.\(^\text{20}\) The supplemented material available on the Journal’s website describes how the theory is modified by the incorporation of a minimum wage, how to change the estimation procedure accordingly and shows the new results. Overall, we find that the minimum wage is not binding enough to substantially change our results.

3.6 Distributions

Figure 2 plots the densities \(\gamma(p)\), \(f_s(p)\) and \(\ell_s(p)\) for all categories of workers in all four industries. The overall shape is log-normal-like. The sampling distribution \(f_s(p)\) is more concentrated than the distribution of productivity \(\hat{p}_{ij}\) across firms, which is itself more concentrated than the distribution of employer productivity levels across workers, \(\ell_s(p)\).

A clear stochastic dominance pattern appears: \(f_s(\cdot)\) is systematically to the left of \(\gamma(\cdot)\)

\(^{19}\)We thank the co-editor in charge of this paper for raising this issue.

\(^{20}\)Note that Postel-Vinay and Robin (2002) found very little evidence of heterogeneous ability among observationally low-skill worker categories. Because minimum wages are most likely to be binding for these low-skill categories, we feel confident that this restriction to homogeneous workers is not a strong limitation on the validity of the results.
which is in turn first-order stochastically dominated—although to a lesser extent—by \( \ell_s (\cdot) \).

< Figures 2 (productivity densities) about here. >

4 The role of between-firm competition in wage determination

In this section, we use our framework to disentangle the respective influence of the bargaining power and between-firm competition on wage determination within each sector.

4.1 Measuring the contribution of between-firm competition to worker market power

As we argued in the Introduction, the conventional approach to evaluating the workers’ bargaining power ignores job-to-job mobility, which amounts to shutting down between-firm competition for employed workers. Our model offers a simple way of assessing the bias in the estimation of \( \beta \) resulting from this simplification. It is this bias that we now examine.

Ignoring job-to-job mobility amounts to forcing \( \kappa_1 = 0 \) in the wage equation (16) that now reads

\[
E(w|p, \kappa_1 = 0) = \beta_0 \alpha_\xi p + (1 - \beta_0) \alpha_\xi p_{\text{min}},
\]

where \( \beta_0 \) denotes the value of \( \beta \) corresponding to this counterfactual experiment. Thus, forbidding on-the-job search, the rent sharing equation takes the most standard form and the bargaining power thus simply measures the mean worker share of match rent \( \alpha_\xi p - \alpha_\xi p_{\text{min}} \):

\[
\beta_0 = \frac{Ew - \alpha_\xi p_{\text{min}}}{\alpha_\xi Ep - \alpha_\xi p_{\text{min}}},
\]

The rent sharing coefficient \( \beta_0 \) is a simple measure of worker market power. We obtain an estimator \( \hat{\beta}_0 \) of \( \beta_0 \) by replacing \( Ew \) and \( Ep \) in (18) by their empirical analogs.

The values of \( \hat{\beta}_0 \) are gathered in the second column of Table 5—while for ease of comparison the first column of that table takes up the estimates of \( \beta \) obtained from the full model with on-the-job search, \( \hat{\beta} \), which were already shown in Table 4.
Comparing estimates with and without on-the-job search—i.e. comparing the first two columns of Table 5—immediately shows that the bargaining power is always overestimated when one ignores job-to-job mobility. The magnitude of this upward bias varies across skill groups and sectors, but the bias always seems to be there, and is always important. This was expected as on-the-job search is a means by which an employee can force her employer to renegotiate her wage upward. Neglecting on-the-job search biases the workers’ bargaining power upward to make it fit the actual share of compensation costs in value-added.

In the last column of Table 5, we compute a rough measure of the contribution of between-firm competition to worker market power $b_0$ as $\frac{\beta_0 - \beta}{\beta_0}$. We find that between-firm competition is by far the most important source of market power for unskilled workers. Concerning high-skilled workers, between 40 an 60 percent of the amount of rent they are able to capture is due to their bargaining power. The fact that low-skill workers have at the same time a low bargaining power and still are the category of workers with the lowest arrival rate of alternative offers $\lambda_1$ could seem a contradiction. However, a low contact rate may simply reflect a low demand for unskilled labor, leading to scarcity of vacancies for low-skill jobs. Lastly, an important component of the bargaining power is the capacity to voice claims during the negotiation process, which capacity may be greater for more educated workers.

< Table 4 (Mean worker share of match rents) about here. >

4.2 Counterfactual evaluation of the effect of on-the-job search on rent sharing

We estimate the average waiting time between two outside offers to lie between 3.5 and 19 years. Outside offers are thus rather rare events. This low value of the (employed) worker-firm contact rate may seem at odds with our finding that interfirm competition explains most of the workers’ rent share. To resolve this apparent inconsistency, we should begin by emphasizing that, from our cross-section, steady-state perspective, what matters in the determination of the workers’ rent share is not how many firms workers can get to compete for their services per unit time (which is what the contact rate $\lambda_1$ measures), but rather the number of firms a worker can bring into competition per employment spell,
i.e. before that worker’s surplus is reset to zero by the occurrence of a layoff. This latter number is precisely $\kappa_1 = \lambda_1/\delta$, which is the correct measure of competitive intensity in our model labor market. In other words, again from our cross-section perspective, measuring competitive intensity requires a “rescaling of time” in terms of the average length of an employment spell, $1/\delta$: labor markets with very low firm-worker contact rate may thus still appear very “competitive” from this point of view if they are also characterized by a long average duration of uninterrupted employment. Moreover, we shall now see that it only takes very little between-firm competition measured in this particular way—i.e. it only takes small values of the parameter $\kappa_1$—to provide the workers with a large share of the match rent.

