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Wage Inequality and Job Stability

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Abstract

How much wage inequality in Brazil is caused by firing costs? To answer this question, I develop and estimate a general equilibrium search and matching model with heterogeneous layoff rates among firms. Using matched employer-employee data from Brazil, I estimate the model, and I find that it replicates the observed residual wage inequality in the data. I simulate a counterfactual removal of existing firing costs, and I find that residual wage inequality drops by 26% as measured by wage variance and by 4.4% as measured by the p95-p5 ratio among 25- to 55-year-old males working in the private sector with at most a high school degree. Worker welfare among this subgroup of households increases by almost 1% in response to the abolishment of firing costs.

1 Introduction

What is the impact of firing costs on wage inequality? The answer to this question crucially depends on who bears the greatest burden of firing taxes: high-wage or low-wage workers. The first contribution of this paper is to use matched employer-employee data to show that low-wage workers are much more likely to be fired, and therefore they disproportionately shoulder the costs of firing taxes. The second contribution of this paper is to develop a theory that can correctly replicate the joint distribution of wages and layoff rates. While many search articles try to understand the forces driving wage dispersion, very few studies take into account that jobs also differ with respect to their stability,[1] and even fewer have analyzed the impact of institutions, such as firing cost regimes, on wage dispersion.[2] I attempt to fill this gap in the literature by developing a general equilibrium model with heterogeneous job tenure and then estimating the impact of firing costs on wage dispersion and welfare.

The mechanism that I theoretically and empirically characterize in this paper replicates the pattern observed in my data: firms with high firing rates pay lower wages. In on-the-job search models, companies typically pay higher wages to reduce the odds that their worker is poached by another firm offering a higher wage. Taking this logic to the extreme, if a worker and firm are going to separate with certainty in the next period, there is no risk that the employee will be poached, and so the firm can pay a small wage. More generally, firms that have high firing rates face much lower effective poaching rates, and their matches generate much less surplus; therefore, they pay lower wages. Because firing costs disproportionately depress the wages of workers in high-turnover jobs, and workers in high-turnover jobs are already at the bottom of the wage distribution, firing costs exacerbate inequality by further

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[1]Exceptions include Shi [2009], Pinheiro and Visschers [2015], Jarosch [2014], and Kuhn and Jung [2016].

[2]Contemporaneous work by Jarosch [2014] studies optimal UI in a model with heterogeneous job tenure.

depressing the wages of low-wage workers. When the government introduces a firing tax, wages will adjust downward more for jobs in which the firing cost is most likely to be incurred, (i.e., in high-turnover jobs). As a consequence, high-turnover, low-wage jobs pay even less when a firing cost is introduced. Through this channel, firing costs increase wage dispersion.

I choose to estimate the model on matched employer-employee data from Brazil because Brazil is a country that boasts high levels of wage inequality as well as high levels of firing costs.[3] On average, firing costs in Brazil are equal to roughly 30% of one year's wage. My main finding is that by abolishing these firing costs, the residual wage inequality in Brazil would drop by 26% when measured by the wage variance and by 4.4% when measured by the p95-p5 ratio among 25- to 55-year-old males working in the private sector with at most a high school degree. Worker welfare among this subgroup of households also increases by almost 1% in response to the abolishment of firing costs. The reason firing costs explain so much wage inequality in Brazil is that, as I show both empirically as well as in my model, high-turnover jobs are also lower-wage jobs. So the introduction of firing costs depresses their wages even more since firms expect to pay the firing cost sooner. On the other hand, high-wage jobs have low firing rates, so the introduction of firing costs causes tiny wage changes for these workers because firms don't expect to pay the firing cost as often. Therefore, the gap between low-wage and high-wage workers increases with the firing cost.

In addition to the quantitative results, I theoretically characterize the link between firing costs and wage dispersion. I depart from existing frameworks by incorporating heterogeneous layoff rates into an otherwise standard Burdett and Mortensen [1998] (BM) model. Existing models such as Burdett and Coles [2003] and Shi [2009] are consistent with the fact that low-wage jobs have higher turnover.[4] However, these models assume identical layoff rates across

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[3]Existing theories of Brazilian wage inequality have pointed toward education and differential productivity gains (Barros et al. [2006]), minimum wages (Ulyssea and Foguel [2006], Engbom and Moser [2016]), as well as other factors.

[4]In those models, firms are indifferent between paying low wages to short-tenure workers (who will leave

jobs, implying that the burden of firing taxes affects both high-wage workers and low-wage workers equally. Recent work by Pinheiro and Visschers [2015] theoretically analyzes wage-turnover relationships in a partial equilibrium BM model, finding that low-wage workers have higher turnover rates. Different from them, I develop a model in general equilibrium with an endogenous job finding rate (so it is therefore useful for the subsequent policy analysis I conduct), and I use the model to assess the role of firing taxes on wage inequality by estimating the model with matched employer-employee data. Also, relative to Pinheiro and Visschers [2015], my model has much more tractability because I assume that the firm hiring rate is proportion to its size (i.e., "balanced matching"[5]), making it possible to solve for the equilibrium without having to track the firm sizes.

This paper relates to a large literature on contract posting (*inter alia* Burdett and Judd [1983], Burdett and Mortensen [1998] (the BM model), Coles and Mortensen [2012], and Moscarini and Postel-Vinay [2013]), as well as a small literature that considers heterogeneous layoff rates (e.g., Shi [2009], Pinheiro and Visschers [2015], and Jarosch [2014]). My contribution to this literature is to integrate layoff heterogeneity into a BM model in which the contact rate between the firm and worker is endogenously determined in general equilibrium, and to use a matched employer-employee dataset to estimate the model.

My policy experiments also relate to the large literature on firing costs (*inter alia* Hopenhayn and Rogerson [1993], Castex and Ricaurte [2011], and Jaef [2011]). In these models, the decision of firms to fire workers is endogenous; however, there is typically no worker or wage heterogeneity, which is essential to answer the question posed in this paper.

My paper relates to recent efforts to understand the sources of wage dispersion in Brazil,

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because of on-the-job search) and high wages to long-tenure workers (who are unlikely to leave for a longer period) as these two contracts will result in the same profits for the firm. In that framework, all firms and workers are identical.

[5]Balanced matching is not very common in the literature; the few exceptions include Menzio [2007] and Gourio and Rudanko [2014].

including Engbom and Moser [2016], who argue that minimum wages mitigated a sizable fraction of Brazil's wage inequality. Across other countries, Blau and Kahn [1996] and Koeniger et al. [2004], among others, study correlations between labor market protection and wage inequality. This literature is subject to severe endogeneity and identification concerns, and so by constructing a structural model of labor market protection and wage inequality, I believe I am able to provide this literature with an unbiased estimate of the impact of firing taxes on wage inequality.

I am also contributing to the literature on compensating differentials, which has found widely conflicting results. Taking a structural approach, Bonhomme and Jolivet [2009] estimate a dynamic model of wages, amenities, and labor mobility, and they conclude that there is no wage/amenity correlation, meaning that low-wage workers are not given compensating differentials. They argue that this happens because there is heterogeneity in mobility costs, even though workers have a large marginal willingness to pay for amenities. Follow-up work by Sorkin [2015] shows that there may be substantial compensating differentials in the US, although he must indirectly infer the amenities from job flows. Other work based on US data by Lane [1999] tabulates turnover rates by education, industry, and other demographics. Her cross-tabs show that less-educated workers, who are also low-wage workers, face higher rates of turnover. Relative to Lane [1999], I use detailed matched employer-employee data to show that even after controlling for both worker and industry fixed effects (as well as other dynamic worker characteristics), higher-turnover jobs pay lower wages.

The remainder of this paper is organized as follows. In Section 2, I describe the model, determine the optimal quit behavior of workers and firms, and derive the optimal contract that a firm with a particular exogenous destruction rate offers to its employees. In Section 3, I extend the model and analyze the impact of a firing tax on wage inequality. In Section 4, I describe the empirical methodology used to calibrate the model, and in Section 5, I calibrate

the model to match key moments of the data, and I simulate the removal of the firing costs. In Section 5.1, I assess the model's fit relative to non-targeted moments, and in Section 6, I show robustness exercises. In a final section, I conclude, discuss some implications of the results, and propose some extensions.

2 An Equilibrium Model with Firm-Specific Firing Rates

My main departure from the existing search and matching literature is to assume that firms vary with respect to their exogenous probability of firing a worker. In later sections, I explore the validity of this assumption in great detail and provide suggestive empirical evidence for this assumption in Section 5.1.

2.1 Basic Framework

Consider a continuous time environment in which there is a unit mass of ex-ante identical workers. Workers are risk neutral, infinitely lived, and seek to maximize preferences over non-durable consumption c_t, discounting the future at a rate of r.

On the other side of the market, there is a continuum of firms that also discount the future at rate r and operate at a constant returns to scale technology, producing a unit flow of output per worker employed. Companies differ with respect to the exogenous rate at which matches become unproductive. Let δ denote the firm-specific job destruction rate; that is, δ is the Poisson intensity with which a match becomes unproductive and the employee is laid off. Workers and firms observe δ before deciding to enter a match. Every period, companies that are matched with existing employees are free to post a vacancy to attract a new worker. There is free entry of firms. Following Mortensen and Pissarides [1994], before a firm enters

the market, it must pay a fixed cost c_e. After entering the market but before matching with a worker, the firm draws δ from some distribution $\delta \sim \Gamma(\underline{\delta}, \overline{\delta})$ and decides whether or not to exit, and δ is constant forever after for the firm.

At each instant, a worker can be either unemployed, in which case the worker receives unemployment benefit b, or employed, in which case the employee works for a firm that promises a lifetime utility of U. Let $G(U)$ denote the cumulative measure of employed workers at companies that offer at most utility U to their employees. Also, let $N(\delta)$ denote the number of workers employed in firms with a separation rate no greater than δ. Workers search for jobs while employed and unemployed.

Let v denote vacancies posted by firms, u denote the mass of unemployed workers, and e denote the measure of employed workers. Because the employed workers are less efficient at searching per unit of time, their search effort is scaled by $s < 1$, whereas unemployed workers' search effort is normalized to one. This is equivalent to having $s.e$ employed workers seeking jobs. The effective number of workers searching for jobs at any instant in time is $x = u + se$. As is standard, $M(x, v)$ represents the total rate of matching between workers and vacancies. I assume random matching as in Mortensen and Pissarides [1994]. The labor market tightness is given by $\theta \equiv \frac{v}{x}$, and the Poisson intensity at which firms meet workers is $q(\theta) = \frac{M(x,v)}{v}$.

Firms hire employees by posting vacancies, and there is recruiting by entrant and incumbent firms. An entrant and an incumbent firm will meet a worker with intensity $q(\theta)$. Let v_e denote the number of entrant firms that is equal to the number of vacancies posted by new firms. The recruitment of existing firms happens when one of her employees meets another worker; therefore, there is a balanced matching: the hiring rate is proportional to firm size. This assumption implies that to analyze the equilibrium, we only need to keep

track of employment across firm type instead of individual firms, simplifying enormously the equilibrium proofs in the subsequent sections. The number of vacancies that incumbent firms post is equal to employment e. Therefore, the total number of vacancies is given by the sum of new entrants v_e and employment at existing firms e, $v = v_e + e$.

Firms post wages that are constant through a lifetime of an employed worker. As shown below, there is a one-to-one mapping from the wage to the utility level of an employee for a given δ.

In equilibrium, each δ is associated with a utility level offered to the worker, $U(\delta)$. Let $H(U)$ represent the distribution of promised utility continuation values among entrants.

The continuation value of an unemployed worker, U_0, is given by

$$rU_0 = b + \theta q(\theta) \left(\int_{U_0}^{\infty} \left(\tilde{U} - U_0 \right) \left(\frac{e}{v} dG(\tilde{U}) + \frac{v_e}{v} dH(\tilde{U}) \right) \right).$$

The continuation value of an unemployed worker is given by the utility flow of being unemployed b, plus the expected utility that he will receive if he receives an offer. This offer can be from an existing firm or a new firm and happens with arrival rate $\theta q(\theta)$. With probability $\frac{v_e}{v}$, this new match is with a new firm, and with probability $\frac{e}{v}$, this match is with an incumbent firm. The distribution of offers from new companies is $dH(U)$. Since incumbent firms post vacancies through their workers (balanced matching), the measure of employment across firms that offers utility U, $dG(U)$, is the distribution of offers from existing firms.

The continuation value of a worker employed in a firm with destruction rate δ and that

offers him a wage of w is given by

$$rU(\delta, w) = w + \delta \left(U_0 - U(\delta, w) \right) +$$
$$s\theta q(\theta) \left(\int_{U(\delta,w)}^{\infty} \left(\tilde{U} - U(\delta, w) \right) \left(\frac{e}{v} dG(\tilde{U}) + \frac{v_e}{v} dH(\tilde{U}) \right) \right). \tag{1}$$

The continuation value of an employed worker is given by the flow wage w, plus the expected loss if fired, plus the expected gain if he finds a new and better job. The worker can have his match destroyed with probability δ, going to unemployment and losing $U_0 - U(\delta, w)$. Also the worker can meet another firm with arrival rate $s\theta q(\theta)$, and this new match can be with a new firm (with probability $\frac{v_e}{v}$) or with an existing firm (with probability $\frac{e}{v}$). The worker will only accept the new offer if it delivers a higher utility, which occurs with probability $dH(U)$ if the match is with a new firm and with probability $dG(U)$ if the match is with an existing firm, since there is balanced matching. Note that equation (1) implicitly defines the wage as a function of the job destruction rate and the promised utility.

It is intuitive that worker utility is increasing with wages and decreasing with the firm destruction rate. The following Corollary 2.1 states these correlations between w, δ, and U.

Corollary 2.1 *Worker utility is increasing with wages and decreasing with the job destruction rate, that is, $\frac{\partial U(w,\delta)}{\partial w} > 0$ and $\frac{\partial U(w,\delta)}{\partial \delta} < 0$.*

Proof

See Appendix A.2.

Since the production function is constant returns to scale, the firm value can be expressed as the multiplication of the number of workers employed and the value per worker. The flow

value per worker for a firm with exogenous layoff rate δ that promises a utility level U for its workers is given by

$$rV\left(\delta, U\right) = 1 - w - \delta V\left(\delta, U\right) - s\theta q(\theta) \left(\frac{e}{v}(1 - G(U)) + \frac{v_e}{v}(1 - H(U))\right) V\left(\delta, U\right)$$
$$+ q(\theta) \left(\frac{se}{x}G(U) + \frac{u}{x}\right) V\left(\delta, U\right). \tag{2}$$

The value per worker is equal to the profit, $1 - w$, minus the capital loss if the match is dissolved, plus the gain that the firm has if it hires a new worker. The match can be dissolved if it becomes unproductive, with probability δ, or if the firm loses the worker to another firm. The loss that the firm has if it loses the worker to another firm is represented by the last term on the first line of equation (2). The job seeking rate for a employed worker is $s\theta q(\theta)$. An employed worker will leave his current job if he meets another existing firm that offers him a higher utility than his current one, with probability $\frac{e}{v}(1 - G(U))$, or if he meets an entrant firm that also offers him a utility higher than his current one, with probability $\frac{v_e}{v}(1 - H(U))$. The gain that the firm has if it hires a new worker is represented by the term on the second line of equation (2). The probability that an existing firm meets another worker is given by $q(\theta)$. The firm will hire the new worker that it meets if the worker is currently employed in a firm that offers the worker a lower utility, with probability $\frac{se}{x}G(U)$, or if the worker is unemployed, with probability $\frac{u}{x}$. Unemployed workers in equilibrium accept any job. Rearranging the equation of the firm value per worker, we get

$$V\left(\delta, U\right) = \frac{1 - w}{r + \delta - q(\theta) \left(\frac{se}{x}G\left(U\right) + \frac{u}{x}\right) + s\theta q(\theta) \left(\frac{e}{v}(1 - G(U)) + \frac{v_e}{v}(1 - H(U))\right)}. \tag{3}$$

The firm wants to maximize its value per worker subject to a promise-keeping constraint (PK) to deliver a promised utility level U to the worker. The promise-keeping constraint

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guarantees that the wage offered by the firm, given the firm's expected match duration, yields promised utility U to the worker. The firm problem is therefore given by

$$V\left(\delta, U\right) = \max_{w} \frac{1 - w}{r + \delta - q(\theta)\left(\frac{se}{x}G\left(U\right) + \frac{u}{x}\right) + s\theta q(\theta)\left(\frac{e}{v}(1 - G(U)) + \frac{v_e}{v}(1 - H(U))\right)}$$

$$s.t. \quad rU(\delta, w) = w + \delta\left(U_0 - U(\delta, w)\right) +$$

$$s\theta q(\theta)\left(\int_{U(\delta, w)}^{\infty}\left(\tilde{U} - U(\delta, w)\right)\left(\frac{e}{v}dG(\tilde{U}) + \frac{v_e}{v}dH(\tilde{U})\right)\right). \quad (PK)$$

The firm always pays a wage that is lower than one, and the wage must also satisfy in excess the participation constraint of the worker. So, from equation (3), the firm value per worker must be positive. Taking the first order condition with respect to U and setting it equal to zero (for algebra, see Appendix A.1) and rearranging, we can obtain the optimal wages.

