Estimation of an Equilibrium Search Model with Productivity Dispersion: Wage Posting *versus* Nash Bargaining

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Abstract

The aim of this paper is to estimate an equilibrium job search model with heterogeneity in productivities of firms using longitudinal microdata from the 2009 Brazilian Monthly Employment Survey (PME). Two mechanisms of wage determination are considered: wage posting by monopsonistic firms and Nash bilateral bargaining. In order to estimate the model, we use the non-parametric method developed by Bontemps, Robin and van den Berg (2000). There is significant heterogeneity among the estimated structural parameters for the six metropolitan regions. Our (indirect) testing procedure supports the model with wage determination through bargaining and rejects the wage posting alternative. Furthermore, workers from more developed regions of Brazil experience higher levels of welfare due to reduced monopsonic power from firms. Finally, we suggest an improvement of public policies in order to mitigate the considerable cost of information existing in the labor markets under analysis.

Keywords: Search Theory, Unemployment Duration, Nonparametric Methods.
JEL Codes: J64, C14, C41.

Resumo

O objetivo deste trabalho é estimar um modelo de busca por emprego com heterogeneidade na produtividade das firmas com microdados da Pesquisa Mensal de Emprego (PME) do ano de 2009. Dois mecanismos de determinação de salários são considerados: salários postados por firmas monopsonistas e barganha bilateral de Nash. Para estimar o modelo, utiliza-se o método não-paramétrico desenvolvido por Bontemps, Robin e van den Berg (2000). Encontra-se uma heterogeneidade relevante entre os parâmetros estruturais estimados para as seis regiões metropolitanas analisadas. O procedimento (indireto) de teste suporta o modelo com determinação salarial via barganha e rejeita a alternativa de salário postado. Ademais, os trabalhadores das regiões metropolitanas mais desenvolvidas experimentam maiores níveis de bem-estar devido ao menor poder de monopsônio das firmas. Por fim, sugere-se uma melhoria nas políticas públicas no intuito de que sejam reduzidos os custos de informação existentes nos mercados de trabalho analisados.

Palavras-Chave: Teoria da Busca, Duração do Desemprego, Métodos Não-Paramétricos.

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1 Introduction

The job search theory considers the labor market an environment of imperfect information. This implies that transactions in this market need time and other resources to be held due to fact that agents are not fully informed about the opportunities and characteristics relevant to the transaction (Eckstein and van den Berg 2007, Rogerson, Shimer, and Wright 2005). Hence, these models serve as a substitute for the analysis of labor markets outside the neoclassical paradigm of labor supply, which precludes the possibility of involuntary unemployment.

In an environment of imperfect information, firms can exploit the fact that workers are not fully informed about all opportunities and thus offer wages lower than the value of labor productivity, even in a situation where firms and workers are homogeneous (Burdett and Mortensen 1998). Thus, the prevailing wage may be smaller than in an environment of perfect competition, where wages would be equal to the marginal productivity of labor. Moreover, from a structural estimation perspective it is possible to analyze jointly, in a context of market equilibrium, labor market issues such as arrival rates of job offers for employed and unemployed workers and the separation rate of employment relations. Hence, one can make an attempt to infer the factors that would account for differences in unemployment rates between regions or would influence the level of frictions present in the labor market on wages, for example.

In this paper, parameters of an equilibrium job search model are estimated, where firms may differ in terms of labor productivity, based on six metropolitan areas located in different regions of Brazil. In terms of wage determination, we investigated two possible maintained assumptions, say: wage posting ex ante by monopsonist firms that set wages unilaterally, based in Bontemps, Robin, and van den Berg (2000), and Nash bilateral bargaining ex post, based in Mortensen (2003). The methodology used to estimate the model is the nonparametric method of Bontemps, Robin, and van den Berg (2000), which makes possible to estimate the model without assuming any parametric probability distribution of firms' productivity. Although, empirical analysis based on structural estimation of search models are already quite developed internationally[1], in Brazil, the literature is virtually nonexistent, and Carvalho (2012) is a rare example of structural analysis from a search model using Brazilian data (Survey of Living Standards - PPV).

The empirical analysis in this study shows significant differences between regions. Some regions have a higher expected unemployment duration, as the metropolitan areas of Salvador and Rio de Janeiro, where the expected completed durations of unemployment are equal to approximately eleven months, while for the metropolitan region of Belo Horizonte this term is near four months. In the metropolitan area of Recife, the employed workers have a low transition rate to jobs that pay higher wages, while regions such as São Paulo and Porto Alegre have a relatively high mobility.

In terms of productivities, depending on the type assumed in the wage determination, we arrive at different conclusions. The model with wage posting inferred high productivity levels, a result also found by Mortensen (2003) and Shimer (2006), and the bilateral bargaining has more plausible values and theoretically admissible that does not violate any theoretical restriction. In the case of bargaining, the metropolitan region of São Paulo has the highest level of productivity and Recife has the lowest level. When compared to Recife, the distribution of productivity of firms in São Paulo is also more dispersed. We believe, our estimates have the potential to contribute to the long standing debate about regional differences in Brazil.

The paper is organized as follows: section 2, presents a review of theoretical and empirical literature, section 3 addresses the empirical part of the paper, dividing into the database and

[1] See Eckstein and van den Berg (2007) for a literature review.

structural estimation, section 4 presents the results and discusses them and, finally, some final considerations are made.

2 Literature Review

Since job search theory was initially developed in 1970s, a complete literature review could lead us too further into the past. So, we prefer to start with the reactions to the famous criticism of Diamond (1971) regarding the degeneracy of the wage offer distribution that prompted a new wave of studies addressing models that could generate an equilibrium with wage dispersion (van den Berg 1999). Basically there are two main approaches that lead to wage dispersion in job search models.

The first approach is represented by the model of Albrecht and Axell (1984). The wage dispersion occurs at the Albrecht and Axell (1984) due to the fact that workers are heterogeneous with respect to the value attributed to leisure (or the opportunity cost of labor). Thus, workers differ in the value of reservation wage. By offering a higher wage, the firm increases the level of employment in steady state, but reduces the profit per worker. It is, then, possible that firms that offer different wages have equal profits, enabling the existence of an equilibrium with wage dispersion. Therefore, in this model the support of the wage offer distribution is equal to a subset of the reservation wages of workers.

The second approach is based mainly on Burdett and Mortensen (1998). The main result of Burdett and Mortensen (1998) is an equilibrium with wage dispersion even if workers and firms are identical. The dispersion is produced by the possibility of on-the-job search. Firms can offer higher wages than the reservation wage because it would also attract more workers from other employers. That is, the labor supply curve for the firm is upward sloping. Thus, using the iso-profit assumption for firms that offer different wages, it is possible to get an equilibrium where the wage distribution is not degenerate on the common reservation wage, avoiding the paradox of Diamond (1971). Finally, the model of Burdett and Mortensen (1998) is characterized as a model of wage posting, in other words, firms unilaterally decide the wage offer and will not occur bargaining between workers and employers.

As to the empirical evidence, the work of Eckstein and Wolpin (1990) is based on the model of Albrecht and Axell (1984) and the study of van den Berg and Ridder (1998) is one of the main empirical analysis made from the Burdett and Mortensen (1998) model. In Eckstein and Wolpin (1990), workers are homogeneous in terms of productivity and heterogeneous in "leisure" value and firms differ in efficiency in terms of labor productivity. The authors estimate the unrestricted and restricted model. The restricted model incorporates the impositions generated by the equilibrium job search model. Eckstein and Wolpin (1990) observe that the restricted model fails to explain wage dispersion, which was the main objective of the model. The wage dispersion is almost entirely attributed to measurement error in wages. However, the paper has great appeal because it is the first to develop a methodology to estimate an equilibrium search model of the labor market. Another important feature of the model is that the arrival rate of wage offers is endogenous, determined by the number of active firms. The approach based on the model of Burdett and Mortensen (1998) assume that this rate is exogenous.