This is illustrated on Figure 3, which is constructed as follows: First, we simulate artificial wages using our wage equation and our estimates as parameter values, with the exception that we force $\beta$ to equal zero and $\kappa_1$ to cover the interval $[0, 15]$. That is, we simulate the wages that workers would receive if they had zero bargaining power, in various competitive environments ranging from $\kappa_1 = 0$—job-to-job mobility is ruled out, implying no between-employer competition—to $\kappa_1 = 15$—job-to-job mobility is very easy, implying fierce between-employer competition. We then compute workers’ market power, $\beta_0$, corresponding to each value of $\kappa_1$ within our range. Figure 3 plots this share against $\kappa_1$, for all skill categories and industries.

< Figure 3 (competition and rent sharing) about here. >

We see on Figure 3 that the dependence on $\kappa_1$ of the workers’ rent share is upward sloping and highly concave: while the workers’ rent share increases very steeply—from 0 to a typical 20-25%—as $\kappa_1$ rises from zero to a value of about 2 or 3, it only increases by a few extra percentage points as one takes $\kappa_1$ to values as unrealistically high as 15. This finding implies that relatively modest values of $\kappa_1$ are enough to guarantee a large share of the match rent for the workers. In other words, it only takes little between-firm competition to raise the workers’ wages by a substantial amount.

A candidate explanation of that phenomenon goes as follows. When a worker finds his/her first job, s/he is initially unemployed. At that point the negotiation outcome is favorable to the employer as the worker’s only outside option is to remain unemployed.
The first outside offer raised by the new employee is of great (expected) value as it allows him/her to renegotiate his/her wage under much more favorable circumstances. The second outside offer is already less valuable (still in expected terms), as the worker’s wage was already raised due to the first offer, and it is therefore less likely that the second offer will get the worker a substantial additional wage increase. As new outside offers come along, the worker’s situation improves, and the expected gain from the next outside offer declines (especially if the distribution of firm productivity levels is not very dispersed). Generally speaking, the returns to on-the-job search are expected to be rapidly declining with the number of outside offers raised since the beginning of the job spell. At this point we should insist once again on the fact that all this is compatible with very low values of the firm-worker contact rate \( \lambda_1 \), so long as layoffs are sufficiently rare events, i.e. so long as spells of continuous employment are on average long enough to leave time for employed workers to raise a few outside job offers.

Figure 3 also brings about a final comment. The solid vertical lines on the four panels indicate the values of \( \kappa_1 \) as we estimated them from the LFS data and the dotted vertical lines locate the 95% bootstrap confidence interval around the estimated value (see Table 3). We see that those values are typically at the very beginning of the “flat region” of the \( \kappa_1 \) – workers’ rent share relationship. A way to express this result is to say that encouraging between-firm competition on the French labor market would likely not have a large impact on wages.

5 Conclusion

This paper is the first attempt at estimating the influence of productivity, the bargaining power and between-firm competition on wages in a unified framework. We use an original equilibrium job search model with on-the-job search and wage bargaining as a theoretical structure, which we bring to the data. The combined use of a panel of matched employer-employee data and of LFS data allows us to implement a multi-stage estimation procedure that yields separate estimates of the search friction parameters (job destruction rates, arrival rates of job offers) and labor productivity at the firm level. These estimated values of the friction parameters and firm productivity levels are then used to estimate the bargaining power that appears in the wage equation delivered by the theoretical
Our main finding is that between-firm competition plays a prominent role in wage determination in France over the period 1993-2000. The bargaining power of workers turns out to be very low—typically between 0 and a third—in all industries, up to a few exceptions among high-skilled workers. However, we definitely find that skilled workers have bargaining power, albeit less than is usually estimated, and are thus able to capture a substantial share of the job surplus for reasons that cannot be entirely explained by the competition for labor services between employers. This is an interesting result which calls for further research in order to better understand what lies inside the “black box” of the bargaining power parameter $\beta$. The game-theoretic model featured in this paper interprets this parameter in terms of different response times for workers and firms and different time discount rates. But we have very little empirical evidence on the dependence of these variables on such intuitive candidate determinants as education or trade union density for example.

Our results also rely on simplifying assumptions that would need further scrutiny. We now list three very desirable extensions.

One set of extensions would improve the capacity of the model to describe individual wage dynamics. Firstly, the current version of the model lacks productivity shocks. This is absolutely not a trivial extension as it implies dealing with the problem of when and why wage contracts are renegotiated following productivity shocks. Yet it would yield much richer and more realistic wage dynamics, would endogenize layoffs and would potentially explain why wages change more when there is an employer change than otherwise. A second desirable extension is to allow for experience accumulation. This is also not a trivial extension as, even if the experience accumulation process is exogenous, the contracts that firms and workers would now negotiate are not single wages any more but full experience-wage profiles (see Carrillo-Tudela, 2005).

A second extension goes into the direction of endogenizing matching parameters to make them a function of worker search effort and firm vacancy-posting behavior. There we need to model labor demand and make the model a full general-equilibrium search-matching model à la Pissarides. This is another non trivial extension.\footnote{Note in passing that it is precisely because the model that we develop here is still a partial equilibrium one that we do not move on to policy analysis. Any interesting policy reform—e.g. a change in payroll} Mortensen
(2000) already bridged the gap between equilibrium search models and search-matching models. We need to follow him in that direction.

The last extension that we have in mind relates to the very strong assumptions that we have made about the value of non labor time ($\varepsilon b$) and about the absence of heterogeneity in the search-matching parameters. If one makes job offer arrival rates worker-specific or if one changes the form of the flow-value of non-labor time, then one loses the property that there is no sorting in equilibrium. For example, if good-quality workers receive alternative offers more often, then they will climb the wage and productivity ladder faster and one gets positive sorting. Solving such an equilibrium search model with sorting and estimating it is surely very difficult, but nevertheless constitutes a very promising area for future research.