An entrant firm pays the entry cost c_e and before matching with a worker draws δ from some distribution $\Gamma(\underline{\delta}, \overline{\delta})$. Then the firm decides whether or not to exit. Since $V(\delta, U)$ is always positive, all firms will choose to stay in the market regardless of δ. Therefore, because there is free entry, in an equilibrium with positive entry, the following equation must hold:

$$c_e = E_\delta\left[V\left(\delta, U\right)\right] = \int_{\underline{\delta}}^{\overline{\delta}} q(\theta)V(\tilde{\delta})\left(\frac{u}{x} + \frac{se}{x}G(U(\tilde{\delta}))\right)d\Gamma(\tilde{\delta}).$$

2.2   Definition of Stationary Recursive Competitive Equilibrium

A stationary recursive competitive equilibrium for this economy is a wage policy function for firms $U(\delta)$ (or equivalent $w(\delta)$), labor market tightness θ, number of new entrants v_e, and a set of distributions for worker employment across firms types $N(\delta)$, such that:

- Given the distributions of workers across firms, the firm policy function for utilities is

optimal and satisfies the promise-keeping constraint.

- The free-entry condition holds.

- The distribution $N(\delta)$ is time invariant and consistent with firm policy functions.

2.3   Equilibrium Properties

In Lemma 2.2, it is proved that the equilibrium utility of the worker is decreasing in the firm's firing rate. The economic intuition behind this lemma is straightforward: Why do low-layoff firms choose to offer the worker a higher utility? If the firm offers a higher utility, it is going to lose fewer workers due to on-the-job search (OJS), and since the firm is a low-layoff (low-δ firm), the worker is more "durable", yields a higher surplus, and is therefore more valuable to retain.

Lemma 2.2 *The utility level of the worker is decreasing in the exogenous layoff rate δ (i.e., job uncertainty):*

$$\frac{\partial U}{\partial \delta} \quad < 0$$

Proof

Applying the implicit function theorem to the firm first order condition $\frac{\partial V(\delta, U)}{\partial U} = 0$,

$$\frac{\partial U}{\partial \delta} = -\frac{\frac{\partial^2 V(\delta, U)}{\partial U \partial \delta}}{\frac{\partial^2 V(\delta, U)}{\partial^2 U}}. \tag{4}$$

Before taking the derivative of the firm first order condition, note that the firm value is decreasing with δ[6]:

$$V\left(\delta,U\right)=\frac{1-rU+\delta\left(U_0-U\right)+s\theta q(\theta)\left(\int\limits_U^\infty\left(\tilde{U}-U\right)\left(\frac{e}{v}dG(\tilde{U})+\frac{v_e}{v}dH(\tilde{U})\right)\right)}{r+\delta-q(\theta)\left(\frac{se}{x}G\left(U\right)+\frac{u}{x}\right)+s\theta q(\theta)\left(\frac{e}{v}(1-G(U))+\frac{v_e}{v}(1-H(U))\right)}\implies$$

$$\frac{\partial V\left(\delta,U(\delta)\right)}{\partial\delta}=\frac{\left(U_0-U\right)}{\left(r+\delta-q(\theta)\left(\frac{se}{x}G(U)+\frac{u}{x}\right)+s\theta q(\theta)\left(\frac{e}{v}(1-G(U))+\frac{v_e}{v}(1-H(U))\right)\right)}$$

$$-\frac{V\left(\delta,U\right)}{\left(r+\delta-q(\theta)\left(\frac{se}{x}G(U)+\frac{u}{x}\right)+s\theta q(\theta)\left(\frac{e}{v}(1-G(U))+\frac{v_e}{v}(1-H(U))\right)\right)}\leq 0. \quad (5)$$

Now take the derivative of both sides of the firm first order condition (equation (4)). The second derivative of $V(\delta,U)$ with respect to U and δ is, respectively,

$$\frac{\partial^2 V\left(\delta,U\right)}{\partial^2 U}<0 \quad \text{guarantees that } U^* \text{ is a maximum (second order condition).}$$

$$\frac{\partial^2 V\left(\delta,U\right)}{\partial U\partial\delta}=-1+\frac{sq(\theta)}{x}\left(2eg\left(U^*\right)+v_e h\left(U^*\right)\right)\underbrace{\frac{\partial V\left(\delta,U^*\right)}{\partial\delta}}_{\leq 0 \text{ Equation (5)}}<0.$$

Substituting the derivatives found above into the equation (4) (derived from the implicit function theorem), we have that the worker utility of equilibrium is decreasing with δ:

$$\frac{\partial U}{\partial\delta}=-\frac{\overset{(-)}{\frac{\partial^2 V(\delta,U)}{\partial U\partial\delta}}}{\underset{(-)}{\frac{\partial^2 V(\delta,U)}{\partial^2 U}}}<0.$$

∎

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[6]Note that $U-U_0\geq 0$ and $V(\delta,U)\geq 0$.

2.4 Equilibrium Worker Flows

Lemma 2.2 demonstrated that worker utility is decreasing with δ, and therefore an employed worker always searches for jobs in firms with lower δ's than that of his or her present employer. On the firm side, firms can always recruit workers employed in other firms with higher δ's. Let $N(\delta)$ denote the number of workers working in a firm with an exogenous layoff rate no greater than δ. The law of motion for the distribution of employed workers is therefore given by

$$\frac{dN(\delta)}{dt} = -\int_{\underline{\delta}}^{\delta} \tilde{\delta}n(\tilde{\delta})d\tilde{\delta} + s\theta q(\theta)(e - N(\delta))\left(\frac{e}{v}\frac{N(\delta)}{e} + \frac{v_e}{v}\Gamma(\delta)\right) + \theta q(\theta)u\left(\frac{e}{v}\frac{N(\delta)}{e} + \frac{v_e}{v}\Gamma(\delta)\right).$$

The first term on the right side of the equation above represents the flow of workers that had their job terminated in firms with $\tilde{\delta} \leq \delta$. The second term on the right side of the equation above represents the flow of employed workers that firms with $\tilde{\delta} \leq \delta$ poached from firms that offer a lower utility than $U(\delta)$. There are $e - N(\delta)$ workers employed in these lower utility firms, these workers have a match intensity of $s\theta q(\theta)$, and they will be poached by incumbents and entrant firms. The probabilities of meeting an incumbent and an entrant firm with a job destruction rate less than δ are respectively given by $\frac{e}{v}\frac{N(\delta)}{e}$ and $\frac{v_e}{v}\Gamma(\delta)$. The last term on the right side of the equation above represents the flow of unemployed workers hired by firms with $\tilde{\delta} \leq \delta$. There are u unemployed workers that have a match intensity of $\theta q(\theta)$, and they can be hired by incumbents and entrant firms. Note that no worker in the pool of employed workers in firms with $\tilde{\delta} \leq \delta$ leaves his or her job because of on-the-job search. Workers can move inside this pool due to OJS, but never leave it, since firms with job destruction rates outside this pool that are greater than δ will offer a lower utility. In equilibrium $\frac{dN(\delta)}{dt} = 0$: $\int_{\underline{\delta}}^{\delta} \tilde{\delta}n(\tilde{\delta})d\tilde{\delta} = \theta q(\theta)\left(\frac{N(\delta)}{v} + \frac{v_e\Gamma(\delta)}{v}\right)(s(e - N(\delta)) + u)$.

Integrating among all firms, it must be the case that in a stationary recursive competitive equilibrium, the expected number of workers that had their jobs terminated has to be equal to the flow of unemployed workers that find a job at every instant: $E(\theta|\text{worker employed}) = \int_{\underline{\delta}}^{\overline{\delta}} \tilde{\delta} n(\tilde{\delta}) d\tilde{\delta} = \theta q(\theta) u$.

Taking the derivative of the worker flow with respect to δ, it is possible to derive the equilibrium number of workers employed in δ type firms:

$$n(\delta) = v_e \gamma(\delta) \frac{x - sN(\delta)}{2sN(\delta) + sv_e\Gamma(\delta) + \frac{x}{q(\theta)}\delta - x} \tag{6}$$

We know that $N(\overline{\delta}) = e$ and $N(\underline{\delta}) = 0$. Therefore, if there is free entry, $v_e > 0$, the numerator of the above quotient, $v_e\gamma(\delta)(x - sN(\delta))$, is always positive.

Assumption 2.3 *The firm match intensity is low enough such that $\underline{\delta} > q(\theta)$.*

Assumption 2.3 implies that $n(\delta)$ is positive for all δ. In particular, this assumption implies that the denominator of equation (6) is always positive. The first two terms in the denominator are always non-negative, and the rest is always positive: $\frac{x}{q(\theta)}(\delta - q(\theta)) \geq \frac{x}{q(\theta)}(\underline{\delta} - q(\theta)) > 0$.

Therefore, since $N(\underline{\delta}) = 0$, $N(\overline{\delta}) = e$, and $dN(\delta) > 0$, it must be the case that the distribution of workers across δ's is well defined and continuous.

Firm Growth

The size of a firm f with separation rate δ_i evolves according to

$$\frac{dn_f(\delta_i)}{dt} =$$
$$\left(-\delta_i - s\theta q(\theta)\left(\frac{e}{v}(1 - G(U(\delta_i))) + \frac{v_e}{v}(1 - H(U(\delta_i))) \right) + q(\theta)\left(\frac{se}{x}G(U(\delta_i)) + \frac{u}{x} \right) \right) n_f(\delta_i).$$

In the Lemma 2.4, we can see that firms with smaller exogenous turnover, which offer a higher utility to the worker, grow faster.

Lemma 2.4 *Firms with a lower separation rate, lower δ, grow faster.*

Proof

See Appendix A.2. ∎

However, in a steady-state equilibrium, all firms maintain their size, losing and gaining the same amount of workers, implying that

$$\frac{dn_f(\delta_i)}{dt} = 0 \implies$$
$$-\delta_i - s\theta q(\theta)\left(\frac{e}{v}(1 - G(U(\delta_i))) + \frac{v_e}{v}(1 - H(U(\delta_i))) \right) + q(\theta)\left(\frac{se}{x}G(U(\delta_i)) + \frac{u}{x} \right) = 0.$$

Separation and On-the-Job Search Rates

As discussed before, the total number of separations that occur at every instant in time among employees working in firms of type δ is due to one of the following reasons: the match is dissolved because of some exogenous shock, or the worker leaves the job to go to a

better job because of OJS. Therefore, the total number of separations can be described as

$$Total\ Separations_{(\delta)} = \underbrace{\delta n(\delta)}_{\text{Separation Due to Exogenous Shock}} + \underbrace{s\theta q(\theta)n(\delta)\left(\frac{N(\delta)}{v} + \frac{v_e\Gamma(\delta)}{v}\right)}_{\text{Separation Due to OJS}}$$

The fraction of total separation due to OJS of workers employed in firms of type δ is given by

$$\frac{Separation\ Due\ to\ OJS}{Total\ Separation}(\delta) = \frac{\frac{s\theta q(\theta)}{v}\left(N(\delta) + v_e\Gamma(\delta)\right)}{\delta + \frac{s\theta q(\theta)}{v}\left(N(\delta) + v_e\Gamma(\delta)\right)}$$

$$\frac{\partial\left(\frac{Separation\ Due\ to\ OJS}{Total\ Separation}(\delta)\right)}{\partial\delta} = \frac{s\theta q(\theta)}{v}\frac{\left(\delta n(\delta) - N(\delta) + \delta v_e\gamma(\delta) - v_e\Gamma(\delta)\right)}{\left(\delta + \frac{s\theta q(\theta)}{v}\left(N(\delta) + v_e\Gamma(\delta)\right)\right)^2}$$

3   Theoretic Analysis of Firing Costs

3.1   Severance Payment

Suppose that the government introduces a firing cost to the firm in the form of a severance payment. If the firm fires the worker (which occurs with probability δ), then the firm must pay a lump-sum transfer to the worker that is proportional to the wage of the worker. The simplest approximation of the FGTS (Fundo de Garantia do Tempo de Servico) unemployment insurance system in Brazil (see Subsection 4.1) is the following: a worker with a wage of w that gets fired will receive τw from the firm. Therefore, it is possible to interpret this type of firing cost as a change of variable: the effective flow compensation of the worker is not w, but $(1 + \delta\tau)w$. The worker receives the wage plus some expected compensation if he

is fired. Proposition 3.1 shows that such a tax is neutral in the sense that it does not change the equilibrium.

Proposition 3.1 *There is no change in the promised utilities, firm value, worker flows, and the distributions of equilibrium with the introduction of a firing cost.*

Proof

See Appendix A.2. ∎

However, in equilibrium, the wage changes. Wages adjust according to the turnover rate of the firm. Wages decrease more for high-turnover firms (which were already paying low wages) relative to low-turnover firms. The new equilibrium wage is given by

$$w^\tau(\delta) = w^{\text{no firing cost}}(\delta)\frac{1}{1+\tau\delta}.$$

As a corollary, it is possible to show that the wage is decreasing with the firing cost.

Corollary 3.2 *The utility level of the worker is decreasing with the layoff rate, δ, in a model with a severance payment, and the wage is decreasing with τ.*

$$\frac{\partial U^\tau(\delta)}{\partial \delta} < 0. \qquad \frac{\partial w(\delta)^\tau}{\partial \tau} < 0.$$

Proof

Since the maximization problem of the firm without the firing cost is analogous to the one with the firing cost, the proof is analogous to that of Lemma 2.2. See Appendix A.2. ∎

3.1.1 The Effect of a Severance Payment on Wage Inequality

Even though equilibrium allocations do not change, observed wage payments become more disperse when a firing cost is introduced. Corollary 3.3 proves that the higher is the layoff rate, δ, the more the wage will be depressed by the firing cost τ. Since these jobs already pay lower wages, the firing cost exacerbates measured wage inequality.

Corollary 3.3 *The higher is δ, the more the wage will be distorted with the firing cost.*

$$\frac{\partial \left(\frac{w^\tau(\delta)}{w^{no\ firing\ cost}(\delta)} \right)}{\partial \delta} = -\frac{\tau}{(1+\tau\delta)^2} < 0$$

Proof

From equation (17): $\frac{w^\tau(\delta)}{w^{no\ firing\ cost}(\delta)} = \frac{1}{1+\tau\delta}$. ∎

This corollary is a key result from the paper. Since econometricians do not observe utility or severance payments (in Brazil), but rather wage payments of continuing workers, this lemma shows that firing taxes will result in more *observed* wage inequality.

3.2 Severance Payment and Firing Tax

Now, suppose that besides the severance payment, the government introduces a firing tax to the firm. If the firm fires the worker, the firm must pay a lump-sum transfer to the worker and a tax to the government. The tax paid to the government is proportional to the amount that the firm has to pay the worker in order to fire him. This is a more accurate approximation to the FGTS unemployment insurance system in Brazil. Assume that for a firm to fire an employee, the firm must pay τw to the worker and ϵw to the government,

where w is the worker's wage. Let $\tau_f = \tau + \epsilon$ denote the total tax rate that the firm must pay. The worker value of equilibrium is given by

$$rU(\delta, w) = w + \delta \left(U_0 + \tau w - U(\delta, w) \right) + s\theta q(\theta) \left(\int_{U(\delta,w)}^{\infty} \left(\tilde{U} - U(\delta, w) \right) \left(\frac{e}{v} dG(\tilde{U}) + \frac{v_e}{v} dH(\tilde{U}) \right) \right).$$

The continuation value per worker for a firm (δ, U) is given by

$$rV(\delta, U) = 1 - w - \delta \tau_f w$$
$$+ \left(-\delta - s\theta q(\theta) \left(\frac{e}{v} (1 - G(U)) + \frac{v_e}{v} (1 - H(U)) \right) + q(\theta) \left(\frac{se}{x} G(U) + \frac{u}{x} \right) \right) V(\delta, U).$$

Now the free-entry condition is given by

$$c_e = E_\delta \left[V(\delta, U; \theta, \epsilon) \right] = \int_{\underline{\delta}}^{\overline{\delta}} q(\theta) V(\delta; \theta, \epsilon) \left(\frac{u}{x} + \frac{se}{x} G(U(\delta; \theta \epsilon)) \right) d\Gamma(\delta).$$

The introduction of the firing tax by the government, (ϵ), decreases the worker's utility in equilibrium. Lemma 3.4 proves this negative relationship between U and ϵ.