The study of van den Berg and Ridder (1998) follows the model of Burdett and Mortensen (1998). The authors consider that the labor market is segmented in relation to some characteristics of workers and, in turn, each segment can be considered a labor market. Thus, it is considered that in each segment workers and firms are homogeneous, but there is heterogeneity between markets. This heterogeneity is important to adjust the model to data. The analysis is performed from a panel data of employed and unemployed workers in the Netherlands. From

the estimates of the parameters of the theoretical model, the authors estimate the degree of monopsony of firms, effects of minimum wages variations and the factors that determine the wage dispersion. The degree of monopsony is estimated between 10% to 17%. The employed workers have a high arrival rate of wage offers that influences the competition by firms, reducing their power. Moreover, the results indicate that only 22% of the observed wage dispersion is explained by the friction in the labor market.

Bontemps, Robin, and van den Berg (2000) extend the Burdett and Mortensen (1998) model by assuming that firms are heterogeneous in terms of labor productivity and introduce a continuous distribution of firms' productivities. The authors argue that in reality the firms use different technologies and that the assumption of identical firms generates a theoretical distribution of wages with an increasing density, which would be as opposed to data which shows that the highest wages occur at a low frequency. Moreover, the authors do not allow the workers to be heterogeneous due to the fact that, from the evidence of Eckstein and Wolpin (1990), this type of heterogeneity explains a small fraction of the variation in wages. Then, the wage dispersion is caused by search friction in the labor market and the difference in the productivity of firms.

The model is estimated by a nonparametric method consisting of three stages and has the advantage of the frictional parameters are estimated consistently independently of the strategy that firms adopt. The model is estimated for some sectors of the French economy (transportation, food, equipment, etc.) using microdata from workers and confront the results with data from employers. The results indicate that firms exploit friction in the labor market, implying a high monopsony power of firms (20% to 100%).

Sulis (2008) estimates the model developed in Bontemps, Robin, and van den Berg (2000) using data from workers in Italy. The results indicate that the arrival rate of wage offers are higher for unemployed workers. Monopsony power is estimated to be considerably high, ranging between 50% to 100%. Kyyrä (2007) estimates various specifications of Burdett and Mortensen's model from Finland's microdata. The author estimates the pure homogeneity model, also considering the possibility of measurement error in wages, and the model with heterogeneity in productivity of firms. In the latter case, the author considers the case of discrete and continuous dispersion in type of firms. The results indicate that the model without heterogeneity fits the data for wages only after the introduction of measurement error in wages.

Despite the advance of equilibrium models with wage posting, Mortensen (2003) finds evidence that reject the model of Bontemps, Robin, and van den Berg (2000) to Denmark. The productivity levels are overestimated, generating a high level of monopsony for firms. Moreover, the theoretical restriction that the relationship between wages and productivity should be increasing is not satisfied, in other words, that more productive firms offer higher wages. Thus, Mortensen (2003) investigates the possibility that wages are formed through a process of bilateral bargaining. The author suggests this possibility because Denmark has a long history of collective bargaining. The results for this case are admissible for all wages and the estimated levels of productivity are plausible.

For Brazil, analysis of job search models are almost nonexistent. In terms of structural estimation, we can cite the work of Carvalho (2012). The analysis is performed using the microdata from the Survey on Living Standards - PPV, held in 1996 and 1997. Carvalho (2012) estimated a search model based on the study of van den Berg and Ridder (1998), but using retrospective duration data. The author uses the results to analyze differences between labor markets in the Northeast and Southeast regions. There is a low arrival rate of wage offers for employed workers in both regions. In terms of productivity, it is estimated a lower level of productivity for the Northeast region.

3 Empirical Analysis

We use empirical data from six metropolitan areas that are covered by the Monthly Employment Survey - PME. From this data, the parameters of the theoretical models are estimated. Although our paper is an empirical one, it is necessary to summarize the theoretical support for the estimable econometric model. Our approach is based on Bontemps, Robin, and van den Berg (2000), with the possibility of wage determination as Mortensen (2003). The model is an extension of Burdett and Mortensen (1998) model, where workers and firms are homogeneous.

3.1 The Theoretical Background

Bontemps, Robin, and van den Berg (2000) incorporate the possibility of heterogeneity in the productivity of firms in an attempt to obtain a better fit for the wage distribution. The assumptions of the model are:

A.1 Workers and active firms are represented by a continuum of mass 1 and m, respectively; they are homogeneous with respect to the ability and the firms are heterogeneous in terms of productivity;

A.2 Unemployed work have a utility flow (discounted search costs) equals to b and workers receive wage offers from a distribution $F(w)$ (known) at a rate λ_0 and λ_1 when unemployed and employed, respectively;

A.3 The wage offer distribution, $F(\cdot)$, is independent of the worker state (employed or unemployed) and the support of F is denoted by supp(F), where $\underline{w} = \inf[supp(F)]$ and $\overline{w} = \sup[supp(F)]$

A.4 An employed worker leaves the job to unemployment at rate δ, which is called the rate of employment separation (quit rate) and workers discount the future at a subjective rate ρ.

Presented the hypotheses, the next step is to define the strategies of workers and firms, and define the equilibrium of the model that serves as a basis for empirical analysis. From the worker's maximization problem and considering the previous assumptions, we arrive at the main equation that relates the reservation wage of a worker with model's fundamentals[2]:

$$w^r = b + (k_0 - k_1) \int_{w^r}^{\overline{w}} \frac{\overline{F}(\tilde{w})}{\beta + 1 + k_1 \overline{F}(\tilde{w})} d\tilde{w} \tag{1}$$

where $k_0 = \lambda_0/\delta$, $k_1 = \lambda_1/\delta$, $\beta = \rho/\delta$, $\overline{F}(x) \equiv 1 - F(x)$. Note that in the definition of the reservation wage, the worker takes into account not only the flow of utility to be unemployed, but the arrival rates of job offers, the separation rate and the wage distribution in the economy.

Before presenting the strategy of firms, it is necessary to comment on worker flows in steady state, however. Steady-state worker flows into and out of unemployment must be equal. Thus, we have that at any time $\lambda_0 u$ workers leave the unemployment state[3] and $(1-u)\delta$ fall in unemployment, where u is the measure of unemployed workers. The dynamics of unemployment is given by

$$\dot{u} = (1-u)\delta + u\lambda_0. \tag{2}$$

At steady state, $\dot{u} = 0$. So

$$u\lambda_0 = (1-u)\delta \Leftrightarrow u = \frac{1}{1+k_0}. \tag{3}$$

Therefore, this equation relates the unemployment rate with the duration (λ_0) and incidence (δ).

[2]We strongly advise the reader to consult the original paper (i.e., Bontemps, Robin, and van den Berg (2000) and the references therein) for details left out here for pragmatic reasons.