Appendix: Details of some theoretical results

A Wage bargaining

This Appendix contains the details of the two negotiation games underlying the wage equations used throughout the paper. Both games are based on Rubinstein’s (1982) alternating offers game.

A.1 Bargaining with unemployed workers

The negotiation game between a type-$\varepsilon$ unemployed worker and a type-$p$ employer is as follows. The worker and the employer make alternating offers. When one of the players offers a contract (a wage), the other player either accepts or rejects the offer. If the offer is accepted, then the bargaining ends and the offered contract is implemented. If the offer is rejected, then the game goes on to a next round after a short time delay, denoted by $\Delta_e$ if the worker just rejected an offer by the firm or by $\Delta_f$ if the firm just rejected an offer by the worker. In the next round, the player who last rejected an offer makes a counter-offer, which again can either be accepted or rejected. The game goes on in this way over an infinite horizon. It is also assumed that the match is destroyed at Poisson rate $s$ and that the worker can receive wage offers from outside firms at rate $\lambda$ during the negotiation game. The discount rates of the worker and the firm are denoted by $\rho$ and $\rho_f$ respectively.

Proposition 1 The outcome of the negotiation game described above is a wage $\phi_0(\varepsilon, p)$ that solves:

$$V(\varepsilon, \phi_0(\varepsilon, p), p) = \beta V(\varepsilon, \varepsilon p, p) + (1 - \beta)V(\varepsilon)$$

when $\Delta_e \to 0$, $\Delta_f \to 0$, $q \to +\infty$, with $\beta = \Delta_f/(\Delta_e + \Delta_f)$.

Taxes or in unemployment insurance benefits—not only affects wages but also labor demand, which is currently mostly exogenous.
The proof is little more than an application of a result by Osborne and Rubinstein (1990, p. 87). Osborne and Rubinstein (1990) have shown that the subgame perfect equilibrium of the negotiation game is a pair of stationary strategies, in which the firm (worker) offers the wage $w_f$ ($w_e$) that makes the other party indifferent between accepting this wage offer instantaneously and waiting their turn to make a counter-offer. More formally, assuming that the firm’s valuation of a vacant job slot is zero, that is:

$$V(\varepsilon, w_f, p) = \frac{1}{1 + \rho e} \left[ b \varepsilon \Delta e + (1 - s \Delta e - \lambda \Delta e) V(\varepsilon, w_e, p) + s \Delta e V_0(\varepsilon) + \lambda \Delta e \tilde{V}(\varepsilon, w_f, p) \right],$$

where $V(\varepsilon, w_f, p)$ is the value to the worker if s/he accepts the firm’s offer $w_f$ and the right-hand side is the value if s/he refuses, and, similarly,

$$\Pi(\varepsilon, w_e, p) = \frac{1}{1 + \rho f \Delta f} \left[ \pi_0 \Delta f + (1 - s \Delta f - \lambda \Delta f) \Pi(\varepsilon, w_f, p) + s \Delta f \Pi_0 + \lambda \Delta f \tilde{\Pi}(\varepsilon, w_e, p) \right],$$

where $\Pi(\varepsilon, w_e, p)$ is the firm’s profit if it accepts worker’s wage offer $w_e$ and $\tilde{V}(\varepsilon, w, p)$ and $\tilde{\Pi}(\varepsilon, w, p)$ denote the worker’s and firm’s (finite) continuation values of the game that is started should the worker receive an outside offer from another firm, and where it has been assumed that the firm’s flow payoff from a vacant job slot is $\pi_0$ and that the present discounted value of such a vacant job is $\Pi_0$.

These last two equations can be rewritten as:

$$V(\varepsilon, w_f, p) - V(\varepsilon, w_e, p) = -\Delta e \left[ (s + \lambda) V(\varepsilon, w_e, p) + \rho V(\varepsilon, w_f, p) - b \varepsilon - s V_0(\varepsilon) + \lambda \tilde{V}(\varepsilon, w_f, p) \right], \quad (A.2)$$

$$\Pi(\varepsilon, w_e, p) - \Pi(\varepsilon, w_f, p) = -\Delta f \left[ (s + \lambda) \Pi(\varepsilon, w_f, p) + \rho \Pi(\varepsilon, w_e, p) - \pi_0 - s \Pi_0 + \lambda \tilde{\Pi}(\varepsilon, w_e, p) \right]. \quad (A.3)$$

Both equations imply that $w_f \to w_e$ when $\Delta_f \to 0$ and $\Delta_e \to 0$. Denoting the common limit of $w_f$ and $w_e$ by $w$, one can write:

$$\frac{\partial V}{\partial w}(\varepsilon, w, p) = \lim_{\Delta_f, \Delta_e \to 0} \frac{V(\varepsilon, w_f, p) - V(\varepsilon, w_e, p)}{w_f - w_e},$$

$$\frac{\partial \Pi}{\partial w}(\varepsilon, w, p) = \lim_{\Delta_f, \Delta_e \to 0} \frac{\Pi(\varepsilon, w_f, p) - \Pi(\varepsilon, w_e, p)}{w_f - w_e}.$$

Using these last two equations and taking the ratio between equation (A.2) and (A.3) for $\Delta_f, \Delta_e \to 0$, we obtain:

$$\frac{\partial V}{\partial \Pi}(\varepsilon, w, p) = \frac{\Delta_e (\rho + s)}{\Delta f (\rho_f + s)} \frac{V(\varepsilon, w, p) - \frac{b \varepsilon + s V_0(\varepsilon) + \lambda \tilde{V}(\varepsilon, w, p)}{\rho + s + \lambda}}{\Pi(\varepsilon, w, p) - \frac{\pi_0 + s \Pi_0 + \lambda \tilde{\Pi}(\varepsilon, w, p)}{\rho_f + s + \lambda}}. \quad (A.4)$$