Lemma 3.4 *The utility level of the worker decreases with the government tax ϵ:* $\frac{\partial U}{\partial \epsilon} < 0$.

Proof

See Appendix A.2. ∎

Unlike the pure severance payment model, in this environment, I am unable to characterize the impact of the firing cost on wage dispersion in closed form. Therefore, in the following section, I quantitatively analyze the importance of the firing tax (ϵ) for wage inequality and welfare.

4   Empirical Methodology

The statistical analysis in this section and the estimation of empirical evidence in later sections are both based on a Brazilian dataset called Relao Anual de Informaes Sociais (RAIS). RAIS is a matched employer-employee annual panel for every formal worker in Brazil. This dataset provides one unique ID number for the establishment and one for the individual, independent of the year or the job of the worker. For simplicity, in this paper I will refer to an establishment as a firm. Because of the size of the data, I chose to analyze one state of Brazil, Bahia. The RAIS dataset includes worker characteristics such as age, education, sex, tenure, average annual wage, hours worked, and so on. RAIS also provides some firm characteristics such as sector. Although there are not many firm characteristics, since it is possible to follow firms and workers using their respective ID numbers, I can construct several additional firm characteristics such as size, turnover rate, and so on.

4.1   Estimation of the Economy Parameters

I solve the model using a discrete state space approximation. I approximate the continuous distribution of δ with a fine grid, and I use discrete time, where one period of time corresponds to one month. In Appendix A.4, I provide the derivation of the discrete model and details of the computational method. I estimate the $\delta's$ of the firm as the average δ of the firm from 2000 to 2010. A large advantage of the Brazilian data over other countries' data is that there is a variable in RAIS that describes the cause of worker separation, so δ is observed.[7] I estimate the model for the largest subgroup of my data: 25- to 55-year-old males working in the private sector with at most a high school degree. All measures of wage dispersion and other worker characteristics are estimated for 2010 using data of the state of Bahia in

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[7]I omit separations which involve the worker moving to another establishment of the same firm.

Brazil.[8]

I use a Cobb-Douglas matching function $M(x,v) = Au^{\zeta}v^{1-\zeta}$, and I use the estimation results from Menzio and Shi [2011], setting the matching function parameter to be $\zeta = 0.6$. In 2010, the average unemployment rate in Bahia, Brazil, was 10.73%, so $u = 0.1073$. I set the matching function efficiency A to target the employment rate $1 - u$. And I set the employed worker's search effort s to target the employment-to-employment rate estimated from the data. Using RAIS, the employment-employment flow divided by the number of employed workers belonging to the subgroup estimated in 2010 was $EE\ Rate = 0.0408$.

To estimate the real interest rate in Brazil in 2010, the period analyzed, I subtract the average interest rate by the cumulative inflation in that year.[9] The result is a yearly real interest rate of 4.6% that corresponds to a monthly interest rate of 0.395%.

Using the unemployment benefit rules in Brazil, I estimate the benefit replacement rate from the data, $b_{data} = 0.677 \times \bar{w}$. To estimate the average employment replacement rate among the subgroup analyzed in Bahia, Brazil, in 2010, I use the following equation:[10]

$$Benefit\ replacement\ rate_{data} = \frac{mean\left(\mathbb{I}_{(w \leq 850)}0.8w + \mathbb{I}_{(850 < w \leq 1,400)}0.5w + \mathbb{I}_{(w > 1,400)}955\right)}{mean(w)}.$$

(7)

I use the estimated firm entry cost from the Doing Business website (*www.doingbusiness.org*). They estimate that the firm entry cost in Brazil is about 4.1% of yearly income per capita.

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[8]Since I am only looking at one state of Brazil, I am not taking into account the workers that move to another job in a different state. However, according to the Brazilian Institute of Geography and Statistics (IBGE) in 2010, only 1.25% of males move out of Bahia every year.

[9]Selic - IPCA, source: Central Bank of Brazil.

[10]The numerator of b_{data} is the unemployment benefit rule in Brazil using values for 2010.

According to Brazilian rules, a firm must make a deposit of 8% of the worker's wage every month into a FGTS bank account. The FGTS was implemented in 1966 and is a severance pay security fund, or employee's dismissal fund, that the worker can access in case of dismissal or some other circumstances.[11] The government uses the FGTS money to finance the Brazilian Development Bank (BNDES) and pays an interest rate that is lower than the real economy interest rate, $r_{\text{fgts}} < r$. The FGTS interest rate is equal to 3% per annum plus the annual inflation rate. An employer must pay the employee 40% of the amount in the FGTS to fire a worker. To estimate the severance payment, I first calculate the expected payment that a firm with separation rate δ must pay to the worker in Brazil:[12]

$$E(\text{layoff payment in Brazil}|\delta) = \sum_{t=1}^{\infty} \delta(1-\delta)^{t-1} \times 40\% \times \frac{8\%w \times \sum_{i=0}^{t-1}(1+r_{\text{fgts}})^i}{(1+r)^t}.$$

In the model, the expected FGTS payment that a firm of type δ must pay to the worker is $E(\text{layoff payment in model}|\delta) = \sum_{t=1}^{\infty} \delta(1-\delta)^{t-1} \times \tau \times \frac{w}{(1+r)^t} = \frac{\delta \times \tau \times w}{(r+\delta)}$.

The expected layoff payment that the worker receives if he is fired must be the same in both the model and the data: $E(\text{layoff payment in model}) = E(\text{layoff payment in Brazil})$. Since the period of the model is trimesters and the period of the data is months, the estimated τ for the model is[13]

$$\hat{\tau} = \frac{1}{4} \times \frac{0.032(1+r)}{r + E(\delta) - r_{\text{fgts}}(1 - E(\delta))} \tag{8}$$

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[11]The worker has access to the FGTS if he is fired, retires, has a serious disease, or is going to use his fund for housing, sanitation, and infrastructure.

[12]$E(\text{layoff payment in Brazil}|\delta) = \frac{0.032\delta w}{r_{fgts}} \sum_{t=1}^{\infty} \left(\frac{1+r_{fgts}}{1+r} \left(\frac{(1-\delta)(1+r_{fgts})}{1+r} \right)^{t-1} - \frac{1}{1+r} \left(\frac{1-\delta}{1+r} \right)^{t-1} \right).$

[13]Note $\sum_{i=0}^{t-1}(1+r_{\text{fgts}})^i = \frac{(1+r_{\text{fgts}})^t - 1}{r_{\text{fgts}}}.$

4.2 Estimation of δ Distribution

Unlike other matched employer-employee datasets, Brazil records the reason for separation. So δ is directly observed, and it is equal to the ratio of involuntary separations over total firm employment. To recover the distribution of $\delta's$ across firms from the data, I first estimate the δ for all firms and all months between the years 2000 and 2010:

$$\hat{\delta}_{firm,month,year} = \frac{\text{Total Separations}_{firm,month,year} - \text{Voluntary Separations}_{firm,month,year}}{\text{Firm Size}_{firm,month,year}}.$$

$$(9)$$

Total separations correspond to the total number of workers that stopped working for the firm. Since I am focusing on the stability of the job, I exclude separations due to worker transfer to another establishment part of the same firm and separations due to the worker's death. Voluntary separations correspond to separations where the worker quit and/or immediately started a new job (i.e., a job-to-job transition).[14] The average $\hat{\delta}_{firm}$ for each firm is the average δ for all months and years of the firm.[15]

The subgroup of workers analyzed in this paper are 25- to 55-year-old males working in the private sector with at most a high school degree, so I have to calculate the average monthly number of workers belonging to the subgroup that are employed in each firm in 2010. Naturally, the number of workers employed in firms with a certain δ must be equal to the sum of the average monthly size of these types of workers in the firms with this estimated δ. I normalize so that the total number of employed workers across all types of firms is equal

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[14]If the worker finds a new job he still has an incentive to get fired instead of quitting, so I will consider a separation as a job-to-job transition if he starts a new job in the same month or in the month immediately following the separation.

[15]I don't have data for the δ for December 2010 because I don't have data for January 2011; therefore, I don't know all separations that were due to job-to-job transitions.

to one:

$$\tilde{n}(\delta_i) = \frac{\sum\limits_{all\ firms} \mathbb{I}(\delta_{\hat{firm}} = \delta_i) \times \text{Employed workers belonging to subgroup}_{firm}}{\text{Number of employed workers belonging to subgroup}}$$

In Figure 1, we can see the distribution of workers belonging to the subgroup that are employed in each δ type firm in Bahia, Brazil, in 2010. The majority of workers are employed in low-turnover firms.

Figure 1: Distribution of Employment across δ Firms, Bahia, 2010. Only 25- to 55-Year-Old Males Working in the Private Sector with at Most a High School Degree.
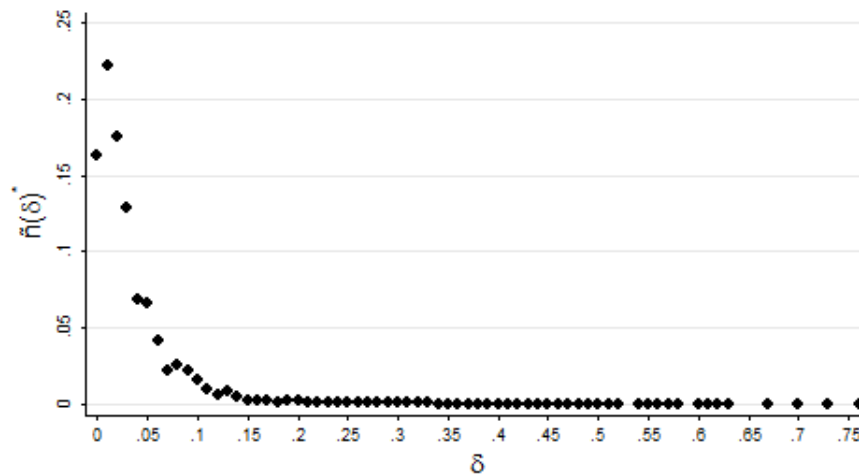
*$\tilde{n}(\delta)$ is the percentage of the total number of employed workers that work for firm type δ. *Source:* RAIS, Bahia, Brazil, 2010.

The estimation of the δ distribution across the entrant firms is analogous to the estimation of $n(\delta)$ described above:

$$\tilde{\gamma}(\delta_i) = \frac{\sum\limits_{f_n = \text{all new firms}} \mathbb{I}(\delta_{\hat{f_n}} = \delta_i)}{\text{Number of new firms}}.$$

A firm can enter in any given month of the year. Therefore, to estimate the delta

distribution among entrants, I use the monthly average of δ for the first two years of the firm. Since I do not have data for 2011, I cannot estimate the delta distribution among entrants for 2010. However, estimating the delta distribution for 2007, 2008, and 2009, I find that this distribution is very similar among entrants (see Table 5 in Appendix A.3). Therefore, I assume that the δ distribution among entrants is the average of the 2007, 2008, and 2009 distributions. The δ distribution among entrants is described in Figure 2.

Figure 2: Average Firing Rate (δ) Distribution among Entrants, Bahia, 2007, 2008, and 2009.
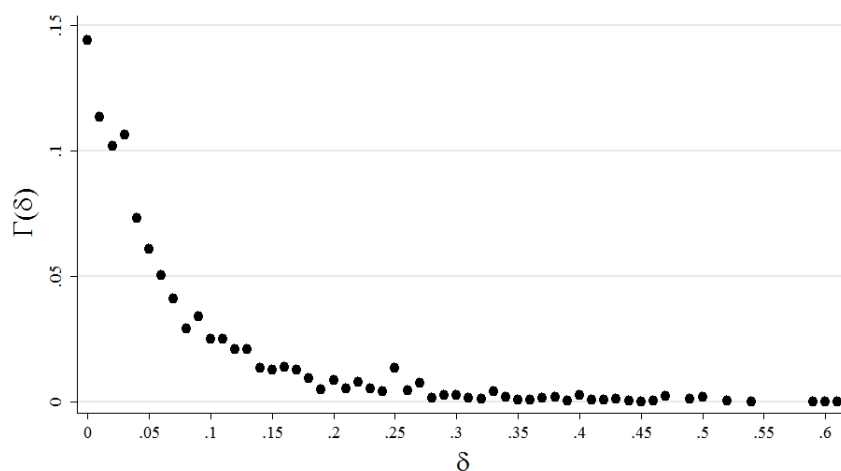
*$\Gamma(\delta)$ is the percentage of new firms with type δ. *Source:* RAIS, Bahia, Brazil, 2007-2010.

5   Quantitative Analysis

Table 1 shows the parameters that are not estimated, but taken directly from the data and the literature. Table 2 describes the calibration results and shows the targeted parameters as well as some non-targeted parameters. In Appendix A.4.2, I describe the solution algorithm in great detail, and all of the calibration results are described in detail in Appendix A.6, Table 7.

I calibrate the matching efficiency A to target the employment rate of the data, and I calibrate the on-the-job search contact rate s to target the employment-employment rate observed in the data. Table 2 illustrates how well the model does at matching the targeted parameters. By setting $A = 0.25$, the model generates the same employment rate as the data, $e = 89\%$. And by setting $s = 0.91$, the model generates almost the same employment-employment rate as the data, $EE_{model} = 0.010$ and $EE_{data} = 0.014$. The job finding rate of equilibrium that makes the firm free-entry condition hold is $\theta q(\theta) = 0.35$.

Table 1: Non-Estimated and Estimated Parameters

Notation	Description	Value	Source
r	Real annual interest rate	0.048	Central Bank of Brazil, 2010
u	Unemployment rate	0.107	Govt. of Bahia, Brazil 2010
EE	Employment-employment annual rate[†]	0.0408	RAIS, Bahia, Brazil, 2010
ζ	Matching function elasticity	0.6	Menzio and Shi [2011]
ce	Firm entry cost	0.041× GDPPC	Doing Business index
$b\bar{w}$	Average employment replacement rate[†]	0.677× avg. wage	Unemployment benefit rule, equation (7)
τw	Firing cost that workers receive[†*]	2.57× monthly wage	Approximation of the firing cost rule, equation (8)
$\epsilon\tau w$	Firing cost that firms pay to the govt	0.25τw	Approximation of the firing cost rule

[†]Estimations made for subgroup. [*]The model uses trimester wage, so τ is divided by 4 on calibration.

Table 2: Estimation Results

Target Parameters

Parameter Notation	Parameter Description	Parameter Value	Target Notation	Target Description	Target Value[†]	Model Value
A	Matching efficiency	0.25	e	Employment rate	0.89	0.89
s	OJS contact rate	0.91	EE^*	Employment-Employment rate	0.014	0.010
θ	Market tightness	2.37	ce	Firm entry cost	0.110	0.110
b	Unempl. benefit	0.55	$b\bar{w}$	Unempl. repl. rate	0.677	0.677

Non-Target Parameters

Notation	Description	Data[†]	Model
$d\tilde{N}(.01)$	Employment level at $\delta^{**} = 0.01$ firm	0.951	0.959
$d\tilde{N}(.02)$	"	0.025	0.017
$d\tilde{N}(.03)$	"	0.013	0.010
$d\tilde{N}(.05)$	"	0.009	0.011
$d\tilde{N}(.08)$	"	0.003	0.003

[†]Estimations are made for the subgroup analyzed. *EE rate by trimester.

**For the calibration, δ's are multiplied by 4, and calculations are for trimesters instead of months.

5.1 Model Fit

The model also does a good job of matching some non-targeted moments of the data.

The article by Corseuil and Pessoa Araujo [2017] contains a summary of the most relevant variables from Bahia, Brazil, in 2010. In that paper, we can see that the turnover rate and the separation rate vary considerably across establishments, and they vary even more for the subgroup studied in this paper 25- to 55-year-old males working in the private sector with at most a high school degree.

It is intuitive to think that firms' and workers' characteristics influence the wage. In this section, I show that high-turnover firms offer lower wages to workers, and I compare the results from the data with the model predictions. Consider the following panel regression:[16]

$$ln \ w_{it} = \alpha_i + \mathbb{I}(\delta_{J(it)}bin) + \mathbb{I}(Year_t) + \phi_{J(it)} + \beta X_{it} + \epsilon_{it}. \tag{10}$$

We have $i = 1, ..., I$ individuals and $j = 1, ..., J$ firms observed over $t = 1, ..., T$ time periods (years). Let $j = J(it)$ denote the firm where worker i is employed at period t. The variable $ln \ w_{it}$ is the dependent variable, and it is the log of the hourly wage of worker i in period t. The variable α_i is the individual fixed effect, and $\phi_{J(it)}$ is the firm fixed effect. The variable $\delta_{J(it)}bin$ is the correspondent bin of the δ of the firm j. Any given firm j only has one separation rate δ_j and one fixed effect ϕ_j; however, each δ bin is composed of many firms. The variable $Year_t$ is a dummy for the year, and X_{it} is the worker tenure at time t. Finally, ϵ_{ijt} is the statistical error term.