[3]In equilibrium, no firm posts a wage below the reservation wage of the worker, which implies that $\overline{F}(w^r) = 0$. Therefore, the risk of leaving the state of unemployment is equal to λ_0

Moreover, the wage distribution in the stock of employed workers is denoted by $G(\cdot)$, where $G(w)$ is the fraction of employed workers receiving a wage less than or equal to w. The dynamics of $G(w)$ is

$$\dot{G}(w)(1-u) = \lambda_0 F(w)u - \delta G(w)(1-u) - \lambda_1(1-F(w))G(w)(1-u), \tag{4}$$

where $\lambda_0 F(w)u$ is the fraction of unemployed workers who find a job and receive a wage less than or equal to w, $\delta G(w)(1-u)$ is the fraction of employed workers receiving a wage less than or equal to w and entering the unemployment state and $\lambda_1(1-F(w))G(w)(1-u)$ is the fraction of employed workers who receive a wage less than or equal to w and find another job that pays more than w.

Again, at steady-state $\dot{G}(w) = 0$, implying that

$$G(w) = \frac{F(w)}{1+k_1(1-F(w))}. \tag{5}$$

Equation (5) establishes the structural relationship between the distribution of wages earned by the stock of employed workers or earnings distribution, $G(\cdot)$, and the wage offer distribution, $F(\cdot)$.

Based on these relations, we can develop the analysis for the firm behavior. We will analyze two types of wage determination: i) wage posting, where the firm unilaterally sets the wage; and Nash bargaining, where after workers and firms meet in the market, they bargain over the wages to be paid by the firm.

WAGE POSTING

In the wage posting setting, firms determine wages and, given these wages, each firm faces a labor supply curve, $l(w)$. The level of employment of a firm that offers a wage w is

$$\begin{aligned} l(w) &= \lim_{\varepsilon \to 0} \frac{1-u}{m} \frac{G(w) - G(w-\varepsilon)}{F(w) - F(w-\varepsilon)} = \frac{1-u}{m} \frac{dG(w)}{dF(w)} \\ &= \frac{1-u}{m} \frac{1+k_1}{[1+k_1(1-F(w))]^2}, \end{aligned} \tag{6}$$

where $(1-u)(G(w) - G(w-\varepsilon))$ is the fraction of employed workers who are receiving a wage in the range $[w-\varepsilon, w]$, and $m(F(w) - F(w-\varepsilon))$ is the fraction of firms offering a wage in the range $[w-\varepsilon, w]$. This equation says that the fraction of workers who receive a wage w are uniformly distributed among firms that offer these wages. When $k_1 = 0$ (no on-the-job search), all firms have the same work force in equilibrium, which equals $(1-u)/m$.

Firms may differ in terms of labor productivity p. The distribution of p is denoted by $\Gamma_0(p)$ with $\underline{p}_0 \geq 0$ being the infimum of its support and $\overline{p}$ the supreme. Assume that $E_{\Gamma_0}(p) < \infty$.

It is considered that a worker generates a revenue flow equal to p and is independent of the number of workers in the firm. Thus, p is the labor productivity at the firm and the firm is of type p. The firm's objective is to maximize the profit flow at steady state

$$\pi(p,w) = (p-w)l(w) \tag{7}$$

Bontemps, Robin, and van den Berg (2000) show that in the case of a continuous distribution of firms' productivities, there exists a function K that maps $supp(\Gamma)$ on $supp(F)$ such that the set

K_p is represented by a single point $K(p)$. So the first order condition for profit maximization problem of the firm is

$$-[1+k_1(1-F(w))]+2k_1f(w)(p-w)=0, \tag{8}$$

under the restriction that $w \geq \max\{w^r, w_{min}\}$, where $w = K(p)$. Firms with the lowest possible level of productivity will offer a wage $\underline{w}$. The second order condition is

$$f'(w)[1+k_1(1-F(w))]-k_1f(w)^2<0, \tag{9}$$

which is equivalent to $f(w)[1+k_1(1-F(w))]$ is decreasing. This implies that the theory can be tested. For the model to be admissible, a second order condition must be satisfied for all wages in the sample.

Bontemps, Robin, and van den Berg (2000) derive the following expression for $K(p)$

$$K(p)=p-[1+k_1\overline{\Gamma}(p)]^2\int_{\underline{w}}^{p}\frac{dx}{[1+k_1\overline{\Gamma}(x)]^2}. \tag{10}$$

This is the fundamental equation of the model, because it defines the strategy of firms. That is, the wage offer is a function that depends on the productivity of the firm, the level of friction in the labor market (k_1) and the distribution of productivity of active firms. Using the structural relation between $G(\cdot)$ and $F(\cdot)$, we can rewrite (10) as

$$K^{-1}(w)=w+\frac{1+k_1G(w)}{2k_1g(w)}. \tag{11}$$

Therefore, the structural parameters of the model are necessary to infer the productivity level associated with a given wage. Given the model solution for the case of monopsonistic firms, we proceed now to describe the solution to the case of bilateral bargaining between firms and workers.

NASH BARGAINING

Mortensen (2003) suggests that the hypothesis that wages are unilaterally determined by firms may not be admissible. Another feature of the wage posting model is to infer high levels of firms' productivities (see Shimer (2006)). So another alternative for wage determination is the possibility that it might be the result of a Nash bargaining process between workers and firms. This process may occur as a result of the presence of unions and classes in the labor market, which is not a very unrealistic assumption for Brazilian labor markets. For example, Mortensen (2003) finds empirical evidences that the appropriate model for Danish data is the bargain. Obviously, this result does not necessarily applies to all economies.

The analysis is somewhat different from the previous problem. First, we can write the value function of a type p firm that pays a wages equal to w as

$$\rho J(p,w)=p-w-(\delta+\lambda_1\overline{F}(w))J(p,w). \tag{12}$$

Note that it is assumed that the value of a vacant position not occupied is zero (free entry condition). Rewriting (12), has

$$J(p,w)=\frac{p-w}{\rho+\delta+\lambda_1\overline{F}(w)}. \tag{13}$$

The value functions for employed and unemployed workers remain the same as those appearing on the wage posting problem. After workers and firms meet, the wage is defined as the Nash solution of the bilateral bargaining process in respect of the surplus value of $V^e(w) - V^u$, for workers and $J(p,w)$, for firms, since the value of staying with the position not occupied is zero for the firm. I.e.,

$$\mathcal{W}(p) = \underset{w \geq w^r}{\arg\max} (V^e(w) - V^u)^{\alpha} J(p,w)^{1-\alpha}, \tag{14}$$

where $\alpha \in (0,1)$ represents the bargaining power of workers. Thus, the first order condition for an interior solution is:

$$\alpha \frac{V^{e\prime}(w)}{V^e(w) - V^u} - (1-\alpha)\left(\frac{1}{p-w} - \frac{\lambda_1 f(w)}{\rho + \delta + \lambda_1 \overline{F}(w)}\right) = 0, \tag{15}$$

where $w \equiv \mathcal{W}(p)$. Again, $\underline{p} = \underline{w}$, which implies that $\mathcal{W}(\underline{p}) = \underline{w}$ since this is the only viable wage for the firm that could be accepted by the worker. Note that the "external option" for the worker is V^u, independent of the individual being unemployed or employed. This is because the bargaining process is *ex post* and as soon as the worker accepted the job, the only external option is unemployment, in other words, workers can not return to previous employment. Moreover, it is assumed that workers observe the firm productivity level when they find a job and thus can infer the resulting wages if they accept the job. Thus, if $\mathcal{W}(p)$ is increasing the employed workers only change to more productive firms.

The inverse function, $\mathcal{W}^{-1}(w)$, obtained from the wage offer function, $\mathcal{W}(p)$ can be derived from (15) as

$$p \equiv \mathcal{W}^{-1}(w) = w + \frac{1}{\frac{\alpha}{1-\alpha}\frac{V^{e\prime}(w)}{V^e(w) - V^u} + \frac{\lambda_1 f(w)}{\rho + \delta + \lambda_1 \overline{F}(w)}}. \tag{16}$$

This function relates the level of productivity, p associated with a given wage w generated from (14).