Assuming that the firm’s valuation of a vacant job slot is zero, that is: $\pi_0 = \Pi_0 = 0$ (as would result from free entry and exit into the search market), we can define the the surplus of
an \((\varepsilon, p)\) match as \(S(\varepsilon, p) = \Pi(\varepsilon, w, p) + V(\varepsilon, w, p) - V_0(\varepsilon)\).\(^{22}\) This implies, together with the identity \(\Pi(\varepsilon, \varepsilon, p) = 0\), that \(\Pi(\varepsilon, w, p) = V(\varepsilon, \varepsilon, p) - V(\varepsilon, w, p)\) for all \(w\). Thus, \(\frac{\partial V}{\partial w}(\varepsilon, w, p) = -\frac{\partial \Pi}{\partial w}(\varepsilon, w, p)\) for all \(w\). Therefore, the wage solution to equation (A.4), denoted by \(\phi_0(\varepsilon, p)\), also solves:

\[
V(\varepsilon, \phi_0(\varepsilon, p), p) = \beta V(\varepsilon, \varepsilon, p) + (1 - \beta) \frac{\rho_e + s V_0(\varepsilon) + \lambda \tilde{V}(\varepsilon, \phi_0(\varepsilon, p), p) - \frac{\beta}{1 - \beta} \frac{\Pi(\varepsilon, \phi_0(\varepsilon, p), p)}{\rho_f + s + \lambda}}{\rho + s + \lambda}
\]

(A.5)

where:

\[
\beta = \frac{\Delta_f (\rho_f + s + \lambda)}{\Delta_f (\rho_f + s + \lambda) + \Delta_e (\rho + s + \lambda)}
\]

(A.6)

As \(s \to \infty\), equation (A.5) confounds itself with our definition (A.1) of \(\phi_0(\varepsilon, p)\), while the bargaining power \(\beta \to \Delta_f/(\Delta_e + \Delta_f)\). This completes the proof of the Proposition.

Our interpretation is that the bargaining power \(\beta\) does not depend on the discount factor, on the destruction rate of operating jobs, or on the arrival rate of job offers if these three parameters are small enough compared to the job destruction rate during the negotiation process.\(^{23}\)

### A.2 Renegotiation

When an employed worker contacts an outside firm, s/he has the opportunity to renegotiate her/his wage according to the following game:

1. The firms make simultaneous noncooperative wage offers;
2. The worker either chooses one wage offer and signs a new contract or keeps the preexisting contract;
3. If the worker has chosen one wage offer at step 2, some time elapses. Then the worker can initiate a renegotiation with the firm whose offer has been refused at stage 2. This renegotiation obeys the same rules as the negotiation game between unemployed workers and firms except now that the outside option is not unemployment but the job and wage contract accepted at step 2.

The negotiation game that is played between two firms and an initially employed worker resembles the game between a firm and an unemployed worker except that the former has three players instead of two. Two steps have been added to enable the worker to maneuver so as to build him/herself an optimal credible threat point in the renegotiation subgame (step 3). Namely, if the worker accepts the offer of the poaching firm at step 2, s/he quits the incumbent firm and this offer becomes her/his threat point in the renegotiation. Conversely, her/his threat point is the offer of the incumbent employer if that offer is accepted at step 2.

\(^{22}\)Shimer (2005) considers a bargaining game in all respects similar to this one, except that incumbent employers cannot match outside offers. The current wage then determines the duration of the match and the bargaining outcome therefore does not satisfy a “surplus splitting” rule. If employers can counter outside offers, mobility is determined by match productivity, not by the wage, and the surplus is then the sum of firm’s profit and worker’s net value.

\(^{23}\)Note that assuming \(\rho_f = \rho\) (firms and workers use the same discount rate) also implies that \(\beta\) only depends on the players’ response times. What is different from equation (1) in this case is the worker’s threat point, as it appears in equation (A.5).
This game can appear somewhat unrealistic at first glance, as it gives the employee the option to momentarily quit her/his initial employer to eventually return with a new contract at the end of the renegotiation. Such back-and-forth worker movements do not happen in the real world. Neither do they in our game, as we wish to emphasize, since temporarily quitting to a less attractive employer is only a threat available for the worker to use, which is never implemented in equilibrium.

**Proposition 2** The renegotiation game has the following outcome when a type-$\varepsilon$ employee paid a wage $w$ in a type-$p$ firm receives an outside offer from a type-$p'$ firm.

- If $p' \leq p$, the worker stays at the type-$p$ firm, with a new wage $\phi(\varepsilon, p', p)$ defined by:
  \[
  V(\varepsilon, \phi(\varepsilon, p', p), p) = V(\varepsilon, \varepsilon p', p') + \beta \left[ V(\varepsilon, \varepsilon p, p) - V(\varepsilon, \varepsilon p', p') \right].
  \]  
  If $\phi(\varepsilon, p', p) > w$ or stays at the type-$p$ firm with the wage $w$ otherwise.

- If $p' > p$, the worker moves to the type-$p'$ job, where s/he gets a wage $\phi(\varepsilon, p, p')$ that solves:
  \[
  V(\varepsilon, \phi(\varepsilon, p, p'), p') = V(\varepsilon, \varepsilon p, p) + \beta \left[ V(\varepsilon, \varepsilon p', p') - V(\varepsilon, \varepsilon p, p) \right].
  \]  

**Proof:** The renegotiation game is solved by backward induction. Let us denote by $w'_1$ and $w_1$ the wage offers made at step 1 by firm $p'$ and $p$ respectively. We assume that if the worker receives two offers yielding the same value, s/he chooses to stay with the incumbent employer.