The results from the panel model described by equation (10) are summarized in Appendix A.5, Table 6. The results show that wages are decreasing and convex with the firm separation rate. For example, *ceteris paribus*, in 2010 a worker that works in a firm with δ equal to 0.01 will have in expectation an 8% higher wage than if the worker was working for a firm with δ equal to 0.06 (the average hourly wage for the subgroup in 2010 is R\$5.07[17]).

Figure 3 plots the effect of the firm separation rate on wages found in the data and predicted in the model. Figure 4 plots the distribution of employment across firm type predicted by the model and estimated from the data. We can conclude that the model does a good job in matching the data.

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[16]For simplicity, I use the word *firm* instead of *establishment*; however, the regressions are at the establishment level.

[17]R\$ is the Brazilian currency reais

Figure 3: Comparing the Effect of δ on Wages[†] Estimated from the Data and the Model.
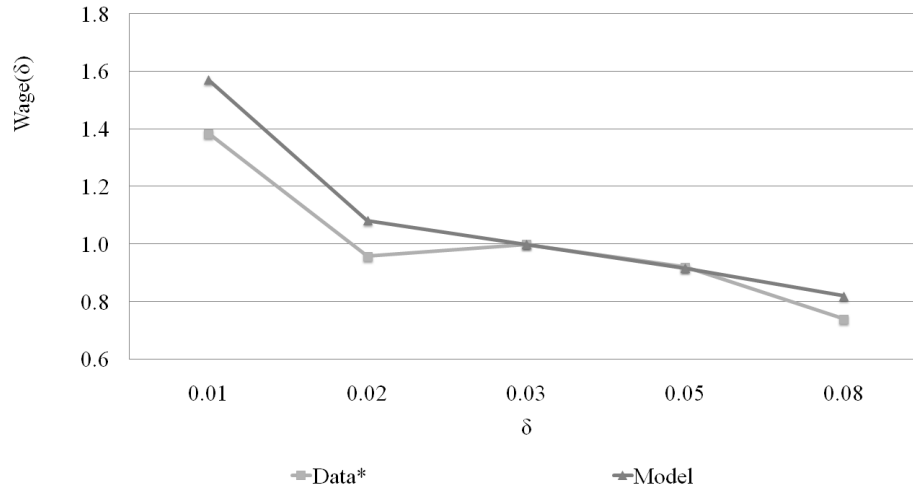
[†]Wage of $\delta = .03$ is normalized to 1. [*]β's are estimated using only data for the subgroup, the results of the regression in Appendix A.5, Table 6.

Figure 4: Comparing the Employment Distribution across Firm Types Generated by the Model with Estimates from the Data[†].
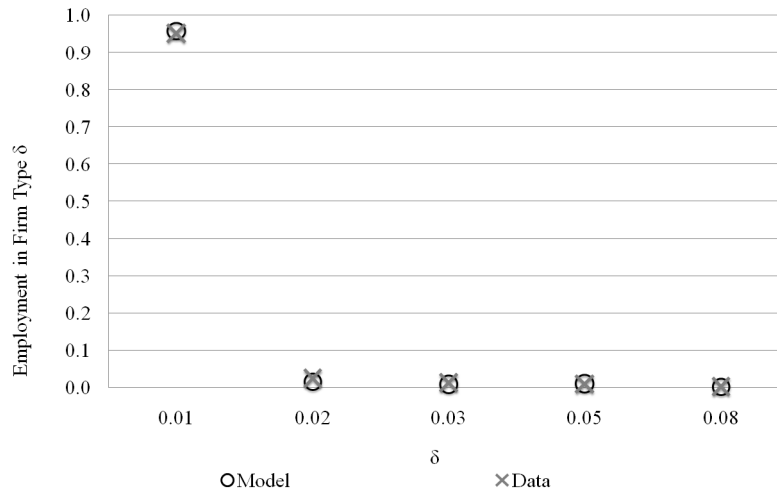
[†]Estimations are made for the subgroup.

5.2 Numerical Experiment: Firing Cost and Wage Inequality

The main experiment is to gradually lower the firing cost until $\tau=0$ and compare the implications of such a reform across the economy. Table 3 describes the change in equilibrium outcomes when the firing costs are completely removed. We can note that for workers in low-wage jobs with greater layoff rates (higher δ's), wages increase disproportionately more than for workers with more secure jobs (lower δ's). Therefore, by taking into account layoff heterogeneity, my model shows how firing costs amplify wage inequality. As a result, the variance in wages falls 26% when the firing cost is removed, dropping from 0.005 to 0.003. One important note is that while I focus on the wage variance, every other measure of wage inequality yields similar results. The p95-p5 wage ratio also drops 4.4%, diminishing from 1.45 to 1.39. Without the firing cost, the employment rate increases by 0.2 percentage point, going from 89.2% to 89.4%. The employment gains are more concentrated among firms with lower turnover rates; however, these changes are very small. When firing costs are repealed, the market tightness decreases by 1.3%. All of the results are described in detail in Table 7 in Appendix A.6.

Table 3: Comparing Baseline Model with the Removal of the Firing Cost

| δ^*	Baseline Model		Model w/o Tax	
	$dN(\delta)$	$w(\delta)$	$dN(\delta)$	$w(\delta)$
0.01	0.959	0.924	0.960	0.953
0.02	0.017	0.636	0.017	0.686
0.03	0.010	0.588	0.009	0.652
0.05	0.011	0.538	0.011	0.627
0.08	0.003	0.482	0.003	0.600
e	0.892		0.894	
θ	2.366		2.335	
wp95-p5	1.45		1.39	
Relative $var(w)$	1.00		0.74	

*δ's are multiplied by 4 since the calculations are for a 4-month period.

Figure 5 is central to the main result of the paper. It plots the impact of the gradual removal of firing costs on wages across each possible exogenous layoff rate δ. The graph illustrates that for workers in low-wage jobs with greater layoff rates, wages always increase disproportionately more than for workers with more secure jobs, independent of the size of the tax break. The utilities are also disproportionately distorted with the firing cost, as we can see in Figure 6. However, the scale of this distortion in the utilities is much smaller. When the firing costs are completely removed, the total increase in workers' welfare is 0.93%.

When 50% of the firing cost is removed, the firms that pay the lowest wages increase their wages by almost 11%, while the firms that pay the highest wages increase their wage by less than 2%. When the firing cost is completely removed, the lowest-paying firms increase their wage by more than 24%, while the highest-paying firms increase their wage by only 3.2%. The increase in wages also translates to increases in utilities. When the firing costs are removed, the utilities of the low-wage workers increases by 1.03%, going from 56.6 to 57.1. The utilities of the high-wage workers increase by 0.91%, going from 57.8 to 58.4.

On the firm side, the decrease in the firing cost affects different firm types in different ways. When the firing cost is removed, the value of the firms declines, with the exception of firms that have the highest layoff rates. The value of a match for a firm with the lowest layoff rate decreases by 1.1%, and this value for the firms with the highest layoff rate increases by 1.4%. However, the value of a match for the firms with the lowest firing rate is still more than twice the value of the firms with the highest firing rate.

Figure 5: Difference in the Equilibrium Wage for Each δ^* with Firing Cost Break
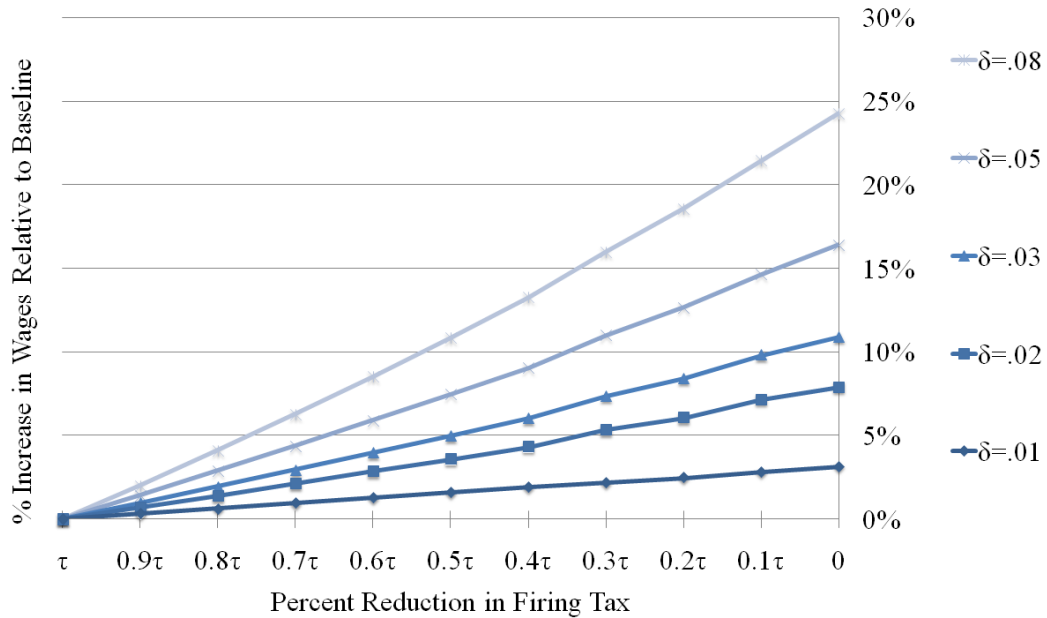
*δ's are multiplied by 4 in the calibration because it is used in a 4-month period.

Figure 6: Difference in the Equilibrium Utility for Each δ^* with Firing Cost Break
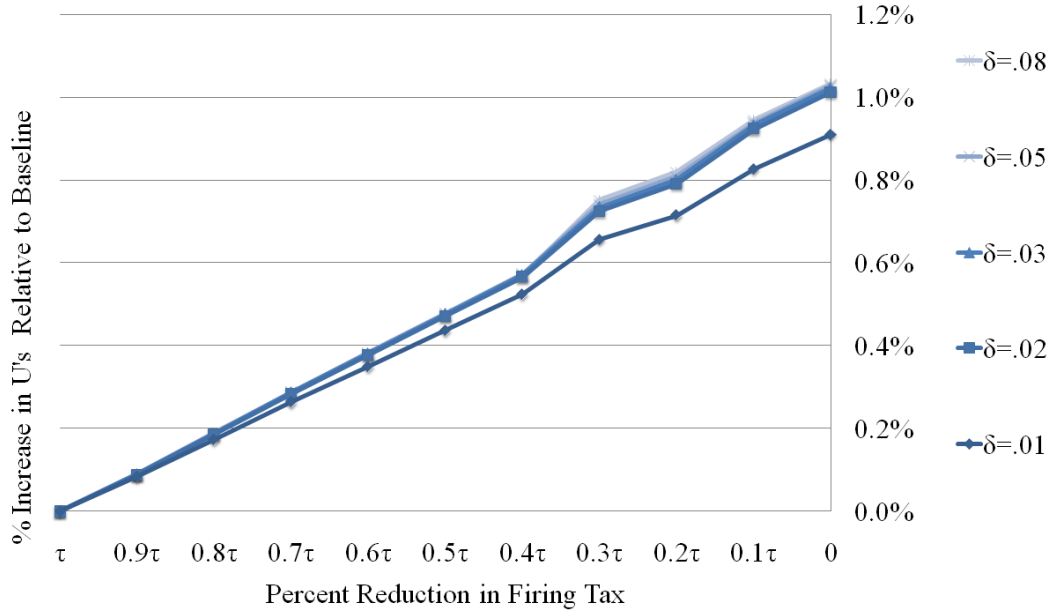
$^*\delta$'s are multiplied by 4 in the calibration because it is used in a 4-month period.

6   Robustness Checks

In this section, I show some robustness check exercises. First I compare the main experiment of the removal of the firing costs with a new experiment where I remove only the firing tax paid to the government. Second, I simulate the removal of firing costs assuming partial equilibrium and compare with the results of the general equilibrium.

Also, in Appendix A.7.3, I recalibrate the model using matching elasticity $\zeta = 0.5$, and I compare the results with the original calibration where I use $\zeta = 0.6$. We can notice that decreasing the matching elasticity to $\zeta = 0.5$ will cause small changes in the calibrated parameters s and A.

6.1 Simulation of the Removal of the Government Firing Tax

In Section 5.2, I simulate the removal of all of the firing costs: the firing tax that the firm pays to the government plus the lump-sum transfer that the firm pays to the worker as a form of severance payment. To analyze the distortion that the government tax has on wages and utilities, in this section I simulate the gradual removal only of the government tax and compare with the results when all costs are removed.

Figures 7 and 8 plot the equilibrium wages and utilities when the firing costs and firing taxes are partially and totally repealed. We can notice that by removing only the firing taxes, there will be very small changes in the wages; however, the utilities will increase much more. In particular, the complete removal of the government firing tax generates a 1% increase in all wages. In the previous experiment, where all of the firing costs were removed, the higher wages increased by 3% and the lower wages increased by 24%. This small increase in wages when the government tax is removed translates into a 0.7% increase in utilities, compared to a 1% increase in utilities when all of the firing costs were removed. We can conclude that most of the distortion in utilities comes from the government tax, since the severance payment enters in the present value of the workers' lifetime wage. The complete results of the simulations of the gradual removal of the government taxes are found in Table 8 in Appendix A.7.

Figure 7: Simulation of Removal of All Firing Costs and Government Tax: Comparing Wages
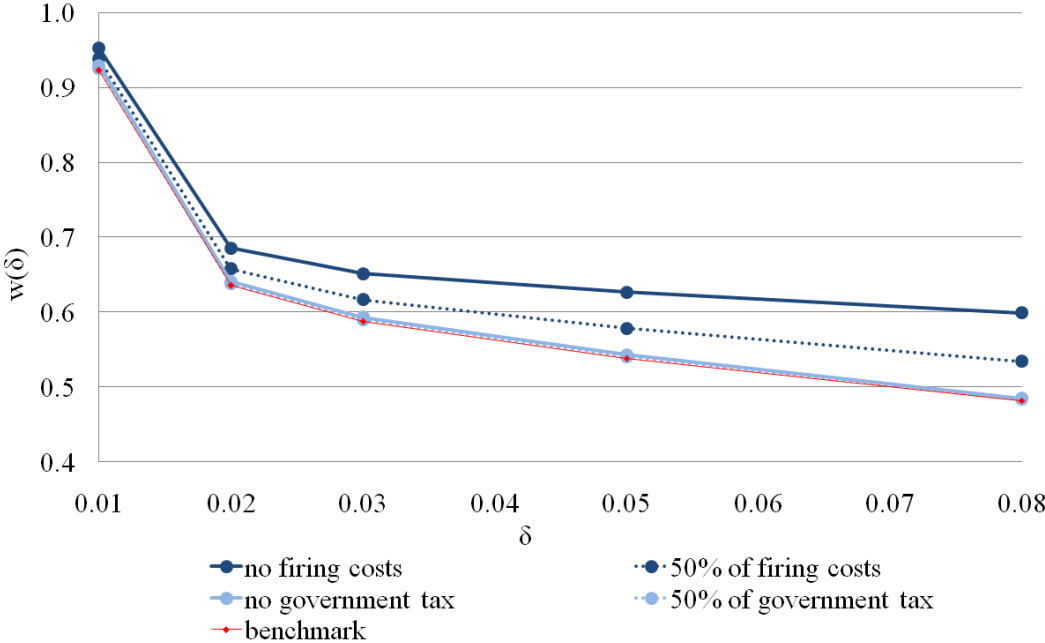
Figure 8: Simulation of Removal of All Firing Costs and Government Tax: Comparing Utilities
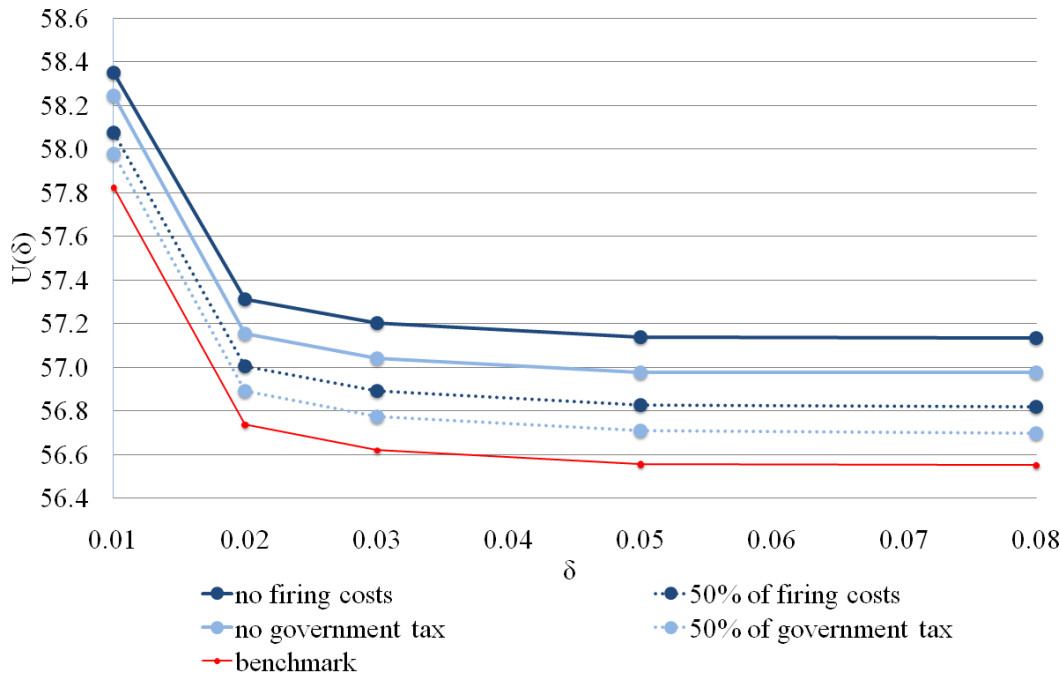
6.2 Impact of Firing Costs in Partial Equilibrium

To analyze the impact of the general equilibrium, I simulate the removal of the firing costs assuming partial equilibrium, and I compare with the results of the general equilibrium. In the simulation of the removal of firing costs assuming partial equilibrium, the firm free-entry condition does not necessarily hold anymore, and the market tightness is fixed and equal to θ found in the calibration of the benchmark model.