Moreover, using the fact that $V^e(w^r) = V^u$, it follows that the surplus that the worker obtains from the matching is

$$\mathcal{W}^{-1}(w) = w + \frac{(1-\alpha)(\rho + \delta + \lambda_1 \overline{F}(w)) \int_{w^r}^{w} \frac{1}{\rho + \delta + \lambda_1 \overline{F}(w')} dw'}{\alpha + \lambda_1 f(w)(1-\alpha) \int_{w^r}^{w} \frac{1}{\rho + \delta + \lambda_1 \overline{F}(w')} dw'} \tag{17}$$

Again, the model can be tested. As Mortensen (2003) and Shimer (2006) asserted[4] the model is admissible if $\frac{\partial \mathcal{W}^{-1}(w)}{\partial w} > 0$.

So, after describing the two different mechanisms of wage determination, the following subsection details how the empirical analysis was performed. It is divided into the database and econometric analysis.

3.2 The Data

The analysis is carried out based on a longitudinal microdata from the Monthly Employment Survey - PME of 2009, which is a database collected by the Brazilian Institute of Geography and Statistics - IBGE. This survey is conducted in six major metropolitan areas of Brazil,

[4]Note that the model of Shimer (2006) differs from model Mortensen (2003), but produces similar results.

namely: Salvador, Recife, Belo Horizonte, São Paulo, Rio de Janeiro and Porto Alegre. Workers interviewed answer several questions related to the labor market and demographic characteristics. Some questions are fundamental to the analysis, as job search duration of an unemployed worker, employment duration, wages, labor market position (employed or unemployed).

The subsample is obtained after the initial selection of workers who answered the fourth consecutive interviews in 2009. Individuals who were out of the labor force were excluded because the model allows only two states, employment and unemployment. Individuals were selected from 16 to 55 years old. All workers who were working on some interviews in the public sector, as self-employed, employer or unpaid, or who were in jobs with working hours shorter than 30 hours were excluded from the subsample. Finally, in order to eliminate potential outliers, we excluded from the subsample wages below R$ 300.00 (808 observations) [5], And 1% higher wages (370 observations). After this cut the final subsample totaled 46,367 workers.

With respect to the generated variables, we have that for unemployed workers we obtain the elapsed time of job search until the date of the first interview[6], t_{0b}, and calculate the residual time in which the individual remained unemployed for the other three remaining interviews, t_{0f}. If the worker leaves the state of unemployment to employment in this period, we observe the accepted wage, w_0, which is a realization of the wage offer distribution, $F(w)$. Furthermore, for individuals who responded that they were seeking a job for 5 years or more[7], the durations of unemployment were treated as left censored, $d_{0b} = 1$ and for those who remained unemployed in remaining interviews the unemployment duration was considered as right censored, $d_{0f} = 1$. Thus, we have that $d_{0b} = 0$ on the date of the first interview if the worker is unemployed for less than 60 months and $d_{0f} = 0$ if the unemployed worker leaves the state of unemployment in the three months after the date of the first interview.

For employed workers, we observe the job durations on the date of the first interview, t_{1b}, and wages, w_1, which is a realization of $G(w)$. Likewise, it is computed the time that the worker remained employed in relation to other interviews, t_{1f}. The worker can leave the current job to unemployment, $v = 1$, or to another job, $v = 0$. Both alternatives are considered and, if the worker stays unemployed less than 1 month before going into another job, it is considered as a job to job transition, as is done in Sulis (2008). Moreover, if the worker remains in the same job during the remaining interviews, the employment duration is right censored, $d_{1f} = 1$.

Table 1 provides descriptive statistics describing the final subsample. Included are some statistics related to demographic characteristics in order to provide an overview of the composition of each metropolitan markets. All metropolitan areas have a men proportion between 53-54%. In terms of educational level, the structure is similar across regions, except for some differences. São Paulo has the largest proportion of workers with higher education, 12%, while in the metropolitan area of Recife, that proportion is only 5%. The mean age of workers is 33 years, and there is not a significant difference between the regions.

The mean unemployment duration ($t_{0b} + t_{0f}$), also considering the incomplete duration, is 8 months in Brazil. Because there are workers who remained unemployed, is likely to understate the actual mean of unemployment durations. The metropolitan area of Belo Horizonte has the lowest average, 4.66 months, and Rio de Janeiro has the largest, 11.77. For employed workers on the date of the first interview, the employment duration mean ($t_{1b} + t_{1f}$) is 55.95 months. Rio de Janeiro has the highest mean, 62.85, while Belo Horizonte has the lowest, 50.43 months.

[5] As of January 2009 the minimum wage was equal to R$ 415.00. After the adjustment in February 2009, the minimum wage rose to R$ 465.00.

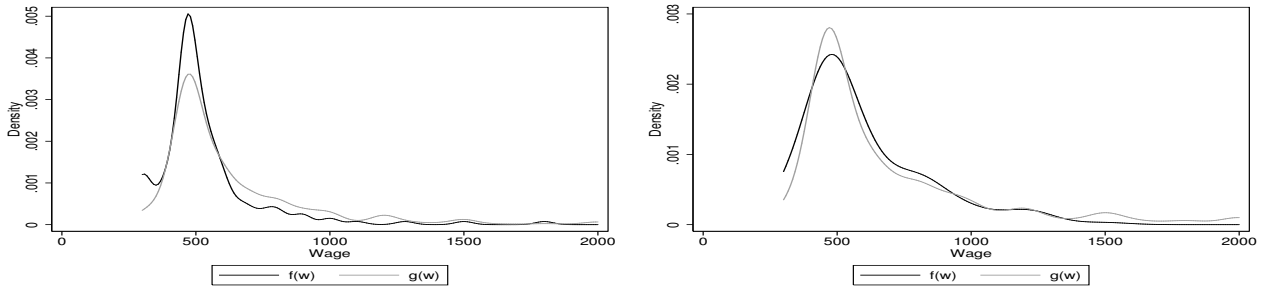
[6] For the interested reader we can provide a diagram showing a detailed account for all possible type of labor market dynamics sampled.

[7] Due to the wording of the questionnaire, the job search duration reported by the respondent is limited to 60