At step 3, the renegotiation follows the same rules as the negotiation between unemployed workers and firms—only with different outside options, and possibly different values of the parameters, notably the arrival rate of outside job offers $\lambda$. Therefore, the worker who accepted a wage offer $w_1$ at step 2 and renegotiates with firm $p'$ at step 3 ends up with a wage $w$ that solves:

\[
V(\varepsilon, w, p') = \beta V(\varepsilon, \varepsilon p', p') + (1 - \beta) \frac{bc + s V(\varepsilon, w_1, p) + \lambda \tilde{V}(\varepsilon, w, p') - \frac{\beta}{1 - \beta} \frac{\lambda \tilde{V}(\varepsilon, \phi(\varepsilon, p), p)}{p' + s + \lambda}}{p + s + \lambda}
\]

where $\beta$ is defined as in equation (A.6). As $s \to +\infty$, this becomes:

\[
V(\varepsilon, w, p') = \beta V(\varepsilon, \varepsilon p', p') + (1 - \beta) V(\varepsilon, w_1, p)
\]

with $\beta = \Delta_f / (\Delta_e + \Delta_f)$. Similarly, the worker who accepted a wage offers $w'_1$ at step 2 and renegotiates with firm $p$ at step 3 gets a wage $w$ that solves, when $s \to +\infty$:

\[
V(\varepsilon, w, p) = \beta V(\varepsilon, \varepsilon p, p) + (1 - \beta) V(\varepsilon, w'_1, p')
\]

These two bargaining solutions imply the following decision pattern for the worker:

- If the worker has accepted $w'_1$ at step 2: bargain and work with $p$ if $V(\varepsilon, \varepsilon p, p) > V(\varepsilon, w'_1, p')$, and otherwise keep $w'_1$.

- If the worker has accepted $w_1$ at step 2: bargain and work with $p'$ if $V(\varepsilon, \varepsilon p', p') > V(\varepsilon, w_1, p)$, and otherwise keep $w_1$. 

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At step 2, the worker accepts the wage offer that leaves him/her with the highest value. If s/he accepts \( w_1 \), s/he knows that s/he will trigger a renegotiation at step 3 if and only if \( V(\varepsilon, \varepsilon p', p') > V(\varepsilon, w_1, p) \). Thus, the value of accepting \( w_1 \) at step 2 equals:

\[
V = \max \left[ \beta V(\varepsilon, \varepsilon p', p') + (1 - \beta) V(\varepsilon, w_1, p), V(\varepsilon, w_1, p) \right].
\]

Similarly, the value of accepting \( w'_1 \) at step 2 equals:

\[
V = \max \left[ \beta V(\varepsilon, \varepsilon p) + (1 - \beta) V(\varepsilon, w'_1, p'), V(\varepsilon, w'_1, p') \right].
\]

At step 1, employers make simultaneous offers. Both employers offer the lowest possible wage that attracts the worker while leaving them with nonnegative profits.

If \( p' > p \), employer \( p' \) must offer \( w'_1 \) such that \( V(\varepsilon, w'_1, p') \geq V(\varepsilon, \varepsilon p, p) \) in order to attract the worker at step 3 because the maximum wage that employer \( p \) can afford to offer is \( \varepsilon p \) and yields a value of \( V(\varepsilon, \varepsilon p, p) \) to the worker. If the worker accepts \( w_1 = \varepsilon p \), then at step 3 s/he will eventually end up being hired at firm \( p' \) for a wage \( \phi(\varepsilon, p, p') \) that solves:

\[
V(\varepsilon, \phi(\varepsilon, p, p'), p') = \beta V(\varepsilon, \varepsilon p, p') + (1 - \beta) V(\varepsilon, \varepsilon p, p).
\]

Firm \( p \) cannot bid this wage which exceeds \( \varepsilon p \). In order to avoid wasting time between steps 2 and 3 of the bargaining game, firm \( p' \) immediately offers \( w'_1 = \phi(\varepsilon, p, p') \) at step 1, which the worker immediately accepts at step 2 without initiating a renegotiation at step 3.

If \( p' \leq p \), things are exactly symmetric: employer \( p \) must offer \( w_1 \) such that \( V(\varepsilon, w_1, p) \geq V(\varepsilon, \varepsilon p', p') \) in order to retain the worker at step 3 because the maximum wage that employer \( p \) can afford to offer yields \( V(\varepsilon, \varepsilon p', p') \) to the worker. If the worker accepts \( w'_1 = \varepsilon p' \), then at step 3 s/he will eventually end up staying at firm \( p \) for a wage \( \phi(\varepsilon, p', p') \) that solves:

\[
V(\varepsilon, \phi(\varepsilon, p', p'), p) = \beta V(\varepsilon, \varepsilon p, p) + (1 - \beta) V(\varepsilon, \varepsilon p', p').
\]

Firm \( p' \) cannot bid this wage which exceeds \( \varepsilon p \). And again to avoid wasting time in unnecessary negotiations, firm \( p' \) offers \( \phi(\varepsilon, p', p) \) immediately, and the worker accepts it immediately, with the qualification that it has to improve on her/his previous situation, i.e. \( \phi(\varepsilon, p', p) > w \). If \( \phi(\varepsilon, p', p) \leq w \), the worker keeps the previous contract with the wage \( w \) and discards any offer from \( p' \).

This completes the characterization of the subgame perfect equilibrium of our bargaining game and the proof of the Proposition.