Table 4 shows the main results of the simulation of the removal of firing costs assuming general equilibrium and partial equilibrium, and compares it to the benchmark model. We can notice that the employment distribution remains almost the same across δ type firms; however, there is a slightly bigger increase in employment across the low firing rate firms

in the partial equilibrium model. The employment level increases by a small amount with the removal of the firing costs in both models. In particular, the employment level increases 0.2 percentage point if we assume general equilibrium, and the employment level increases 0.7% if we assume fixed θ. In both cases, the removal of firing costs generates roughly the same change in the wages and utilities (see Table 9 in Appendix A.7). The firm value of a match changes by the same amount when firing costs are removed, with exception of the low firing rate firms. The value of these firms does not change in the experiment with partial equilibrium.

Table 4: Results of the Simulation of the Removal of Firing Cost in General Equilibrium and Partial Equilibrium*.

		Simulation of the Removal of Firing Taxes			
	Baseline	**General Equilibrium**		**Partial Equilibrium**	
$\underline{d\tilde{N}}$**'s**			ΔBasel.		ΔBasel.
0.01	95.9%	96.0%	(0.2%)	96.2%	(0.3%)
0.02	1.7%	1.7%	(-0.1%)	1.6%	(-0.1%)
0.03	1.0%	0.9%	(0.0%)	0.9%	(-0.1%)
0.05	1.1%	1.1%	(0.0%)	1.0%	(-0.1%)
0.08	0.3%	0.3%	(0.0%)	0.3%	(0.0%)
V's			%ΔBasel.		%ΔBasel.
0.01	1.46	1.45	(-1.1%)	1.47	(0.1%)
0.02	1.15	1.11	(-3.2%)	1.11	(-3.3%)
0.03	1.00	0.98	(-2.3%)	0.98	(-2.4%)
0.05	0.82	0.82	(-0.8%)	0.81	(-0.9%)
0.08	0.64	0.65	(1.4%)	0.65	(1.0%)

*In the simulations in partial equilibrium, θ is fixed to be the one estimated in the calibration.

7 Conclusion

In this paper, I answer the following question: How much wage inequality in Brazil is caused by firing costs? To answer this question, I make two contributions. My first contribution is

to build a general equilibrium search model based on Burdett and Mortensen [1998] in which layoff rates differ among firms. Furthermore, I theoretically characterize the link between firing costs and wage dispersion in the model. My second contribution is to estimate the model and assess the impact of the firing costs on wage inequality. To do this, I use matched employer-employee data from Brazil to estimate the key parameters of my model.[18] With the estimated model in hand, I conduct my main experiment. I simulate a counterfactual removal of existing firing costs, and I find that residual wage inequality drops by 26% as measured by wage variance and by 4.4% as measured by the p95-p5 ratio among 25- to 55-year-old males working in the private sector with at most a high school degree. Worker welfare among this subgroup of households increases by almost 1% in response to the abolishment of firing costs.

In future research, I plan to consider the role of heterogeneity among workers as well as heterogeneity among firms in terms of productivity. The matched employer-employee data will allow me to consider the implications of labor market regulations on assortative matching and inequality. I also plan to analyze the impact of a minimum wage on equilibrium job flows. Existing studies such as Dube et al. [2016] find that minimum wages have a sizable negative effect on employment flows, especially among low-tenure workers.

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[18]What allows me to estimate the model and differentiate between layoffs versus separation due to OJS search is that the data explicitly record layoffs separately from quits. I can then use the data to estimate the distribution of layoff rates across firms. Using worker and firm fixed effects, I can actually parse out what fraction of a firm's layoff rate is due to worker characteristics versus firm characteristics.

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A Appendix

A.1 Algebra

Solving the Firm Maximization Problem: The firm maximization problem can be written as

$$V\left(\delta,U\right)=\max_{U}\frac{1-rU+\delta\left(U_{0}-U\right)+s\theta q(\theta)\left(\int_{U}^{\infty}\left(\tilde{U}-U\right)\left(\frac{e}{v}dG(\tilde{U})+\frac{v_{e}}{v}dH(\tilde{U})\right)\right)}{r+\delta-q(\theta)\left(\frac{se}{x}G\left(U\right)+\frac{u}{x}\right)+s\theta q(\theta)\left(\frac{e}{v}(1-G(U))+\frac{v_{e}}{v}(1-H(U))\right)}. \quad (11)$$

To solve the firm problem, take the first order condition with respect to U of equation (11) and set it equal to zero:

$$\left.\frac{\partial V\left(\delta,U\right)}{\partial U}\right|_{U^{*}}=\frac{-r-\delta+s\theta q(\theta)\left((U-U)\left(\frac{e}{v}g(U)+\frac{v_{e}}{v}h(U)\right)-\left(\frac{e}{v}(1-G(U))+\frac{v_{e}}{v}(1-H(U))\right)\right)}{r+\delta-q(\theta)\left(\frac{u}{x}+\frac{se}{x}G\left(U\right)\right)+s\theta q(\theta)\left(\frac{e}{v}(1-G(U))+\frac{v_{e}}{v}(1-H(U))\right)}$$

$$-\frac{\left(1-rU+\delta\left(U_{0}-U\right)+\frac{sq(\theta)}{x}\left(\int_{U}^{\infty}\left(\tilde{U}-U\right)\left(eg(\tilde{U})+v_{e}h(\tilde{U})\right)d\tilde{U}\right)\right)}{\left(r+\delta-q(\theta)\left(\frac{u}{x}+\frac{se}{x}G\left(U\right)\right)+s\theta q(\theta)\left(\frac{e}{v}(1-G(U))+\frac{v_{e}}{v}(1-H(U))\right)\right)^{2}}\times$$

$$\left(-q(\theta)\frac{se}{x}g\left(U\right)-s\theta q(\theta)\left(\frac{e}{v}g\left(U\right)+\frac{v_{e}}{v}h\left(U\right)\right)\right)=0$$

Substituting the fact that $\frac{\left(1-rU+\delta(U_{0}-U)+\frac{sq(\theta)}{x}\left(\int_{U}^{\infty}(\tilde{U}-U)\left(eg(\tilde{U})+v_{e}h(\tilde{U})\right)d\tilde{U}\right)\right)}{r+\delta-q(\theta)\left(\frac{u}{x}+\frac{se}{x}G(U)\right)+s\theta q(\theta)\left(\frac{e}{v}(1-G(U))+\frac{v_{e}}{v}(1-H(U))\right)}=V(\delta,U)$, we have that

$$-r-\delta-s\theta q(\theta)\left(\left(\frac{e}{v}\overline{G(U)}+\frac{v_{e}}{v}\overline{H(U)}\right)-\left(\frac{2e}{v}g(U)+\frac{v_{e}}{v}h(U)\right)V\left(\delta,U\right)\right)=0 \quad (12)$$

Implying in equation (13): $V\left(\delta,U\right)=\dfrac{r+\delta+s\theta q(\theta)\left(\frac{e}{v}(1-G(U))+\frac{v_{e}}{v}(1-H(U))\right)}{\frac{sq(\theta)}{x}\left(2eg\left(U\right)+v_{e}h\left(U\right)\right)}>0$

The firm optimal value is

$$V\left(\delta, U\right) = \frac{r + \delta + s\theta q(\theta)\left(\frac{e}{v}(1 - G(U)) + \frac{v_e}{v}(1 - H(U))\right)}{s\theta q(\theta)\left(\frac{2e}{v}g\left(U\right) + \frac{v_e}{v}h\left(U\right)\right)} > 0 \tag{13}$$

Equating the optimal value for the firm (equation (13)) with the value of the firm given by equation (3), we can pin down the optimal wage for each δ.

$$w^*(\delta) = 1 - \left(r + \delta - q(\theta)\left(\frac{se}{x}G(U(\delta)) + \frac{u}{x}\right) + s\theta q(\theta)\left(\frac{e}{v}(1 - G(U(\delta))) + \frac{v_e}{v}(1 - H(U(\delta)))\right)\right) \times$$

$$\frac{\left(r + \delta + s\theta q(\theta)\left(\frac{e}{v}(1 - G(U(\delta))) + \frac{v_e}{v}(1 - H(U(\delta)))\right)\right)}{s\theta q(\theta)\left(\frac{2e}{v}g(U(\delta)) + \frac{v_e}{v}h(U(\delta))\right)} \tag{14}$$

A.2 Proofs

Proof

of Corollary 2.1 Taking the derivative of the worker utility (equation(1)) with respect to w and δ respectively, we have

$$r\frac{dU(\delta,w)}{dw} = 1 - \delta\frac{dU(\delta,w)}{dw} - s\theta q(\theta)\frac{dU(\delta,w)}{dw}\left(\tilde{U}\bigg|_{U(\delta,w)} - U(\delta,w)\right)\left(\frac{e}{v}g(\tilde{U}\bigg|_{U(\delta,w)}) + \frac{v_e}{v}h(\tilde{U}\bigg|_{U(\delta,w)})\right)$$

$$- s\theta q(\theta)\int_{U(\delta,w)}^{\infty}\frac{dU(\delta,w)}{dw}\left(\frac{e}{v}g(\tilde{U}) + \frac{v_e}{v}h(\tilde{U})\right)d\tilde{U}$$

$$\Rightarrow \frac{dU(\delta,w)}{dw} = \frac{1}{r + \delta + s\theta q(\theta)\left(\frac{e}{v}(1 - G(U(\delta,w))) + \frac{v_e}{v}(1 - H(U(\delta,w)))\right)} > 0$$

$$r\frac{dU(\delta,w)}{d\delta} = U_0 - U(\delta,w) - \delta\frac{dU(\delta,w)}{d\delta} - s\theta q(\theta)\frac{dU(\delta,w)}{d\delta}\left(\tilde{U}\bigg|_{U(\delta,w)} - U(\delta,w)\right)\left(\frac{e}{v}g(\tilde{U}\bigg|_{U(\delta,w)}) + \frac{v_e}{v}h(\tilde{U}\bigg|_{U(\delta,w)})\right)$$

$$- s\theta q(\theta)\int_{U(\delta,w)}^{\infty}\frac{dU(\delta,w)}{d\delta}\left(\frac{e}{v}g(\tilde{U}) + \frac{v_e}{v}h(\tilde{U})\right)d\tilde{U}$$

$$\Rightarrow \frac{dU(\delta,w)}{d\delta} = \frac{-(U(\delta,w) - U_0)}{r + \delta + s\theta q(\theta)\left(\frac{e}{v}(1 - G(U(\delta,w))) + \frac{v_e}{v}(1 - H(U(\delta,w)))\right)} \leq 0$$

Proof

of Lemma 2.4 The firm growth rate is

$$\frac{dn_f(\delta_i)/dt}{n_f(\delta_i)} = -\delta_i - s\theta q(\theta)\left(\frac{e}{v}(1 - G(U(\delta_i))) + \frac{v_e}{v}(1 - H(U(\delta_i)))\right) + q(\theta)\left(\frac{se}{x}G(U(\delta_i)) + \frac{u}{x}\right)$$

Implying that the growth rate decreases with the firm separation rate δ_i:

$$\frac{\partial\left(\frac{dn_f(\delta_i)/dt}{n_f(\delta_i)}\right)}{\partial\delta_i} = -1 + s\theta q(\theta)\left(\frac{e}{v}g(U(\delta_i)) + \frac{v_e}{v}h(U(\delta_i))\right)\underset{(-)}{\frac{dU(\delta_i)}{d\delta_i}} + q(\theta)\frac{se}{x}g(U(\delta_i))\underset{(-)}{\frac{dU(\delta_i)}{d\delta_i}} < 0$$

∎

Proof

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of Proposition 3.1 With the introduction of a firing cost, the worker continuation value can be written as

$$rU(\delta, w) = w + \delta \left(U_0 + \tau w - U(\delta, w)\right) + s\theta q(\theta) \int_{U(\delta,w)}^{\infty} \left(\tilde{U} - U(\delta, w)\right) \left(\frac{e}{v}g(\tilde{U}) + \frac{v_e}{v}h(\tilde{U})\right) d\tilde{U}$$

The continuation value of an unemployed worker remains the same as before. The continuation value per worker for a firm with δ that promises a utility level U for its workers is

$$rV(\delta, U) = 1 - w - \delta \left(V(\delta, U) + \tau w\right) + q(\theta) \left(\frac{se}{x}G(U) + \frac{u}{x}\right) V(\delta, U)$$
$$- s\theta q(\theta) \left(\frac{e}{v}(1 - G(U)) + \frac{v_e}{v}(1 - H(U))\right) V(\delta, U) \tag{15}$$

The firm maximization problem with the tax is

$$V(\delta, U) = \max_{w} \frac{1 - w(1 + \tau\delta)}{r + \delta - q(\theta)\left(\frac{se}{x}G(U) + \frac{u}{x}\right) + s\theta q(\theta)\left(\frac{e}{v}(1 - G(U)) + \frac{v_e}{v}(1 - H(U))\right)}$$

$$s.t. \quad rU(\delta, w) = w + \delta \left(U_0 + \tau w - U(\delta, w)\right) + s\theta q(\theta) \int_{U(\delta,w)}^{\infty} \left(\tilde{U} - U(\delta, w)\right) \left(\frac{e}{v}g(\tilde{U}) + \frac{v_e}{v}h(\tilde{U})\right) d\tilde{U} \quad (PK)$$

$$\Rightarrow$$

$$V(\delta, U) = \max_{U} \frac{1 - rU + \delta \left(U_0 - U\right) + s\theta q(\theta) \int_{U(\delta,w)}^{\infty} \left(\tilde{U} - U(\delta, w)\right) \left(\frac{e}{v}g(\tilde{U}) + \frac{v_e}{v}h(\tilde{U})\right) d\tilde{U}}{r + \delta - q(\theta)\left(\frac{se}{x}G(U) + \frac{u}{x}\right) + s\theta q(\theta)\left(\frac{e}{v}(1 - G(U)) + \frac{v_e}{v}(1 - H(U))\right)} \tag{16}$$

The last line in the equation above implies that the firm maximization problem is analogous to the problem without firing cost shown in the previous section. Therefore, the first order condition and the firm optimal value are the same as in the economy with no firing cost, equations (12) and (13), respectively. To obtain the equilibrium wage with the firing cost, we equate the optimal value for the firm, equation (13), with the new value of the firm,

equation (15):

$$w^{\tau}(\delta) = w^{\text{no firing cost}}(\delta) \frac{1}{1 + \tau\delta} \tag{17}$$

The firm entry condition is the same as before. The derivative of $V(\delta, U(\delta))$ with respect to δ, using the maximization problem of the firm, is the same as before with no tax since the firm problem is the same:

$$\frac{\partial V(\delta, U(\delta))}{\partial \tau} = \frac{dV(\delta, U(\delta))}{d\tau} + \overbrace{\frac{\partial V(\delta, U(\delta))}{\partial U(\delta)}}^{=0 \text{ at optimum}} \frac{dU(\delta)}{d\tau} = 0$$

Applying the implicit function theorem to the firm optimal solution of the profit maximization, $\frac{\partial V(\delta, U)}{\partial U} = 0$:

$$\frac{dU}{d\tau} = -\frac{\frac{\partial^2 V(\delta, U)}{\partial U \partial \tau}}{\frac{\partial^2 V(\delta, U)}{\partial^2 U}}$$