Table 1: Descriptive Statistics of Subsample

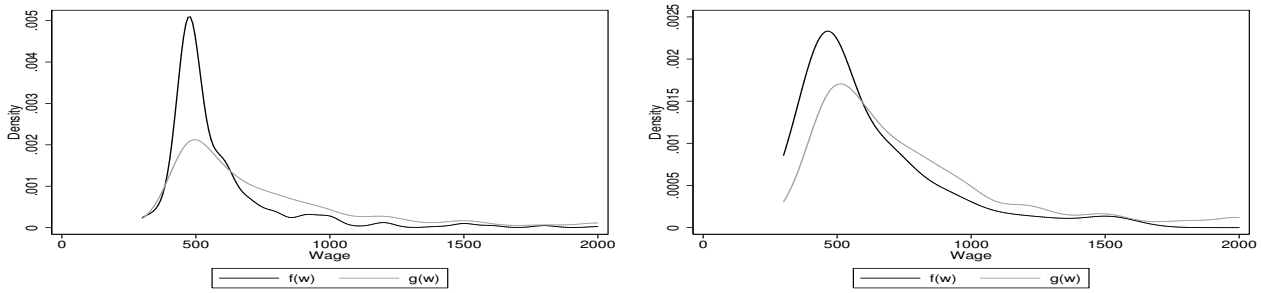
	Total	Recife	Salvador	Belo Horizonte	Rio de Janeiro	São Paulo	Porto Alegre
Number of Workers	46367	3272	5380	9333	8377	12564	7441
Employed (%)	0.87	0.83	0.79	0.90	0.88	0.86	0.91
Unemployed (%)	0:13	0:17	0:21	0:10	0:12	0:14	0:09
Men (%)	53.81	53.55	53.75	54.61	53.67	53.38	53.81
Education							
Uneducated (%)	0:01	0:01	0:01	0:01	0:01	0:01	0:00
Literacy (%)	0:23	0:21	0:20	0:25	0:24	0:19	0:26
Elementary Education (%)	0:20	0:18	0:18	0:22	0:21	0:18	0:24
High School (%)	0:48	0:55	0:54	0:45	0:44	0:50	0:44
University (%)	0:09	0:05	0:07	0:07	0:10	0:12	0:06
Age (Std. Dev.)	32.93 (10.12)	32.79 (9.66)	32.87 (9:59)	32.28 (10.14)	34.48 (2.10)	32.35 (10.23)	33.09 (10.23)
Unemployed							
Left Censored (%)	0.78	0:52	1:45	0:00	0:28	1.75	0.94
Right censored (%)	74.21	72.03	86.27	58.18	86.91	72.74	64.59
Incomplete Duration. Mean (Std. Dev.)	8.00 (8.79)	06.26 (6.97)	25.09 (10.91)	4.66 (4.5)	11.77 (11.52)	7:59 (6.99)	07.09 (8.22)
Employed							
Left Censored (%)	0:00	0:00	0:00	0:00	0:00	0:00	0:00
Right censored (%)	87.93	74.81	89.33	83.95	94.42	90.13	86.59
Incomplete Duration. Mean (Std. Dev.)	55.95 (67.28)	57.54 (65.74)	59.9 (71.74)	50.43 (63.95)	62.85 (72.89)	54.77 (65.39)	53.95 (64.78)
Transitions to Unemployment	3364	582	297	898	270	680	637
Transitions to another job	1504	1998	159	443	143	386	275
Earnings Distribution $G(w)$:							
Minimum	300	300	300	300	300	300	300
P_{10}	465	415	415	465	465	480	465
Q_1	500	465	465	470	500	600	550
Q_2	700	505	550	600	700	800	700
Q_3	1000	700	800	915	1000	1200	1000
P_{90}	1680	1000	1400	1500	1700	2000	1600
P_{90}/P_{10}	3.61	2:41	3:37	3:23	4:17	3:44	3.66
Mean (Std. Dev.)	926.48 (751.37)	658.51 (406.27)	786.52 (647.12)	867.61 (699.6)	927.54 (765.88)	1087.44 (879.76)	936.29 (681.47)

Source: Elaborated by the authors.



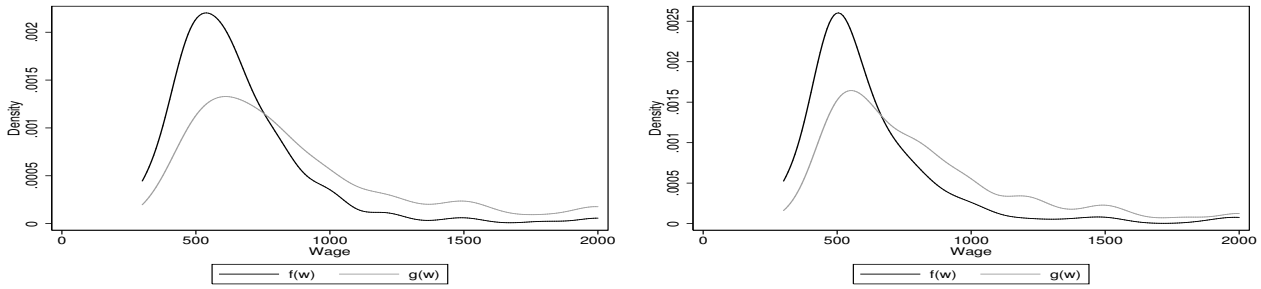
(a) Recife

(b) Salvador



(c) Belo Horizonte

(d) Rio de Janeiro



(e) São Paulo

(f) Porto Alegre

Figure 1: Kernel Estimates of Wage Distributions

Regarding the wage distribution of employed workers on the date of the first interview, we observe a considerable difference between the metropolitan areas studied. The metropolitan region of São Paulo has the highest mean R$ 1087.44, and Recife has the lowest average, 658.51, which represents only 60% of the São Paulo's mean. Observing the ratio between the ninetieth and tenth percentiles, Recife also has a low wage dispersion when compared to other metropolitan areas.

Finally, Figure 1 shows the kernel estimates of the density functions of the distribution of accepted wages by workers who left the unemployment state of during the survey, $f(w)$ (wage offer distribution), and the distribution of wages earned by workers who were employed at the date of the first interview, $g(w)$ (earnings distribution). Theory predicts that the wage offer distribution is dominated by the earnings distribution, due to the fact that the employed workers can migrate to jobs that pay higher wages. Referring to Figure 1, there is a little difference between $f(w)$ and $g(w)$ for the metropolitan areas of Recife and Salvador. However, for other regions, especially for those of São Paulo and Porto Alegre, there is a considerable difference between these distributions, which may be showing greater mobility of workers to jobs that pay better wages.

3.3 Structural Estimation

Job search models are usually estimated by maximum likelihood. In the case of the model in question, the distribution of wage offers $F(w)$ does not have an explicit form. Thus, Bontemps, Robin, and van den Berg (2000) proposed a three-stage procedure to estimate the nonparametric model.

First, we need to specify the likelihood function. The model predicts that the unemployment duration is exponentially distributed with parameter λ_0, due to the fact that the time between two events of a Poisson process is exponentially distributed. The exponential distribution has the characteristic of being memoryless distribution. Thus, this distribution has the property that the elapsed unemployment duration to date of interview, t_{0b}, and the residua unemployment duration(referring to remaining interviews), t_{0f}, are independent and exponentially distributed [8] with parameter λ_0. The probability of sampling an unemployed worker at the date of the first interview is equal to $1/(1+k_0)$ and if he receives a wage offer , w_0, this wage offer will be a realization of $F(\cdot)$. Thus, we can write the likelihood function for an unemployed worker as:

$$\mathcal{L}_d = \frac{\lambda_0^{2-d_{0b}-d_{0f}}}{1+k_0} \exp[-\lambda_0(t_{0b}+t_{0f})] f(w_0)^{(1-d_{0f})} \tag{18}$$

where d_{0b} is equal to 1 if t_{0b} is left censored and d_{0f} is equal to 1 if t_{0f} is right censored.

The probability that an employed worker is observed is equal to $k_0/(1+k_0)$ and the wage received w_1 is a realization of the earnings distribution, $G(\cdot)$. The job duration is exponentially distributed with parameter θ, where $\theta = \delta + \lambda_1 \overline{F}(w_1)$, given w_1. The probability that a worker leaves the current job to unemployment or to another job are equal to $\delta/(\delta+\lambda_1\overline{F}(w_1))$ and $\lambda_1\overline{F}(w_1)/(\delta+\lambda_1\overline{F}(w_1))$, respectively. Again, t_{1b} and t_{1f} are the elapsed and residual job duration, respectively, and are assumed to be independent. The likelihood function for an employed worker is:

$$\begin{aligned} \mathcal{L}_e &= \frac{k_0}{1+k_0} g(w_1)[\delta+\lambda_1\overline{F}(w_1)]^{1-d_{1b}} \exp\{-[\delta+\lambda_1\overline{F}(w_1)](t_{1b}+t_{1f})\} \\ &\quad \times\{\delta^v[\lambda_1\overline{F}(w_1)]^{1-v}\}^{1-d1f} \end{aligned} \tag{19}$$

months.