### A.3 Additional remarks about those bargaining games

It is worth introducing some extra notation at this point (for use in the main text): we see that the minimal value of \( p' \) for which “something happens” (i.e. either causing a wage increase or an employer change) is \( q(\varepsilon, w, p) \) such that

\[
V(\varepsilon, w, p) = \beta V(\varepsilon, \varepsilon p, p) + (1 - \beta) V(\varepsilon, \varepsilon q(\varepsilon, w, p), q(\varepsilon, w, p)),
\]

which is equivalent to \( \phi(\varepsilon, q(\varepsilon, w, p), q(\varepsilon, w, p)) = w \).

We should also once more emphasize two main assumptions underlying the two wage equations (1) and (2) that we use in the paper. The first (and most disputable) one is that the rate of job destruction \( s \) is high while workers and firms bargain. The second one is that we assume that \( \beta \) is the equal across worker-firm pairs (in particular, unemployed workers are assumed to have the same bargaining power as “insiders”. According to the game-theoretic interpretation that we offer in this Appendix, this is tantamount to assuming that response times (\( \Delta_e \) and \( \Delta_f \)) are equal across all worker-firm pairs.
B  Equilibrium wage determination

Here we derive the precise closed-form of equilibrium wages $\phi_0(\varepsilon, p)$ and $\phi(\varepsilon, p, p')$ defined in equations (1) and (2) respectively. The first step is to derive the value functions $V_0(\varepsilon)$ and $V(\cdot)$. Since offers accrue to unemployed workers at rate $\lambda_0$, $V_0(\varepsilon)$ solves the following Bellman equation:

$$(\rho + \lambda_0) V_0(\varepsilon) = \varepsilon b + \lambda_0 \int_{p_{inf}}^{p_{max}} V(\varepsilon, \phi_0(\varepsilon, X), X) dF(x),$$

(B.10)

where $p_{inf}$ is such that $V(\varepsilon, \varepsilon p_{inf}, p_{inf}) = V_0(\varepsilon)$. Now turning to employed workers, consider a type-$\varepsilon$ worker employed at a type-$p$ firm. Since layoffs occur at rates $\delta$, we may now write the Bellman equation solved by the value function $V(\varepsilon, w, p)$:

$$[\rho + \delta + \lambda_1 F(q(\varepsilon, w, p))] V(\varepsilon, w, p) = w + \delta V_0(\varepsilon) + \lambda_1 \int_{q(\varepsilon, w, p)}^{p} \left[ (1 - \beta) V(\varepsilon, \varepsilon x, x) + \beta V(\varepsilon, \varepsilon p, p) \right] dF(x) + \lambda_1 \int_{p}^{p_{max}} \left[ (1 - \beta) V(\varepsilon, \varepsilon p, p) + \beta V(\varepsilon, \varepsilon x, x) \right] dF(x).$$

(B.11)

Let us denote by $p_{max}$ the upper support of $p$. Using the rent splitting rules established in Proposition 2 yields the equivalent expression:

$$[\rho + \delta + \lambda_1 F(q(\varepsilon, w, p))] V(\varepsilon, w, p) = w + \delta V_0(\varepsilon) + \lambda_1 \int_{q(\varepsilon, w, p)}^{p} \left[ (1 - \beta) V(\varepsilon, \varepsilon x, x) + \beta V(\varepsilon, \varepsilon p, p) \right] dF(x) + \lambda_1 \int_{p}^{p_{max}} \left[ (1 - \beta) V(\varepsilon, \varepsilon p, p) + \beta V(\varepsilon, \varepsilon x, x) \right] dF(x).$$

(B.12)

Imposing $w = \varepsilon p$ in (B.12), taking the derivative, and noticing that the definition (A.9) of $q(\varepsilon, w, p)$ implies that $q(\varepsilon, \varepsilon p, p) = p$, one gets:

$$\frac{dV}{dp} (\varepsilon, \varepsilon p, p) = \frac{\varepsilon}{\rho + \delta + \lambda_1 \beta F(p)}.$$  

(B.13)

Then, integrating by parts in equation (B.12):

$$(\rho + \delta) V(\varepsilon, w, p) = w + \delta V_0(\varepsilon) + \beta \lambda_1 \varepsilon \int_{p}^{p_{max}} \frac{F(x)}{\rho + \delta + \lambda_1 \beta F(x)} dx$$

$$+ (1 - \beta) \lambda_1 \varepsilon \int_{q(\varepsilon, w, p)}^{p} \frac{F(x)}{p + \delta + \lambda_1 \beta F(x)} dx.$$  

(B.14)

Let $w = \phi(\varepsilon, \varepsilon p', p)$ with $p' \leq p$. Straightforward algebra shows that:

$$\phi(\varepsilon, \varepsilon p', p) = \beta \varepsilon p + (1 - \beta) \varepsilon p' - (1 - \beta)^2 \lambda_1 \int_{p'}^{p} \frac{\varepsilon F(x)}{\rho + \delta + \lambda_1 \beta F(x)} dx.$$  

(B.15)

The lower support of the distribution of marginal productivity levels, $p_{min}$, cannot fall short of the value $p_{inf}$ such that $V(\varepsilon, \varepsilon p_{inf}, p_{inf}) = V_0(\varepsilon)$. Using the definitions (B.10), of $V_0(\varepsilon)$, and (B.14), of $V(\varepsilon, w, p)$, this identity yields:

$$p_{inf} = b + \beta (\lambda_0 - \lambda_1) \int_{p_{inf}}^{p_{max}} \frac{F(x)}{\rho + \delta + \lambda_1 \beta F(x)} dx.$$  

(B.16)
the form:

\[ a \text{ mass point at } \]

The steady-state equality between flows into and out of the stocks are hired away from a firm less productive than for any type- \( \epsilon \) workers in that firm earns his marginal productivity \( \epsilon p \).

\[ G(\epsilon, p, \omega) = G(\epsilon, q, w, p) \]