The first order condition $=0$ is the same as the one without tax:

$$\frac{\partial V(\delta, U)}{\partial U} = -r - \delta + s\theta q(\theta)\left(-\frac{e}{v}(1 - G(U)) - \frac{v_e}{v}(1 - H(U)) + \left(2\frac{e}{v}g(U) + \frac{v_e}{v}h(U)\right)V(\delta, U)\right) = 0$$

Taking the second derivative of $V(\delta, U)$ with respect to τ:

$$\frac{\partial^2 V(\delta, U)}{\partial U \partial \tau} = s\theta q(\theta)\left(2\frac{e}{v}g(U) + \frac{v_e}{v}h(U)\right)\underbrace{\frac{\partial V(\delta, U)}{\partial \tau}}_{=0} = 0$$

Substituting the derivatives found above into the equation from the implicit function theorem, we have that the worker utility does not change with τ: $\frac{\partial U}{\partial \tau} = 0$

Proof

of Corollary 3.2 Taking the derivative of the worker continuation value with respect to τ:

$$r\frac{dU(\delta)}{d\tau} = \frac{dw(\delta)}{d\tau}(1+\tau\delta) + \delta w(\delta) - \delta\frac{dU(\delta)}{d\tau}$$
$$+ s\frac{q(\theta)}{x}\left(U(\delta)\left(eg(U)+v_e h(U)\right) - \left(e\overline{G(U)}+v_e\overline{H(U)}\right) - U(\delta)\left(eg(U)+v_e h(U)\right)\right)\frac{dU(\delta)}{d\tau}$$

$$\text{Since: } \frac{dU(\delta)}{d\tau} = 0 \Rightarrow \qquad \frac{dw(\delta)}{d\tau} = -\frac{\delta w(\delta)}{(1+\tau\delta)} < 0$$

Taking the derivative of the worker continuation value with firing cost, with respect to δ:

$$r\frac{dU(\delta)}{d\delta} = \frac{dw^\tau(\delta)}{d\delta}(1+\tau\delta) + \tau w^\tau(\delta) + (U_0 - U(\delta)) - \delta\frac{dU(\delta)}{d\delta} - s\frac{q(\theta)}{x}U(\delta)\left(eg(U)+v_e h(U)\right)\frac{dU(\delta)}{d\delta}$$
$$s\theta q(\theta)\left(-\left(\frac{e}{v}(1-G(U)) + \frac{v_e}{v}(1-H(U))\right)\frac{dU(\delta)}{d\delta} + U(\delta)\left(\frac{e}{g}(U) + \frac{v_e}{v}h(U)\right)\frac{dU(\delta)}{d\delta}\right) \Rightarrow$$

$$\frac{dw^\tau(\delta)}{d\delta} = \frac{\overbrace{\frac{dU(\delta)}{d\delta}}^{(-)}\left(r+\delta+s\theta q(\theta)\left(\frac{e}{v}(1-G(U)) + \frac{v_e}{v}(1-H(U))\right)\right) + U(\delta) - U_0 - \tau w(\delta)}{1+\tau\delta}$$

Since U is decreasing with δ, proven in Lemma 2.2 above, the highest δ firm will offer the smallest utility. Therefore, for the highest $\overline{\delta}$, $U(\overline{\delta}) = U_0$ implying that $\frac{dw^\tau(\delta)}{d\delta} < 0$ for this type of firm. By continuity, the inequality also holds for high δ firms. ∎

Proof

of Lemma 3.4

The first order condition of the firm maximization problem implies: $\frac{\partial V(\delta,U)}{\partial U} = 0$ and $\frac{\partial^2 V(\delta,U)}{\partial^2 U} < 0$ (guarantees a maximum). Using the envelope theorem we have:

$$\frac{\partial U(\delta)}{\partial \epsilon} = -\frac{\frac{\partial^2 V(\delta,U)}{\partial U \partial \epsilon}}{\underbrace{\frac{\partial^2 V(\delta,U)}{\partial^2 U}}_{(-)}} \tag{18}$$

The firm value can be written as:[19]

$$V\left(\delta,U\right) = \frac{1 - w(1+\delta\tau_f)}{r + \delta + s\theta q(\theta)\left(\frac{e}{v}\overline{G(U)} + \frac{v_e}{v}\overline{H(U)}\right) - \theta q(\theta)\left(\frac{se}{v}G(U) + \frac{u}{v}\right)}, \qquad \text{where}$$

$$w = \frac{U(\delta,w)\left(\delta + r + s\theta q(\theta)\left(\frac{e}{v}\overline{G(U)} + \frac{v_e}{v}\overline{H(U)}\right)\right) - s\theta q(\theta)\int\limits_{U(\delta,w)}^{\infty}\tilde{U}\left(\frac{e}{v}dG(\tilde{U}) + \frac{v_e}{v}dH(\tilde{U})\right) - \delta U_0}{1 + \delta\tau}$$

Let BT denote the bottom term of the firm value: $BT = r + \delta + s\theta q(\theta)\left(\frac{e}{v}\overline{G(U)} + \frac{v_e}{v}\overline{H(U)}\right) - \theta q(\theta)\left(\frac{se}{v}G(U) + \frac{u}{v}\right)$. Taking the derivative of the firm value with respect to U:

$$\frac{\partial V\left(\delta,U\right)}{\partial U} = \frac{\frac{\partial\left(1 - w(1+\delta\tau_f)\right)}{\partial U}BT - (1 - w(1+\delta\tau_f))\frac{\partial BT}{\partial U}}{BT^2} = -\frac{(1+\delta\tau_f)\frac{\partial w}{\partial U}BT + (1 - w(1+\delta\tau_f))\frac{\partial BT}{\partial U}}{BT^2}$$

Now taking the derivative with respect to ϵ:

$$\frac{\partial^2 V(\delta,U)}{\partial U \partial \epsilon} = BT^{-4} \times$$

$$\left(-\frac{\partial\left((1+\delta\tau_f)\frac{\partial w}{\partial U}BT + (1 - w(1+\delta\tau_f))\frac{\partial BT}{\partial U}\right)}{\partial \epsilon}BT^2 + \left((1+\delta\tau_f)\frac{\partial w}{\partial U}BT + (1 - w(1+\delta\tau_f))\frac{\partial BT}{\partial U}\right)\frac{\partial BT^2}{\partial \epsilon}\right)$$

Calculating the derivatives that are on the equation above, we have:

- $\frac{\partial w}{\partial U} = \frac{\delta + r + s\theta q(\theta)\left(\frac{e}{v}\overline{G(U)} + \frac{v_e}{v}\overline{H(U)}\right)}{1 + \delta\tau} > 0$

- $\frac{\partial BT}{\partial U} = -s\theta q(\theta)\left(2\frac{e}{v}g(U) + \frac{v_e}{v}h(U)\right) < 0$

- $\frac{\partial w}{\partial \epsilon} = \frac{\partial^2 w}{\partial U \partial \epsilon} = \frac{\partial BT}{\partial \epsilon} = \frac{\partial^2 BT}{\partial U \partial \epsilon} = 0.$

Substituting into $\frac{\partial^2 V(\delta,U)}{\partial U \partial \epsilon}$, we can see that this term is negative:[20]

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[19]$1 - G(U) = \overline{G(U)}$ and $1 - H(U) = \overline{H(U)}$, and note that $q(\theta)\left(\frac{se}{x}G(U) + \frac{u}{x}\right) = \theta q(\theta)\left(\frac{se}{v}G(U) + \frac{u}{v}\right)$

[20]Note that $\frac{\partial^2 V(\delta,U)}{\partial U \partial \epsilon} = -\frac{(1+\delta\tau_f)\left(\frac{\partial^2 w}{\partial U \partial \epsilon}BT + \frac{\partial w}{\partial U}\frac{\partial BT}{\partial \epsilon}\right) + \delta\frac{\partial w}{\partial U}BT - \left(\frac{\partial w}{\partial \epsilon}(1+\delta\tau_f) + w\delta\right)\frac{\partial BT}{\partial U} + (1 - w(1+\delta\tau_f))\frac{\partial^2 BT}{\partial U \partial \epsilon}}{BT^2} + $

$\frac{\left((1+\delta\tau_f)\frac{\partial w}{\partial U}BT + (1 - w(1+\delta\tau_f))\frac{\partial BT}{\partial U}\right)2\frac{\partial BT}{\partial \epsilon}}{BT^3}$

$$\frac{\partial^2 V(\delta,U)}{\partial U \partial \epsilon} = -\frac{\delta\left(BT\overbrace{\frac{\partial w}{\partial U}}^{(+)} - w\overbrace{\frac{\partial BT}{\partial U}}^{(-)}\right)}{BT^2} < 0$$

Substituting into equation (18): $\frac{\partial U(\delta)}{\partial \epsilon} = -\dfrac{\overbrace{\frac{\partial^2 V(\delta,U)}{\partial U \partial \epsilon}}^{(-)}}{\underbrace{\frac{\partial^2 V(\delta,U)}{\partial^2 U}}_{(-)}} < 0$

Now to analyze the relationship between θ and ϵ, we can also use the envelope theorem and write:

$$\frac{\partial \theta}{\partial \epsilon} = -\frac{\overbrace{\frac{\partial^2 V(\delta,U)}{\partial U \partial \epsilon}}^{(-)}}{\frac{\partial^2 V(\delta,U)}{\partial U \partial \theta}} \tag{19}$$

Taking the derivative of $\frac{\partial V(\delta,U)}{\partial U}$ with respect to θ:

$$\frac{\partial^2 V(\delta,U)}{\partial U \partial \theta} = \frac{-\frac{\partial\left((1+\delta\tau_f)\frac{\partial w}{\partial U}BT+(1-w(1+\delta\tau_f))\frac{\partial BT}{\partial U}\right)}{\partial \theta}BT^2 + \left((1+\delta\tau_f)\frac{\partial w}{\partial U}BT + (1-w(1+\delta\tau_f))\frac{\partial BT}{\partial U}\right)\frac{\partial BT^2}{\partial \theta}}{BT^4}$$

$$=$$

$$-\frac{BT^2\left((1+\delta\tau_f)\left(\frac{\partial^2 w}{\partial U \partial \theta}BT + \frac{\partial w}{\partial U}\frac{\partial BT}{\partial \theta}\right) - \frac{\partial w}{\partial \theta}(1+\delta\tau_f)\frac{\partial BT}{\partial U} + (1-w(1+\delta\tau_f))\frac{\partial^2 BT}{\partial U \partial \theta}\right)}{BT^4}$$

$$+\frac{\left((1+\delta\tau_f)\frac{\partial w}{\partial U}BT + (1-w(1+\delta\tau_f))\frac{\partial BT}{\partial U}\right)2BT\frac{\partial BT}{\partial \theta}}{BT^4}$$

Assume that $\frac{\partial q(\theta)}{\partial \theta} < 0$ and $\frac{\partial \theta q(\theta)}{\partial \theta} > 0$, an example of a matching function with these properties is $q(\theta) = \theta^{-\varsigma}$. Calculating the derivatives with respect to θ that are on the equation above we have:

- $\frac{\partial w}{\partial \theta} = \dfrac{-\frac{\partial s\theta q(\theta)}{\partial \theta}\int\limits_{U(\delta,w)}^{\infty} \tilde{U}\left(\frac{e}{v}dG(\tilde{U}) + \frac{v_e}{v}dH(\tilde{U})\right)}{1+\delta\tau} < 0$

- $\frac{\partial^2 w}{\partial U \partial \theta} = \dfrac{\frac{\partial s\theta q(\theta)}{\partial \theta}\left(\frac{e}{v}\overline{G(U)} + \frac{v_e}{v}\overline{H(U)}\right)}{1+\delta\tau} > 0$

- $\frac{\partial BT}{\partial \theta} = \frac{\partial s\theta q(\theta)}{\partial \theta} \left(\frac{e}{v}\overline{G(U)} + \frac{v_e}{v}\overline{H(U)} \right) - \frac{\partial \theta q(\theta)}{\partial \theta} \left(\frac{se}{v}G(U) + \frac{u}{v} \right)$

- $\frac{\partial^2 BT}{\partial U \partial \theta} = -\frac{\partial s\theta q(\theta)}{\partial \theta} \left(2\frac{e}{v}g(U) + \frac{v_e}{v}h(U) \right) < 0$

Rearranging $\frac{\partial^2 w}{\partial U \partial \theta}$[21] and substituting into $\frac{\partial BT}{\partial \theta}$, we can write $\frac{\partial BT}{\partial \theta}$ as a function of $\frac{\partial^2 w}{\partial U \partial \theta}$:
$\frac{\partial BT}{\partial \theta} = (1 + \delta\tau)\frac{\partial^2 w}{\partial U \partial \theta} - \frac{\partial \theta q(\theta)}{\partial \theta} \left(\frac{se}{v}G(U) + \frac{u}{v} \right)$. Also, rearranging BT [22] and substituting into
the derivative of the wage with respect to the utility, we can write $\frac{\partial w}{\partial U}$ as a function of BT:
$\frac{\partial w}{\partial U} = \frac{BT + q(\theta)\left(\frac{se}{x}G(U) + \frac{u}{x} \right)}{1 + \delta\tau}$. Substituting into $\frac{\partial^2 V(\delta, U)}{\partial U \partial \theta}$ we have[23]:

$$\frac{\partial^2 V(\delta, U)}{\partial U \partial \theta} =$$

$$-\frac{BT^2 \left((1 + \delta\tau_f)\left(\frac{\partial^2 w}{\partial U \partial \theta}BT + \frac{\partial w}{\partial U}\frac{\partial BT}{\partial \theta} \right) - \frac{\partial w}{\partial \theta}(1 + \delta\tau_f)\frac{\partial BT}{\partial U} + (1 - w(1 + \delta\tau_f))\frac{\partial^2 BT}{\partial U \partial \theta} \right)}{BT^4}$$

$$+\frac{\left((1 + \delta\tau_f)\frac{\partial w}{\partial U}BT + (1 - w(1 + \delta\tau_f))\frac{\partial BT}{\partial U} \right)2BT\frac{\partial BT}{\partial \theta}}{BT^4} =$$

$$-\frac{BT^2 \left((1 + \delta\tau_f)\frac{\partial^2 w}{\partial U \partial \theta}BT - (1 + \delta\tau_f)\frac{\partial w}{\partial \theta}\frac{\partial BT}{\partial U} + (1 - w(1 + \delta\tau_f))\frac{\partial^2 BT}{\partial U \partial \theta} \right)}{BT^4}$$

$$+\frac{(1 + \delta\tau_f)BT^2\frac{\partial w}{\partial U}\frac{\partial BT}{\partial \theta} + (1 - w(1 + \delta\tau_f))2BT\frac{\partial BT}{\partial U}\frac{\partial BT}{\partial \theta}}{BT^4} =$$

$$\frac{-BT^2(1 + \delta\tau_f)\frac{\partial^2 w}{\partial U \partial \theta}BT + BT^2(1 + \delta\tau_f)\frac{\partial w}{\partial \theta}\frac{\partial BT}{\partial U} - BT^2\left(1 - w(1 + \delta\tau_f) \right)\frac{\partial^2 BT}{\partial U \partial \theta}}{BT^4}$$

$$+\frac{(1 + \delta\tau_f)BT^2\frac{\partial w}{\partial U}\frac{\partial BT}{\partial \theta} + (1 - w(1 + \delta\tau_f))2BT\frac{\partial BT}{\partial U}\frac{\partial BT}{\partial \theta}}{BT^4} =$$

$$\frac{BT^2(1 + \delta\tau_f)\frac{\partial w}{\partial \theta}\frac{\partial BT}{\partial U} - BT^2\left(1 - w(1 + \delta\tau_f) \right)\frac{\partial^2 BT}{\partial U \partial \theta} + (1 - w(1 + \delta\tau_f))2BT\frac{\partial BT}{\partial U}\frac{\partial BT}{\partial \theta}}{BT^4}$$

$$+\frac{BT^2(1 + \delta\tau_f)\left(-\frac{\partial^2 w}{\partial U \partial \theta}BT + \frac{\partial w}{\partial U}\frac{\partial BT}{\partial \theta} \right)}{BT^4} =$$

---

[21]Rearranging $\frac{\partial^2 w}{\partial U \partial \theta} = \frac{\frac{\partial s\theta q(\theta)}{\partial \theta}\left(\frac{e}{v}\overline{G(U)} + \frac{v_e}{v}\overline{H(U)} \right)}{1 + \delta\tau}$ we have: $(1 + \delta\tau)\frac{\partial^2 w}{\partial U \partial \theta} = \frac{\partial s\theta q(\theta)}{\partial \theta}\left(\frac{e}{v}\overline{G(U)} + \frac{v_e}{v}\overline{H(U)} \right)$

[22]Rearranging BT we have: $r + \delta + s\theta q(\theta)\left(\frac{e}{v}\overline{G(U)} + \frac{v_e}{v}\overline{H(U)} \right) = BT + q(\theta)\left(\frac{se}{x}G(U) + \frac{u}{x} \right)$