[8] For more details see Lancaster (1990) and Cameron and Trivedi (2005).

where d_{1b} is equal to 1 if t_{1b} is left censored, d_{1f} is equal to 1 if t_{1f} is right censored, and v is equal to 1 if the transition is to unemployment and 0 if it is for another job.

Therefore, one can write the likelihood function for a sample of size N as:

$$\mathcal{L} = \prod_{i=1}^{N} \mathcal{L}_{di}^{x} \mathcal{L}_{ei}^{(1-x)} \tag{20}$$

where x is equal to 1 if the worker is unemployed at the time the first interview and 0 if he/she is employed.

Moreover, using the relation between $F(\cdot)$ and $\Gamma(\cdot)$, we can generate the density function of firms' productivities, $\gamma(\cdot)$. Thus, considering that the wage policy function[9] is $w(p)$, the density function of firms' productivity is

$$\frac{d\Gamma(p)}{dp} \equiv \gamma(p) = f(w)w'(p). \tag{21}$$

Using the inverse relationship with $w(p)$, we can rewrite (21) as

$$\gamma(p) = \frac{f(w)}{(w^{-1})'(w)} \tag{22}$$

where $(w^{-1})'(w) = \frac{\partial w^{-1}(w)}{\partial w}$. Therefore, it becomes possible to obtain an expression for $\gamma(p)$ for the two wage determination cases.

As already mentioned, $F(w)$ does not have an explicit form, which makes impossible the use of the likelihood function alone. Thus, we adopt the procedure proposed by Bontemps, Robin, and van den Berg (2000). To estimate the bilateral bargaining model, we set $\rho = 0$. As it is also assumed in Burdett and Mortensen (1998) in the wage posting model, due to the fact that this parameter can not be identified from the data. We set as well $\alpha = 0.5$ as mentioned above and the estimated reservation wage to $\widehat{w}^r = \min\{w_i\}_{i=1}^{N}$.

Note that that by this procedure, the frictional parameters estimation (λ_0, λ_1 and δ), which is held in the first two steps, is based only on worker behavior. Thus, it is expected that the estimatives of these parameters are consistent with different forms of firms' behavior (Bontemps, Robin, and van den Berg 2000). Another important point is the fact that for the model not to be rejected by the data it must have $\gamma(p) > 0$. Then, from (22) wages and productivities must be positively related, which is a restriction generated by the theoretical model. For the estimation of $g(w)$, we use the Gaussian kernel function.

Finally, standard errors or confidence intervals of $\hat{\lambda}_0$, $\hat{\lambda}_1$ and $\hat{\delta}$, are obtained using bootstrap replications procedures, including the first stage. The bootstrap method is also useful to generate the confidence interval of $k_1 = \lambda_1/\delta$, serving as an alternative to the delta method. The results follow.

4 Results

This section presents the results of the structural estimation of the job search model. The results are divided into two sections. The first presents the results for the frictional parameters that are independent of the any wage setting behavior of firms. The second section presents the results for the estimated productivities distribution considering the two possibilities of wage determination.

[9] In the case of wage posting models, $w(p) \equiv K(p)$, and to the bilateral bargain $w(p) = \mathcal{W}(p)$.

4.1 Frictional Parameters

The frictional parameters are a measure of the search frictions present in the labor market that represent the difficulty of workers and employers to establish working relationships. Table 2 presents the estimatives for the six metropolitan areas that make up the PME.

First, the arrival rate of wage offers by unemployed workers, λ_0, shows a considerable heterogeneity among the metropolitan areas studied. This rate in the metropolitan area of Belo Horizonte is 22.77%, while in Salvador this rate is only 8.98%, which implies an expected completed unemployment duration[10] of approximately 11 months. This rate has a direct influence on unemployment rates, because the faster unemployed workers find jobs, the lower the unemployment rate in the economy, given a level of destruction of employment relations (separation rate).

Compared to other studies, the estimated values of λ_0 in our paper are relatively higher. In Bontemps, Robin, and van den Berg (2000) this rate is on average 0.07 and in Sulis (2008) this rate ranges between 0.04 to 0.07, but the author highlights the fact that the measure of unemployment duration used in the study is the time that the worker remains outside the administrative records used, which may be caused by unemployment, employment in public service, self-employment and inactivity. On the other hand, according to Bontemps, Robin, and van den Berg (2000) the parameters estimated by Kiefer and Neumann (1993) are two times higher than those estimated by the first authors, which would be closer to the values we have found here.

Table 2: Estimates of Frictional Parameters

	λ_0	λ_1	δ	k_1
Recife	0.1497	0.0089	0.0196	0.4515
	[0.1361;0.1618]	[0.007;0.0106]	[0.0186;0.0205]	[0.3467;0.5571]
Salvador	0.0898	0.0133	0.0153	0.8670
	[0.0849;0.0942]	[0.0111;0.0159]	[0.0146;0.016]	[0.7283;1.0824]
Belo Horizonte	0.2277	0.0307	0.0164	1.8683
	[0.2191;0.2397]	[0.0275;0.0343]	[0.0158;0.0171]	[1.6828;2.1442]
Rio de Janeiro	0.0915	0.0209	0.0115	1.8182
	[0.086;0.096]	[0.0183;0.024]	[0.0111;0.012]	[1.536;2.1304]
São Paulo	0.1284	0.0306	0.0141	2.1697
	[0.1234;0.1329]	[0.0271;0.0337]	[0.0136;0.0145]	[1.8963;2.4559]
Porto Alegre	0.1615	0.0311	0.0141	2.2078
	[0.1523;0.1713]	[0.0271;0.0356]	[0.0135;0.0146]	[1.8941;2.6102]

Time unit: months.
2.5% e 97.5% percentiles of bootstrap distribution. 100 replications.
Fonte: Elaborated by the authors.

Regarding the arrival rate of wage offers for employed workers, λ_1, we find that this rate is considerably smaller than λ_0. This is in accordance with the international literature. Thus, it is clear that in Brazilian labor markets the level of job search by employed workers is low. Compared to other metropolitan areas, Recife has a considerably low level of λ_1, only 0.89%. São Paulo and Porto Alegre have a rate approximately three times greater than Recife's rate. This fact is already an indication that workers have greater mobility in these metropolitan areas, which implies higher competition among employers.

The separation rate is more homogeneous among the metropolitan areas. On average, approximately 1.5% of employed workers become unemployed per month. Rio de Janeiro has the lowest separation rate among the regions analyzed, indicating that the labor market in this

[10] As the duration of unemployment is assumed distributed exponentially with parameter λ_0, the expected full length is simply equal to $1/\lambda_0$.

region has a lower turnover. The results coming from the international literature are distinct. van den Berg and Ridder (1998) and Bontemps, Robin, and van den Berg (2000) estimate a rate on average of 0.005 and 0.0061 for the Netherlands and France respectively. On the other hand, Sulis (2008) estimated a rate of 0.0128 for Italy and Bunzel et al. (2001) estimate δ between 0.01 to 0.02 for Denmark, which are closer to those estimated by us. Kyyrä (2007) found high values of δ for Finland, estimatives of δ in his work range from 0.05 to 0.01.