On the inflow side, workers entering the category (ability \( \epsilon \), wage \( \leq w \), mpl \( p \)) come from two distinct sources. Either they are hired away from a firm less productive than \( q(\epsilon, w, p) \), or they come from unemployment. The steady-state equality between flows into and out of the stocks \( G(w|\epsilon, p) \ell(\epsilon, p) \) thus takes the form:

\[
\{ \delta + \lambda_1 F(q(\epsilon, w, p)) \} G(w|\epsilon, p) \ell(\epsilon, p) (1 - u) M
\]

\[
= \left\{ \lambda_0 u M \ h(\epsilon) + \lambda_1 (1 - u) M \int_{p_{\min}}^{q(\epsilon, w, p)} \ell(\epsilon, x) dx \right\} f(p)
\]

\[
= \left\{ \delta h(\epsilon) + \lambda_1 \int_{p_{\min}}^{q(\epsilon, w, p)} \ell(\epsilon, x) dx \right\} (1 - u) M f(p),
\]

\[
(C.18)
\]

since \( \lambda_0 u = \delta(1 - u) \). Applying this identity for \( w = \epsilon p \) (which has the property that \( G(\epsilon p|\epsilon, p) = 1 \) and \( q(\epsilon, \epsilon p, p) = p \)), we get:

\[
\{ \delta + \lambda_1 F(p) \} \ell(\epsilon, p) = \left\{ \delta h(\epsilon) + \lambda_1 \int_{p_{\min}}^{p} \ell(\epsilon, x) dx \right\} f(p),
\]

which solves as

\[
\ell(\epsilon, p) = \frac{1 + \kappa_1}{(1 + \kappa_1 F(p))^2} h(\epsilon) f(p).
\]

This shows that \( \ell(\epsilon, p) \) has the form \( h(\epsilon) \ell(p) \) (absence of sorting), and gives the expression of \( \ell(p) \). Hence the equations (8) and (9). Equation (8) can be integrated between \( p_{\min} \) and \( p \) to obtain (7). Substituting (7), (8) and (9) into (C.18) finally yields equation (10).

\section{Derivation of \( E[T(w)|p] \) for any function \( T(w) \)}

The lowest paid type-\( \epsilon \) worker in a type-\( p \) firm is one that has just been hired, therefore earning \( \phi_{0}(\epsilon, p) = \phi(\epsilon, p_{\inf}, p) \), while the highest-paid type-\( \epsilon \) worker in that firm earns his marginal productivity \( \epsilon p \). Thus, the support of the within-firm earnings distribution of type \( \epsilon \) workers for any type-\( p \) firm belongs to the interval \([p_{\inf}, p]\). Noticing that \( \tilde{G}(q|p) = G(\phi(\epsilon, q, p)|\epsilon, p) \) has a mass point at \( p_{\inf} \) and is otherwise continuous over the interval \([p_{\min}, p]\), we can readily show
that for any integrable function \( T(w) \),
\[
\mathbb{E}[T(w)|p] = \int_{\varepsilon_{\text{min}}}^{\varepsilon_{\text{max}}} \left( \int_{\phi(\varepsilon,p_{\text{min}},p)}^{\varepsilon_p} T(w) G(dw|\varepsilon,p) + T(\phi_0(\varepsilon,p)) G(\phi_0(\varepsilon,p)|\varepsilon,p) \right) h(\varepsilon)d\varepsilon
\]
\[
= \int_{\varepsilon_{\text{min}}}^{\varepsilon_{\text{max}}} T(\varepsilon)p h(\varepsilon)d\varepsilon + \frac{1 + \kappa_1 F(p)}{1 + \kappa_1^2} \int_{\varepsilon_{\text{min}}}^{\varepsilon_{\text{max}}} \left[ T(\phi_0(\varepsilon,p)) - T(\phi(\varepsilon,p_{\text{min}},p)) \right] h(\varepsilon)d\varepsilon
\]
\[
- \left[ 1 + \kappa_1 F(p) \right]^2 \int_{p_{\text{min}}}^{p} \left[ \int_{\varepsilon_{\text{min}}}^{\varepsilon_{\text{max}}} T'(\phi(\varepsilon,q,p)) \varepsilon h(\varepsilon)d\varepsilon \right] \frac{(1 - \beta) [1 + (1 - \sigma) \kappa_1 F(q)]}{[1 + (1 - \sigma) \kappa_1 F(q)] [1 + \kappa_1 F(q)]^2} dq.
\]

(D.19)

The entrants’ wage \( \phi_0(\varepsilon,p) \) equals \( \phi(\varepsilon,p_{\text{inf}},p) \). This implies that equation (D.19) can be further simplified by noticing that if the lower support of viable productivity levels \( p_{\text{inf}} \) equals the lower support of observed productivity levels \( p_{\text{min}} \) (which amounts to assuming free entry and exit of firms on the search market), then the second term in the right hand side vanishes, changing (D.19) to:
\[
\mathbb{E}[T(w)|p] = \int_{\varepsilon_{\text{min}}}^{\varepsilon_{\text{max}}} T(\varepsilon)p h(\varepsilon)d\varepsilon
\]
\[
- \left[ 1 + \kappa_1 F(p) \right]^2 \int_{p_{\text{min}}}^{p} \left[ \int_{\varepsilon_{\text{min}}}^{\varepsilon_{\text{max}}} T'(\phi(\varepsilon,q,p)) \varepsilon h(\varepsilon)d\varepsilon \right] \frac{(1 - \beta) [1 + (1 - \sigma) \kappa_1 F(q)]}{[1 + (1 - \sigma) \kappa_1 F(q)] [1 + \kappa_1 F(q)]^2} dq.
\]