[23]Note that we can write $\frac{\partial^2 V(\delta, U)}{\partial U \partial \theta} = \frac{BT^2(1 + \delta\tau_f)\frac{\partial w}{\partial \theta}\frac{\partial BT}{\partial U} + BT(1 - w(1 + \delta\tau_f))\left(-BT\frac{\partial^2 BT}{\partial U \partial \theta} + 2\frac{\partial BT}{\partial U}\frac{\partial BT}{\partial \theta} \right)}{BT^4}$ +
$\frac{BT^2(1 + \delta\tau_f)\left(-\frac{\partial^2 w}{\partial U \partial \theta}BT + \frac{\partial w}{\partial U}\frac{\partial BT}{\partial \theta} \right)}{BT^4}$

$$\frac{\partial^2 V(\delta, U)}{\partial U \partial \theta} =$$

$$\frac{BT^2(1+\delta\tau_f)\frac{\partial w}{\partial\theta}\frac{\partial BT}{\partial U} + BT\left(1 - w(1+\delta\tau_f)\right)\left(-BT\frac{\partial^2 BT}{\partial U \partial\theta} + 2\frac{\partial BT}{\partial U}\frac{\partial BT}{\partial\theta}\right)}{BT^4}$$

$$+ \frac{BT^2\frac{(1+\delta\tau_f)}{1+\delta\tau}\left(-\left(\frac{\partial BT}{\partial\theta} + \frac{\partial q(\theta)}{\partial\theta}\left(\frac{se}{x}G(U) + \frac{u}{x}\right)\right)BT + \left(BT + q(\theta)\left(\frac{se}{x}G(U) + \frac{u}{x}\right)\right)\frac{\partial BT}{\partial\theta}\right)}{BT^4} =$$

$$= \frac{BT^2(1+\delta\tau_f)\frac{\partial w}{\partial\theta}\frac{\partial BT}{\partial U}}{BT^4}$$

$$+ \frac{BT\left(1 - w(1+\delta\tau_f)\right)\left(-BT\frac{\partial^2 BT}{\partial U \partial\theta} + 2\frac{\partial BT}{\partial U}\left((1+\delta\tau)\frac{\partial^2 w}{\partial U \partial\theta} - \frac{\partial\theta q(\theta)}{\partial\theta}\left(\frac{se}{v}G(U) + \frac{u}{v}\right)\right)\right)}{BT^4}$$

$$+ \frac{BT^2(1+\delta\tau_f)\left(-\frac{\partial^2 w}{\partial U \partial\theta}BT + \frac{\partial w}{\partial U}\left((1+\delta\tau)\frac{\partial^2 w}{\partial U \partial\theta} - \frac{\partial\theta q(\theta)}{\partial\theta}\left(\frac{se}{v}G(U) + \frac{u}{v}\right)\right)\right)}{BT^4}$$

$$=$$

$$= \frac{BT^2(1+\delta\tau_f)\frac{\partial w}{\partial\theta}\frac{\partial BT}{\partial U} - BT^2\left(1 - w(1+\delta\tau_f)\right)\frac{\partial^2 BT}{\partial U \partial\theta}}{BT^4}$$

$$+ \frac{\left((1+\delta\tau)\frac{\partial^2 w}{\partial U \partial\theta} - \frac{\partial\theta q(\theta)}{\partial\theta}\left(\frac{se}{v}G(U) + \frac{u}{v}\right)\right)\left(BT + BT(1+\delta\tau_f)\left(-w2\frac{\partial BT}{\partial U} + \frac{\partial w}{\partial U}BT\right)\right)}{BT^4}$$

$$- \frac{BT^2(1+\delta\tau_f)\frac{\partial^2 w}{\partial U \partial\theta}BT}{BT^4}$$

$$=$$

$$\frac{BT^2(1+\delta\tau_f)\overbrace{\frac{\partial w}{\partial\theta}}^{(-)}\overbrace{\frac{\partial BT}{\partial U}}^{(-)} + BT\left(1 - w(1+\delta\tau_f)\right)\left(-BT\overbrace{\frac{\partial^2 BT}{\partial U \partial\theta}}^{()} + 2\overbrace{\frac{\partial BT}{\partial U}}^{(-)}\overbrace{\frac{\partial BT}{\partial\theta}}^{(+)}\right)}{BT^4}$$

$$+ \frac{BT^2\frac{(1+\delta\tau_f)}{1+\delta\tau}\left(\frac{se}{x}G(U) + \frac{u}{x}\right)\left(-BT\frac{\partial q(\theta)}{\partial\theta} + q(\theta)\frac{\partial BT}{\partial\theta}\right)}{BT^4}$$

$$\frac{\partial^2 V\left(\delta,U\right)}{\partial U \partial \epsilon} = -\frac{\delta\left(BT\ \overbrace{\frac{\partial w}{\partial U}}^{(+)} - w\ \overbrace{\frac{\partial BT}{\partial U}}^{(-)}\right)}{BT^2} < 0$$

Substituting into equation (19): $\dfrac{\partial U(\delta)}{\partial \epsilon} = -\dfrac{\overbrace{\partial\left(\dfrac{\partial V(\delta,U)}{\partial U}\right)/\partial \epsilon}^{(-)}}{\underbrace{\dfrac{\partial^2 V(\delta,U)}{\partial^2 U}}_{(-)}} < 0$ ∎

A.3   Estimation of δ Distribution

Table 5 describes the estimated δ distribution. See the main text for details.

Table 5: Estimation of δ Distribution among Entrants[†] for the Years 2007[‡], 2008[‡], and 2009[‡].

| | Year the Firm Entered | | | |
| | 2007 | 2008 | 2009 | Average |
δ	$\Gamma(\delta)$	$\Gamma(\delta)$	$\Gamma(\delta)$	$\Gamma(\delta)$
0.00	0.143	0.134	0.155	0.144
0.01	0.122	0.098	0.120	0.114
0.02	0.090	0.095	0.121	0.102
0.03	0.106	0.109	0.105	0.107
0.04	0.071	0.078	0.070	0.073
0.05	0.062	0.063	0.059	0.061
0.06	0.047	0.051	0.054	0.050
0.07	0.041	0.041	0.041	0.041
0.08	0.025	0.033	0.028	0.029
0.09	0.040	0.033	0.028	0.034
0.10	0.026	0.027	0.022	0.025
0.11	0.014	0.036	0.024	0.025
0.12	0.018	0.035	0.010	0.021
0.13	0.019	0.019	0.025	0.021
0.14	0.010	0.015	0.015	0.013
0.15	0.012	0.010	0.016	0.013
0.16	0.020	0.013	0.008	0.014
0.17	0.013	0.013	0.012	0.013
0.18	0.005	0.004	0.019	0.009
0.19	0.008	0.004	0.003	0.005
0.20	0.005	0.008	0.012	0.008
0.21	0.006	0.004	0.005	0.005
0.22	0.010	0.004	0.010	0.008
0.23	0.008	0.004	0.003	0.005
0.24	0.004	0.008	0.001	0.004
0.25	0.011	0.021	0.008	0.013
0.26	0.006	0.006	0.001	0.004
0.27	0.017	0.004	0.001	0.007
0.28	0.001	0.003	0.001	0.002
0.29	0.001	0.004	0.003	0.003
0.30	0.004	0.002	0.002	0.003
0.31	0.001	0.001	0.001	0.001
0.32	0.001	0.001	0.001	0.001
0.33	0.003	0.005	0.004	0.004
0.34	0.003	0.002	0.001	0.002
0.35 or higher	0.027	0.012	0.010	0.017

[†]Source: RAIS, Bahia, Brazil, 2007-2010.

[‡] δ estimated is the monthly average between the first two years of the firm.

A.4 Calibration with Discrete Time and δ's

For the estimation and calibration part of this paper, I assume that the time interval and the firm job destruction rate are discrete. The time interval is given by Δt and the firm destruction rate is denoted by δ_i where $i = 1, 2, ..., N$, assuming that $\delta_1 < \delta_2 < ... < \delta_N$.

In Brazilian labor law, in order for the firm to fire the worker, the firm must pay 40% of the FGTS to the worker and 10% of the FGTS to the government. This means that if the firm has to pay x to fire the worker, the firm must also pay $0.25x$ to the government. Let τ denote the proportion of the worker's wage that the firm has to pay the worker to fire him (this amount is equivalent to the one in the data estimated in Section 4.1). Therefore, for the firm to fire the worker, the firm must pay $\tau_f = (1 + 0.25)\tau$ times the worker's monthly wage.

A.4.1 Solution of Worker and Firm Problems

In Lemma 2.2 it is proven that the worker's utility in equilibrium is decreasing with δ. Since $\delta_1 < \delta_2 < ... < \delta_N$, it must be the case that $U(\delta_1) > U(\delta_2) > ... > U(\delta_N)$. Let $\tilde{g}(U)$ denote $\tilde{g}(U) = \frac{e}{v}g(U) + \frac{v_e}{v}h(U)$. Also, let $U(\delta_i, w)$ denote the value of a worker employed in a firm with destruction rate δ_i that pays w, $U_i = U(\delta_i, w)$ is given by,

$$
\begin{aligned}
U_i =& w(\delta_i, U_i)\Delta t + \delta_i \left(U_0 + \tau w(\delta_i, U_i)\right) \frac{\Delta t}{1 + r\Delta t} \\
& + s\theta q(\theta) \sum_{\tilde{U}} \max\left\{\tilde{U}, U_i\right\} \tilde{g}(\tilde{U}) \frac{\Delta t}{1 + r\Delta t} + \left(1 - \left(\delta_i + s\theta q(\theta)\right)\Delta t\right) U_i \frac{1}{1 + r\Delta t} \quad (20)
\end{aligned}
$$

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Call $w(\delta_i, U_i) = w_i^*$. We can rewrite equation (20) as:[24]

$$U_i = \frac{w_i^*(1 + \tau\delta_i + r\Delta t) + \delta_i U_0 + s\theta q(\theta) \sum\limits_{\tilde{U}=U_1}^{U_i} \tilde{U}\tilde{g}(\tilde{U})}{r + \delta_i + s\theta q(\theta)\left(1 - \tilde{G}(U_{i+1})\right)} \tag{21}$$

Using equation (20) to write U_{i+1} and rearranging, we can write $\sum\limits_{\tilde{U}=U_1}^{U_i} \tilde{U}\tilde{g}(\tilde{U})$ as a function of U_{i+1}.[25] Substituting into equation (21) we can write U_i as a function of U_{i+1} and U_0:

$$U_i = \frac{w_i^*(1 + \tau\delta_i + r\Delta t) - w_{i+1}^*(1 + \tau\delta_{i+1} + r\Delta t)}{r + \delta_i + s\theta q(\theta)\left(1 - \tilde{G}(U_{i+1})\right)}$$

$$+ \frac{(\delta_i - \delta_{i+1})U_0 + U_{i+1}\left(r + \delta_{i+1} + s\theta q(\theta)\left(1 - \tilde{G}(U_{i+1})\right)\right)}{r + \delta_i + s\theta q(\theta)\left(1 - \tilde{G}(U_{i+1})\right)} \tag{22}$$

The value of an unemployed worker is given by:

$$U_0 = b\Delta t + \left(\theta q(\theta)\Delta t \sum\limits_{all\tilde{U}} \tilde{U}\tilde{g}(\tilde{U}) + \left(1 - \theta q(\theta)\Delta t\right)U_0\right)\frac{1}{1 + r\Delta t} \tag{23}$$

The firm with the highest δ, (δ_N), will pay a wage such that the worker is indifferent between accepting or not accepting the job, $U_N = U_0$:

---

[24] $\sum\limits_{\tilde{U}} \max\left(\tilde{U}, U_i\right)\tilde{g}(\tilde{U}) = \sum\limits_{\tilde{U}=U_1}^{U_i} \max\left(\tilde{U}, U_i\right)\tilde{g}(\tilde{U}) + \sum\limits_{\tilde{U}=U_{i+1}}^{U_N} \max\left(\tilde{U}, U_i\right)\tilde{g}(\tilde{U}) = \sum\limits_{\tilde{U}=U_1}^{U_i} \tilde{U}\tilde{g}(\tilde{U}) + U_i\tilde{G}(U_{i+1})$.

[25] $U_{i+1} = \left(w_{i+1}^*(1 + \tau\delta_{i+1} + r\Delta t) + \delta_{i+1}U_0 + s\theta q(\theta) \sum\limits_{\tilde{U}=U_1}^{U_i} \tilde{U}\tilde{g}(\tilde{U})\right) / \left(r + \delta_{i+1} + s\theta q(\theta)\left(1 - \tilde{G}(U_{i+1})\right)\right)$.

$$U_N = \frac{w_N^*(1 + \tau\delta_N + r\Delta t) + \delta_N U_0 + s\theta q(\theta) \sum_{all\tilde{U}} \tilde{U}\tilde{g}(\tilde{U})}{r + \delta_N + s\theta q(\theta)\left(\frac{e}{v} + \frac{v_e}{v}\right)}$$

Substituting $\theta q(\theta)\sum_{all\tilde{U}}\tilde{U}\tilde{g}(\tilde{U}) = U_0\left(r + \theta q(\theta)\right) - b(1 + r\Delta t)$ from equation (23), we get

$$w_N^* = \frac{sb(1 + r\Delta t) + (1 - s)rU_0}{1 + \tau\delta_N + r\Delta t}. \tag{24}$$

Let $V(\delta_i, U_i)$ denote the value per worker of a firm with δ_i that promises a utility level U_i for its workers. $V_i = V(\delta_i, U_i)$ is given by,

$$V_i = (1 - w_i^*)\Delta t - \delta_i \tau_f w_i^* \frac{\Delta t}{1 + r\Delta t} + q(\theta)\left(\left(\frac{se}{x}G(U_{i+1}) + \frac{u}{x}\right)2V_i + \frac{se}{x}\overline{G(U_{i+1})}V_i\right)\frac{\Delta t}{1 + r\Delta t}$$

$$+ s\theta q(\theta)\tilde{G}(U_i)V_i\frac{\Delta t}{1 + r\Delta t} + \left(1 - \left(\delta_i + q(\theta) + s\theta q(\theta)\right)\Delta t\right)V_i\frac{1}{1 + r\Delta t}$$

The incentive-compatibility constraint of the firm (IC) must guarantee that the firm prefers to offer U_i associated with her specific δ_i, than a lower (higher) utility level $U_{i+1} < U_i$ ($U_{i-1} > U_i$) associated with $\delta_{i+1} > \delta_i$ ($\delta_{i-1} < \delta_i$). The firm's first IC constraint is $V_i \geq V(\delta_i, U_{i+1})$, implying[26]:

$$w_i^* \leq \frac{(1 + r\Delta t)(1 - Z_{i,i+1}^{\delta_i}) + w(\delta_i, U_{i+1})(1 + \tau_f\delta_i + r\Delta t)Z_{i,i+1}^{\delta_i}}{1 + \tau_f\delta_i + r\Delta t}, \tag{25}$$

---

[26] $\dfrac{1 + r\Delta t - w_i^*(1 + \tau_f\delta_i + r\Delta t)}{r + \delta_i - q(\theta)\left(\frac{se}{x}G(U_{i+1}) + \frac{u}{x}\right) + s\theta q(\theta)\left(1 - \tilde{G}(U_i)\right)} \geq \dfrac{1 + r\Delta t - w(\delta_i, U_{i+1})(1 + \tau_f\delta_i + r\Delta t)}{r + \delta_i - q(\theta)\left(\frac{se}{x}G(U_{i+2}) + \frac{u}{x}\right) + s\theta q(\theta)\left(1 - \tilde{G}(U_{i+1})\right)}$

where $Z_{i,i+1}^{\delta_i} = \dfrac{r + \delta_i - q(\theta)\left(\frac{se}{x}G\left(U_{i+1}\right) + \frac{u}{x}\right) + s\theta q(\theta)\left(1 - \tilde{G}(U_i)\right)}{r + \delta_i - q(\theta)\left(\frac{se}{x}G\left(U_{i+2}\right) + \frac{u}{x}\right) + s\theta q(\theta)\left(1 - \tilde{G}(U_{i+1})\right)} \in (0,1). \quad (26)$

The wage that guarantees a utility of U_{i+1} for a worker employed in a firm with exogenous destruction rate δ_{i+1} and δ_i, respectively, is:

$$w(\delta_i, U_{i+1}) = \frac{U_{i+1}\left(r + \delta_i + s\theta q(\theta)\left(1 - \tilde{G}(U_{i+2})\right)\right) - \delta_i U_0 - s\theta q(\theta) \sum\limits_{\tilde{U}=U_1}^{U_{i+1}} \tilde{U}\tilde{g}(\tilde{U})}{(1 + \tau\delta_i + r\Delta t)}$$

$$w_{i+1}^* = \frac{U_{i+1}\left(r + \delta_{i+1} + s\theta q(\theta)\left(1 - \tilde{G}(U_{i+2})\right)\right) - \delta_{i+1} U_0 - s\theta q(\theta) \sum\limits_{\tilde{U}=U_1}^{U_{i+1}} \tilde{U}\tilde{g}(\tilde{U})}{(1 + \tau\delta_{i+1} + r\Delta t)}$$