From λ_1 and δ one can obtain k_1, which is a parameter of great importance in the model because it is a measure of the level of friction in the labor market, see (van den Berg and van Vuuren 2003). This is because k_1 measures the number of expected job offers to be received by a worker during an episode of employment, reflecting the level of competition among firms in the market. Hence, in a market that employed workers receive alternative offers at a higher rate, employers have incentives to offer better wages to reduce the outflow of workers. Besides this effect, of course, workers move more quickly into jobs that pay better wages, which implies that the earnings distribution, $g(w)$, tends to dominate the wage offer distribution, $f(w)$.

The effect of k_1 on the distributions is evident at Figure 1. It is observed that for the metropolitan areas that have lower k_1 values, the distributions $f(w)$ and $g(w)$ are closer, which is the case of the metropolitan areas of Recife and Salvador. However, São Paulo and Porto Alegre have values of k_1, approximately four times higher than that of Recife and the effect is that $g(w)$ moves away from $f(w)$, i.e., workers have a faster wage growth in these regions. Thus, we got some evidence that the higher the level of friction in the market (lower k_1), the wage distribution is more concentrated because workers have a low transition rate to jobs that pay better wages.

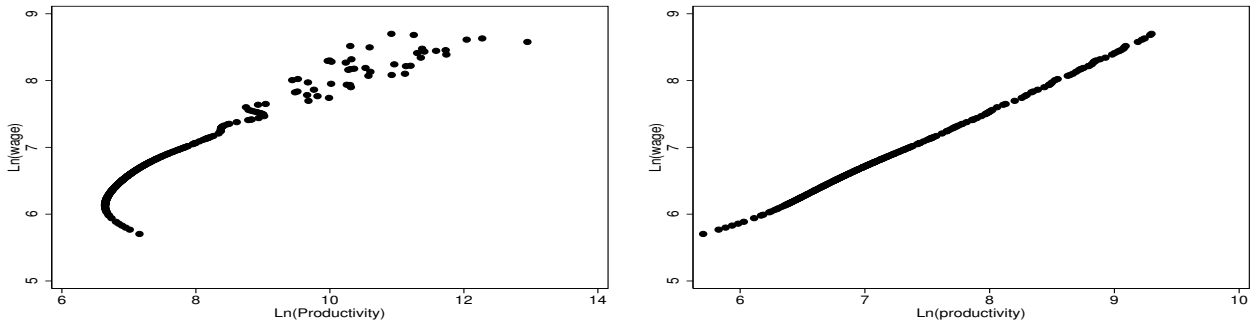
The estimated value of λ_0 in our paper is considerably higher than those on other studies, but Carvalho (2012) has a value close to that estimated in this study. As explained earlier, some authors use of nonemployment durations, which include individuals who remained out of the workforce instead of using strictly unemployment duration data. Therefore, it is expected that the mean of nonemployment duration be higher than the unemployment duration mean, which is calculated based on those workers who are actively seeking employment. There is also a chance of encountering a memory bias due to the fact that respondents underestimate the actual time they are searching for a job, which contribute to the estimation of high values of λ_0. As to λ_1, our estimatives is only slightly less than that estimated in van den Berg and Ridder (1998).

By comparing k_1, the value found here is close to the estimate for France by Bontemps, Robin, and van den Berg (2000). However, in van den Berg and Ridder (1998), the value of k_1 is estimated at about 9.40, which is considerably high and the authors find a low level of monopsony power by firms. On the other hand, Sulis (2008) estimated a low k_1 which means high levels of monopsony power.

In the model with homogeneous firms, such as Burdett and Mortensen (1998), wage dispersion is caused only by search frictions. However, when we include heterogeneity in the productivity of firms, the dispersion is also caused by differences of firms. Next section investigates the productivity distribution from the two possibilities of firms' behavior assumed in this work.

4.2 Productivities Distribution

The productivity distribution is obtained from the 3rd step of the estimation process (see, Bontemps, Robin, and van den Berg (2000)). Such step is related to finding the productivity levels associated with observed wages in the sample, exploiting the first order conditions, given the frictional parameters estimated in previous steps. In addition, for each level of productivity,



(a) Wage Posting

(b) Bilateral Bargaining

Figure 2: Relationship Between Wages e Productivities

we estimate the corresponding value of the density function, $\gamma(p)$ associated to $\Gamma(\cdot)$ which is one of the model's primitive.

This step is performed for each possible wage determination analyzed: bilateral bargaining and wage posting. One of the restrictions shared by both wage determination mechanisms is to observe a increasing relationship between wages and productivities. This condition is satisfied for the bilateral bargaining case, but not wage posting. Mortensen (2003) finds the same result for the labor market in Denmark. This result can be seen in Figure 2[11]. In the wage posting case the theory is rejected at lowest observed wages, where the relationship is decreasing, implying that those wages can not be profits maximizing for firms. That is, the model does not explain the left tail of the wage distribution. The shape of the relationship between wages and productivity is similar to that found by Mortensen (2003, p. 103).

Besides the fact of not observing an increasing relationship between wages and productivity, the wage posting model generates implausible values for the productivity levels of firms. Table 3 shows the estimated productivity levels for stock of employed workers on the date of the first interview. As the largest and most developed metropolis it is expected that firms in São Paulo have the highest average level of productivity. However, the metropolitan area of Recife has the highest average productivity level and after Recife, Salvador has the second highest level of average productivity. This may be due to the fact that estimated productivity levels are too high for firms that pay the highest wages and are in the right tail of the distribution. Therefore, as the probability mass at the end of the distribution tends to zero, the productivity level estimated tends to be extremely high, inflating the mean. In Figure 1, we find that the density function of wages to Recife is closer to zero for higher wages than to São Paulo.

Shimer (2006) and Mortensen (2003) noted that the model with wage posting tends to estimate implausible levels of productivity. Sulis (2008) also found high values for the estimated productivity and restricts its analysis to qualitative questions. Bontemps, Robin, and van den Berg (2000) argue that large differences in productivity and wages for some firms are due to the presence of large capital stock of the employer, not treated in the model, which would generate a positive effect on labor productivity.

Table 4 shows the estimated productivity distribution for employed workers, considering the case in which wages are determined as a result of a bilateral bargaining process. In this case, the metropolitan area of Recife has the lowest average level of productivity, R$ 956.46. Now, São Paulo has, on average, the highest estimated level of labor productivity, R$ 1617.22

[11] It represents the relationship between wages and productivity for the metropolitan region of São Paulo. Other metropolitan areas have an analogous pattern.

Table 3: Estimated Productivities Distribution: Wage Posting

	Minimum	P_{10}	Q_1	Q_2	Q_3	P_{90}	P_{90}/P_{10}	Mean
Recife	849.94	851.63	851.63	1149.04	2812.47	6298.05	7.40	5903.52
Salvador	730.30	748.52	748.52	1109.06	2308.59	8190.00	10.94	5350.19
Belo Horizonte	642.59	661.69	676.81	941.36	1993.42	6159.22	9.31	4264.10
Rio de Janeiro	694.92	712.04	747.33	1174.25	2327.15	8801.40	12.36	4424.64
São Paulo	768.79	781.69	883.96	1268.75	3139.06	8156.23	10.43	4147.55
Porto Alegre	694.14	710.52	788.53	1068.96	2070.59	6424.08	9.04	4142.61

P_{10}, P_{90}, Q_1, Q_2, Q_3 are percentiles e quartiles.
Source: Elaborated by the authors.