We shall maintain this assumption throughout the paper.\(^{24}\) Next, using equation (8) to substitute \( F(p) = \frac{1 - L(p)}{1 + \kappa_1 L(p)} \), we obtain:
\[
\mathbb{E}[T(w)|p] = \int_{\varepsilon_{\text{min}}}^{\varepsilon_{\text{max}}} T(\varepsilon)p h(\varepsilon)d\varepsilon
\]
\[
- \frac{1 - \beta}{[1 + \kappa_1 L(p)]^2} \int_{p_{\text{min}}}^{p} \left[ \int_{\varepsilon_{\text{min}}}^{\varepsilon_{\text{max}}} T'(\phi(\varepsilon,q,p)) \varepsilon h(\varepsilon)d\varepsilon \right] \frac{[1 + \kappa_1 (1 - \sigma) + \sigma \kappa_1 L(q)] [1 + \kappa_1 L(q)]^2}{1 + \beta \kappa_1 (1 - \sigma) + (1 - \beta + \beta \sigma) \kappa_1 L(q)} dq.
\]

(D.20)

References

[1] Abramowitz, M. and I. A. Stegun (1972), Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables, Department of Commerce.


\(^{24}\)Yet, we tried to estimate the unconstrained equation, but these unconstrained estimations always lead to the conclusion that \( p_{\text{inf}} \) indeed equals \( p_{\text{min}} \).


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<td>5.71</td>
<td>0.055</td>
<td>18.25</td>
<td>3.19</td>
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<td>0.174</td>
<td>5.76</td>
<td>0.055</td>
<td>18.34</td>
<td>3.18</td>
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<td>0.254</td>
<td>3.94</td>
<td>0.102</td>
<td>9.78</td>
<td>2.49</td>
</tr>
<tr>
<td>Trade</td>
<td>1</td>
<td>0.190</td>
<td>5.28</td>
<td>0.044</td>
<td>22.56</td>
<td>4.27</td>
</tr>
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<td>0.286</td>
<td>3.50</td>
<td>0.045</td>
<td>22.24</td>
<td>6.36</td>
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<td>0.053</td>
<td>19.01</td>
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<td>9.80</td>
<td>0.075</td>
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<td>0.038</td>
<td>26.63</td>
<td>5.69</td>
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<tr>
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<td>0.119</td>
<td>8.44</td>
<td>0.044</td>
<td>22.82</td>
<td>2.71</td>
</tr>
<tr>
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<td>0.191</td>
<td>5.24</td>
<td>0.055</td>
<td>18.30</td>
<td>3.49</td>
</tr>
<tr>
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<td>0.321</td>
<td>3.12</td>
<td>0.098</td>
<td>10.25</td>
<td>3.29</td>
</tr>
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</table>

Notes:  
\(^1\)Per annum.  
\(^2\)Standard errors in parentheses.
TABLE 4: Wage Equation Estimates$^{1,2}$

<table>
<thead>
<tr>
<th>Industry</th>
<th>Bargaining power</th>
<th>Productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta_1$</td>
<td>$\beta_2$</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.35 (0.042)</td>
<td>0.13 (0.072)</td>
</tr>
<tr>
<td>Construction</td>
<td>0.98 (0.051)</td>
<td>0.26 (0.040)</td>
</tr>
<tr>
<td>Trade</td>
<td>0.38 (0.025)</td>
<td>0.33 (0.025)</td>
</tr>
<tr>
<td>Services</td>
<td>0.16 (0.040)</td>
<td>0.00 (0.028)</td>
</tr>
</tbody>
</table>

Notes: $^1$Discount rate $e^\rho = 0.95$.

$^2$Bootstrap standard errors in parentheses.
TABLE 5: Mean worker share of match rents

<table>
<thead>
<tr>
<th>Industry</th>
<th>Labor category</th>
<th>Estimated bargaining power with OTJ search (β from Table 3)</th>
<th>Observed worker share of rent: ( β₀ )</th>
<th>( \frac{β₀ − β}{β₀} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>1</td>
<td>0.35</td>
<td>0.62</td>
<td>44%</td>
</tr>
<tr>
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<td>2</td>
<td>0.13</td>
<td>0.34</td>
<td>62%</td>
</tr>
<tr>
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<td>3</td>
<td>0.00</td>
<td>0.20</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0.00</td>
<td>0.15</td>
<td>100%</td>
</tr>
<tr>
<td>Construction</td>
<td>1</td>
<td>0.98</td>
<td>0.95</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.26</td>
<td>0.37</td>
<td>30%</td>
</tr>
<tr>
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<td>3</td>
<td>0.15</td>
<td>0.43</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0.17</td>
<td>0.31</td>
<td>45%</td>
</tr>
<tr>
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<td>0.38</td>
<td>0.66</td>
<td>42%</td>
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<tr>
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<td>2</td>
<td>0.33</td>
<td>0.61</td>
<td>46%</td>
</tr>
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<td>3</td>
<td>0.14</td>
<td>0.35</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0.00</td>
<td>0.20</td>
<td>100%</td>
</tr>
<tr>
<td>Services</td>
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<td>0.16</td>
<td>0.46</td>
<td>65%</td>
</tr>
<tr>
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<td>2</td>
<td>0.00</td>
<td>0.14</td>
<td>100%</td>
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<td>3</td>
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<td>0.32</td>
<td>75%</td>
</tr>
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<td>4</td>
<td>0.00</td>
<td>0.09</td>
<td>100%</td>
</tr>
</tbody>
</table>

Note: ¹Discount rate \( e^ρ = 0.95 \).
Figure 1: The wage–productivity relationship
4 - low skilled  3 - medium skilled  2 - skilled  1 - high skilled

Figure 2: Productivity densities

Manufacturing

Construction

Trade

Services
Figure 3: Competition and rent sharing

Workers rent share (%)