Table 4: Estimated Productivities Distribution: Bilateral Bargaining

	Minimum	P_{10}	Q_1	Q_2	Q_3	P_{90}	P_{90}/P_{10}	Mean
Recife	300.00	515.61	593.03	656.90	1018.52	1591.67	3.09	956.46
Salvador	300.00	507.43	581.71	717.42	1166.16	2317.39	4.57	1174.23
Belo Horizonte	300.00	568.27	574.95	763.98	1289.42	2373.75	4.18	1265.98
Rio de Janeiro	300.00	576.47	625.32	926.82	1434.59	2775.68	4.81	1372.77
São Paulo	300.00	605.46	767.02	1056.84	1757.31	3164.49	5.23	1617.22
Porto Alegre	300.00	575.30	686.68	904.65	1398.28	2504.62	4.35	1352.76

P_{10}, P_{90}, Q_1, Q_2, Q_3 are percentiles e quartiles.
Source: Elaborated by the authors.

approximately 69% higher than the average of Recife. Note that the values are much smaller than those presented in Table 3. In terms of dispersion and considering the ratio between the ninetieth and tenth percentiles, São Paulo and Rio de Janeiro have the greatest productivity dispersion.

An important result is obtained when comparing the metropolitan areas of Rio de Janeiro and Porto Alegre. According to Table 1, the mean wage of an employed worker is R$ 927.54 and R$ 936.39 for Rio de Janeiro and Porto Alegre, respectively. However, Porto Alegre has a lower average level of productivity than that of Rio de Janeiro. Thus, it was expected that workers were better off in the region with more productive firms. However, from Table 2, we have that the level of search frictions in the labor market is higher in Rio de Janeiro than in Porto Alegre. Therefore, workers in this region has a higher transition rate towards more productive firms that pay higher wages. This result is important because it reflects the inefficiency problem due to imperfect information in the labor market, where less productive firms retain workers with low wages even if there are jobs associated with higher levels of productivity and wages. Also it is important to consider the density functions. The estimated distributions have similar shapes, with a concentration of firms at a low productivity level and a long right tail[12]. However, for example, may be noted that the firms's productivities distribution is less dispersed in Recife than it is in São Paulo.

To analyze the difference between the productivity levels and wages received by workers, it is interesting to observe what is called the " monopsony power index". This index[13] Is defined as:

$$\mu(p) = \frac{p - \mathcal{W}(p)}{p}, \tag{23}$$

where $\mathcal{W}(p) \equiv w$. The analysis is performed only for the bargaining model, due to the fact that

[12]The interested reader can obtain the graph for estimated productivities from the authors.
[13]The index is defined as in Bontemps, Robin, and van den Berg (2000).

the wage posting model do not generate acceptable results from the theoretical point of view. This index provides the share of labor productivity that is appropriated by the firm. The index is equal to 0 in the case of wages equal to productivity, and is equal to 1, in which case the firm appropriates all productivity.

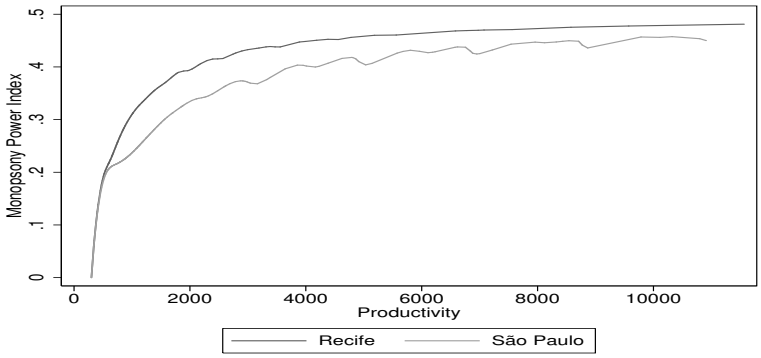


Figure 3: Monopsony Power Index: Recife x São Paulo

Figure 3 shows the monopsony power index for the metropolitan regions of São Paulo and Recife[14]. For the lower levels of productivity regions provide similar values. In addition to these levels, we find that the resulting wages are closer to the labor productivity value. This is probably because the less productive firms experiencing a higher rate of workers outflow, so they react by increasing the wages of workers in order to reduce this outflow. This index grows rapidly up to the level of productivity of R$ 2,000. At this productivity level, the index is approximately 40% and 30% in Recife and São Paulo respectively. This result reveals that employed workers in Recife are in a worse situation than those in São Paulo. This is because, for the same level of productivity, workers in Recife receive relatively lower wages. What can be partly explained by the higher level of friction present in the labor market in this region.

Thus, from the results obtained in the case of wage determination via bilateral bargaining one can infer a lower monopsony power compared to the case where firms post wages, as evidenced by in Bontemps, Robin, and van den Berg (2000) and Sulis (2008). Part of this difference is explained by the fact that if the firms post wages, they have the full power on the wage determination and the only factor influencing the reduction in their power would be the competition between firms. In the case of bilateral bargaining, apart from the competition with other firms, workers have some power over the wage determination.

5 Concluding Remarks

By considering the presence of search frictions in the labor market, job search theory is able to generate interesting theoretical results, such as involuntary unemployment, monopsony power and wage dispersion. However, although there is already a literature on empirical studies based on models of job search internationally well developed[15], this literature is almost nonexistent in Brazil. Thus, this study sought to develop an empirical analysis for the Brazilian labor market based on the job search theory. To this end, the paper developed a comparison between

[14]For the sake of clarity in the exhibition shows the graph only for these two regions.

[15]See Eckstein and van den Berg (2007).

metropolitan areas that make up the PME basen on an equilibrium job search model with continuous productivity disperson. Moreover, two forms of wage determination are considered: bilateral bargaining and wage posting. We tried to get evidence to determine which way is best suited to the Brazilian labor market, and found favorable evidence to the bilateral bargaining solution. The work follows the paradigm of structural econometrics by incorporating theoretical constraints upon model estimation. The analysis is performed using the nonparametric method developed in Bontemps, Robin, and van den Berg (2000). From the estimation of frictional parameters and the type of wage determination made, the method allows to recover the productivity distribution (unobserved) associated with the observed distribution of wages.

Regarding the results, there are differences in the values of estimated frictional parameters for the regions. The unemployment duration is considerably lower in the metropolitan area of Belo Horizonte, 4.39 months, while for Salvador, the expected duration of a complete episode of unemployment is approximately 11 months. Metropolitan areas like Recife and Salvador have a higher level of search friction, which has direct impact on competition between firms. With respect to the type of wage determination, the determination hypothesis via a bilateral bargaining process seems more appropriate than the assumption of wage posting. In the case of wage posting, we are not able to find the (theoretical expected) strictly increasing relationship between wages and productivity, which is a violation of the theoretical restriction that wage policy function must be increasing in relation to productivity of the firm. This condition is satisfied if we assume the case of bilateral bargaining. This result is the same found by Mortensen (2003) to Denmark.

From the estimated values of productivity, we calculated the proportion of productivity that remains within the firm, i.e., it is not appropriated in the form of wage by the worker. Comparing the metropolitan areas of Recife and São Paulo, one realizes that the later contains lower levels of monopsony power than the former. For the same level of productivity, a worker in the metropolitan region of São Paulo has a higher wage. This is possibly a result of a higher level of competition between firms in this region caused by a lower level of search friction in the labor market. In terms of public policy, it is evident that the information flow among workers and employers have a key role in the labor market. Thus, employment agencies could possibly reduce the information cost, reducing the inefficiencies generated by search friction in the market. Moreover, more flexible labor laws can reduce the costs associated with changes between jobs by workers decreasing regional disparities on earnings.

Some extensions of the work becomes interesting. The analysis can easily be extended to various demographic groups defined by gender, age, education, etc. Another extension would be a study based on a model that incorporates the presence of formal and informal sectors, which seems to be relevant to the analysis of the Brazilian labor market.

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