Subtracting $w(\delta_i, U_{i+1})(1 + \tau\delta_i + r\Delta t)$ from $w_{i+1}^*(1 + \tau\delta_{i+1} + r\Delta t)$ [27] and substituting $w(\delta_i, U_{i+1})(1 + \tau\delta_i + \Delta t)$ into equation (25), we can write the optimal worker wage in firm δ_i, w_i^*, as a function of the optimal wage in firm δ_{i+1}, w_{i+1}^*:

$$w_i^* \leq \frac{(1 + r\Delta t)\left(1 - Z_{i,i+1}^{\delta_i}\right)}{1 + \tau_f\delta_i + r\Delta t} + \frac{\left(w_{i+1}^*(1 + \tau\delta_{i+1} + r\Delta t) + (\delta_i - \delta_{i+1})(U_{i+1} - U_0)\right) Z_{i,i+1}^{\delta_i}}{1 + \tau\delta_i + r\Delta t}$$

$$(27)$$

---

[27] $w(\delta_i, U_{i+1})(1 + \tau\delta_i + r\Delta t) - w_{i+1}^*(1 + \tau\delta_{i+1} + r\Delta t) = (\delta_i - \delta_{i+1})(U_{i+1} - U_0)$

Symmetrically, the second IC constraint for the firm is $V_i \geq V(\delta_i, U_{i-1})$, implying

$$w_i^* \leq \frac{(1 + r\Delta t)\left(1 - Z_{i,i-1}^{\delta_i}\right)}{1 + \tau_f \delta_i + r\Delta t} + \frac{\left(w_{i-1}^*(1 + \tau \delta_{i-1} + r\Delta t) + (\delta_i - \delta_{i-1})(U_{i-1} - U_0)\right) Z_{i,i-1}^{\delta_i}}{1 + \tau \delta_i + r\Delta t}.$$

Finally, for a discrete δ the firm free-entry condition is given by:

$$E\{V_i\} = q(\theta) \sum_{all\ \delta_i} \left(\frac{se}{x}G(U(\delta_i)) + \frac{u}{x}\right)\gamma(\delta_i)V_i = c_e$$

Worker Flow: Since we are assuming that time and δ are discrete and $\delta_1 < \delta_2 < ... < \delta_N$, then $n_t(\delta_i) = N_t(\delta_i) - N_t(\delta_{i-1})$, $\gamma(\delta_i) = \Gamma(\delta_i) - \Gamma(\delta_{i-1})$ and the number of workers employed in a firm with δ evolves according to:

$$n_{t+1}(\delta_i) - n_t(\delta_i) = -\underbrace{\delta_i n_t(\delta_i)}_{\substack{\text{matches} \\ \text{that ends}}} + \underbrace{s\theta_t q(\theta_t)(e_t - N_t(\delta_i))\left(\frac{e_t}{v_t}\frac{n_t(\delta_i)}{e_t} + \frac{v_{et}}{v_t}\gamma(\delta_i)\right)}_{\substack{\text{employed workers hired} \\ \text{from highest } \delta \text{ firms and from new firms}}}$$

$$+ \underbrace{\theta_t q(\theta_t)u_t\left(\frac{e_t}{v_t}\frac{n_t(\delta_i)}{e_t} + \frac{v_{et}}{v_t}\gamma(\delta_i)\right)}_{\substack{\text{unemployed workers hired} \\ \text{from existing firms and from new firms}}} - \underbrace{s\theta_t q(\theta_t)n_t(\delta_i)\left(\frac{e_t}{v_t}\frac{N_t(\delta_{i-1})}{e_t} + \frac{v_{et}}{v_t}\Gamma(\delta_{i-1})\right)}_{\substack{\text{workers that left because found} \\ \text{job in existing firms or in new firms}}}$$

(28)

At equilibrium $n_{t+1}(\delta) = n_t(\delta) = n(\delta) =$, and $\theta_t = \theta$, $e_t = e$, $v_t = v$.... $\forall t$ [28]:

$$\gamma(\delta_i) = \frac{n(\delta_i)\left(sn(\delta_i) + \frac{x\delta_i}{q(\theta)} - x + 2sN(\delta_{i-1}) + sv_e\Gamma(\delta_{i-1})\right)}{v_e\left(x - sN(\delta_i)\right)}$$

(29)

---

[28] $\left(\frac{x}{q(\theta)}\delta_i - x + s(N(\delta_i) + N(\delta_{i-1}) + v_e\Gamma(\delta_{i-1}))\right)n(\delta_i) = (x - sN(\delta_i))v_e\gamma(\delta_i)$

OJS Rate: The total number of separations that occurs at every instant in time among employees working in firm type δ can be distinguished between two causes. The first is that the match is dissolved because of some exogenous shock (δ_i). The second is OJS: the worker leaves the job to go to a better job.

$$Total\ Separations_{(\delta_i)} = \underbrace{\delta_i n(\delta_i)}_{\text{separation due to exogenous shock}} + \underbrace{s\theta q(\theta)n(\delta_i)\left(\frac{N(\delta_{i-1})}{v} + \frac{v_e\Gamma(\delta_{i-1})}{v}\right)}_{\text{separation due to OJS}}$$

The fraction of total separation due to OJS of workers employed in firms of type δ is:

$$\frac{Separation\ Due\ To\ OJS}{Total\ Separation}(\delta_i) = \frac{s\theta q(\theta)\left(\frac{N(\delta_{i-1})}{v} + \frac{v_e\Gamma(\delta_{i-1})}{v}\right)}{\delta_i + s\theta q(\theta)\left(\frac{N(\delta_{i-1})}{v} + \frac{v_e\Gamma(\delta_{i-1})}{v}\right)}$$

Firm Growth:

$$dn_f(\delta_i)_{t+1} - n_f(\delta_i)_t = 0 \implies$$

$$-\delta_i - s\theta q(\theta)\left(\frac{e}{v}(1 - G(U(\delta_i))) + \frac{v_e}{v}(1 - H(U(\delta_i)))\right) + q(\theta)\left(\frac{se}{x}G(U(\delta_{i+1})) + \frac{u}{x}\right) = 0$$

A.4.2   Estimation Strategy

For the estimation of the model, I use estimated and non-estimated parameters from the data: δ and $\Gamma(\delta)$ (see Section 4.2), b, u, EE, τ, τ_f, c_e, ζ and r (see Section 4.1 for description and Table 1 in Section 5 for estimations). I assume a trimester period, and I let $\Delta t = 1$.

For the calibration, I estimate A and s to match targets of the data, in particular:

- Estimate the parameter A that makes the equilibrium of the model match the moments of the data: employment level.

- Estimate the parameter s that makes the equilibrium of the model match the moments of the data: employment-employment flow.

I) Create a grid over s and A, and calculate the equilibrium for each combination of (A, s):

Given (A, s): Algorithm used to find the equilibrium (*fsolve*): Calculate the equilibrium wages, market tightness, employment level, and unemployed worker utility for the economy.

(a) Guess w, θ, e, U_0, and b.

(b) Given the guesses, recover the employment distribution (dN, N) and the utilities $(U's)$.

- $N(\delta_N) = e$

- For $i = N, ..., 2$ recover $n(\delta_i)$ and $N(\delta_{i-1})$ using[29]
$$2n(\delta_i)^2 - n(\delta_i)\left(\frac{x\delta_i}{q(\theta)} - x + 2sN(\delta_i) + sv_e\Gamma(\delta_{i-1})\right) + \gamma(\delta_i)v_e\left(x - sN(\delta_i)\right) = 0 \text{ and}$$
$N(\delta_{i-1}) = N(\delta_i) - n(\delta_i).$

- $n(\delta_1) = N(\delta_1)$.

- $g(w(\delta_i)) = n(\delta_i)$ and G is the cumulative sum of $g(w(\delta_i))$ ordered by $w(\delta_i)$[30]

- $U_N = U_0$

- $U_1 = \frac{w_1(1+\tau\delta_1+r)+\delta_1 U_0}{r+\delta_1}$

---

[29]Comes from rearranging equation (29) and substituting $N(\delta_{i-1})$ for $N(\delta_i) - n(\delta_i)$.
[30]That is the inverse order of δ_i since $w(\delta_i) < w(\delta_{i-1})$.

- For $i = 2, ..., N-1$: $U_i = \dfrac{w_i(1+\tau\delta_i+r)+\delta_i U_0+s\theta q(\theta)\sum\limits_{j=1}^{i-1} U_j\tilde{g}(\delta_j)}{r+\delta_i+s\theta q(\theta)\left(1-\tilde{G}(\delta_i)\right)}$

(c) Given w, the firm incentive constraints must hold. Both of the IC's (equations (22), (24), and (27)) for the firms must hold for all wages.

(d) Given θ, the firm free-entry condition must hold.

- $FE(\theta) : \sum\limits_{i=1}^{N} q(\theta)V\left(\delta_i\right)\left(\frac{u}{x} + \frac{se}{x}G(U(\delta_i))\right)\gamma(\delta_i) \cong ce$.

(e) Given e, flow of employment-unemployment must hold.

- $\sum_i \delta_i dN(\delta_i) - \theta q(\theta)(1-e) = 0$

(f) Given U_0, worker indifference condition must hold for the worst job (highest δ).

- $w_N = \dfrac{sb(1+r)+(1-s)rU_0}{1+\tau\delta_N+r}$.

(g) Given b, the unemployment replacement rate must be the same as the data.

- $b = \sum_i w_i dN(\delta_i)b_{data}$.

II) Choose A and s to target moments of the data.

- Choose the parameter A to target the employment rate:

  Employment rate in equilibrium in the model $\cong$ Employment rate from data

- Choose the parameter s to target the flow of employment-employment rate:

  Employment-to-employment rate in equilibrium in the model $\cong$ Employment-to-employment rate from data

A.5   Comparing Model to Data: Regression Results

Table 6: Regression Results, Dependent Variable: Log of Hourly Wages[†].

	Subgroup Coef.	All Workers Coef.
$\delta < .015$	0.127	0.116
$.015 < \delta < .025$	-0.429	-0.489
$.025 < \delta < .035$	-0.396	-0.455
$.035 < \delta < .065$	-0.402	-0.456
$.065 < \delta < .095$	-0.415	-0.465
$\delta > .095^*$	0.000	0.000
Tenure	0.001	0.001
Constant	0.734	0.750
Worker FE	Yes	Yes
Firm FE	Yes	Yes
Year FE	Yes	Yes
SD of FE's		
Worker	0.45	0.51
Firm	0.36	0.36
Correlation	0.18	0.22
N. observations	8,796,135	17,959,501
N. categories worker	1,944,725	3,858,113
N. categories firm	206,075	277,288
F-statistic	20.26**	24.62**
R-squared	0.87	0.88
Adj R-squared	0.82	0.84
Root MSE	0.27	0.28

[†]RAIS, Bahia, Brazil, 2000-2010, private sector. *0.2% of workers are employed in firms with $\delta > .95$.
**Prob>F=0.00.

A.6 Main Experiment: Simulation of Removal of all Firing Costs (Severance Payment and Government Tax)

Table 7: Calibration and Main Experiment Results: Gradual Repeal of Firing Costs

Break	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	0%
Wages											
0.01	0.95	0.95	0.95	0.94	0.94	0.94	0.94	0.93	0.93	0.93	0.92
0.02	0.69	0.68	0.67	0.67	0.66	0.66	0.65	0.65	0.64	0.64	0.64
0.03	0.65	0.65	0.64	0.63	0.62	0.62	0.61	0.61	0.60	0.59	0.59
0.05	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.55	0.54
0.08	0.60	0.59	0.57	0.56	0.55	0.53	0.52	0.51	0.50	0.49	0.48
dN's											
0.01	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U's											
0.01	58.4	58.3	58.2	58.2	58.1	58.1	58.0	58.0	57.9	57.9	57.8
0.02	57.3	57.3	57.2	57.1	57.1	57.0	57.0	56.9	56.8	56.8	56.7
0.03	57.2	57.2	57.1	57.0	56.9	56.9	56.8	56.8	56.7	56.7	56.6
0.05	57.1	57.1	57.0	57.0	56.9	56.8	56.8	56.7	56.7	56.6	56.6
0.08	57.1	57.1	57.0	57.0	56.9	56.8	56.8	56.7	56.7	56.6	56.6
V's											
0.01	1.45	1.45	1.46	1.46	1.45	1.45	1.45	1.46	1.46	1.46	1.46
0.02	1.11	1.11	1.12	1.12	1.13	1.14	1.14	1.14	1.14	1.15	1.15
0.03	0.98	0.98	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.05	0.82	0.81	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
0.08	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.64	0.64
θ	2.34	2.34	2.34	2.34	2.34	2.34	2.35	2.35	2.36	2.36	2.37
Welfare	59.3	59.3	59.2	59.2	59.1	59.0	59.0	58.9	58.9	58.8	58.8

A.7 Robustness Check Results

A.7.1 Simulation of Removal of Government Tax

Table 8: Government Tax Experiment Results: Gradual Repeal of ONLY Firing Taxes

Break	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	0%
Wages											
0.01	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.92	0.92	0.92
0.02	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
0.03	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
0.05	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
0.08	0.49	0.49	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
dN's											
0.01	0.85	0.85	0.85	0.85	0.85	0.86	0.86	0.86	0.86	0.86	0.86
0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U's											
0.01	58.2	58.2	58.2	58.1	58.1	58.0	57.9	57.9	57.9	57.9	57.8
0.02	57.2	57.1	57.1	57.1	57.0	56.9	56.9	56.8	56.8	56.8	56.7
0.03	57.0	57.0	57.0	56.9	56.9	56.8	56.7	56.7	56.7	56.7	56.6
0.05	57.0	56.9	56.9	56.9	56.8	56.7	56.7	56.6	56.6	56.6	56.6
0.08	57.0	56.9	56.9	56.9	56.8	56.7	56.7	56.6	56.6	56.6	56.6
V's											
0.01	1.46	1.46	1.45	1.45	1.45	1.47	1.47	1.47	1.47	1.46	1.46
0.02	1.16	1.16	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
0.03	1.02	1.02	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01	1.00
0.05	0.85	0.85	0.84	0.84	0.84	0.83	0.83	0.83	0.83	0.82	0.82
0.08	0.68	0.68	0.67	0.67	0.67	0.66	0.66	0.65	0.65	0.65	0.64
θ	2.34	2.34	2.34	2.34	2.34	2.37	2.37	2.37	2.37	2.37	2.37
Welfare	59.2	59.2	59.1	59.1	59.1	58.9	58.9	58.9	58.9	58.8	58.8

Table 9: Results of the Simulation of the Removal of Firing Cost in General Equilibrium and Partial Equilibrium*

	Baseline	Simulation of the Removal of Firing Taxes			
		General Equilibrium		Partial Equilibrium	
Wages			%ΔBasel.		%ΔBasel.
0.01	0.92	0.95	(3.2%)	0.95	(2.9%)
0.02	0.64	0.69	(7.9%)	0.68	(7.6%)
0.03	0.59	0.65	(10.9%)	0.65	(10.7%)
0.05	0.54	0.63	(16.4%)	0.63	(16.2%)
0.08	0.48	0.60	(24.3%)	0.60	(24.3%)
U's			%ΔBasel.		%ΔBasel.
0.01	57.8	58.4	(0.91%)	58.2	(0.69%)
0.02	56.7	57.3	(1.01%)	57.2	(0.80%)
0.03	56.6	57.2	(1.02%)	57.1	(0.81%)
0.05	56.6	57.1	(1.03%)	57.0	(0.82%)
0.08	56.6	57.1	(1.03%)	57.0	(0.82%)

*In the simulations in partial equilibrium, θ is fixed to be the one estimated in the calibration.

A.7.2 Partial Equilibrium: Simulation of Removal of Firing Costs

A.7.3 Calibration Using Match Elasticity $\zeta = 0.5$

To measure the sensitivity of the model with respect to the assumption of the match elasticity $\zeta = 0.6$[31], I recalibrate the model using another common assumption in the literature of $\zeta = 0.5$ proposed initially by Shimer [2005]. Table 10 compares the results of these two calibrations assuming different ζ's and analyzes how well each of the calibrations matches the data.

We can notice that decreasing the matching elasticity to $\zeta = 0.5$ will cause small changes in the calibrated parameters s and A. In particular, using this new elasticity, the matching function parameter chosen to target the employment rate increases from $A = 0.25$ to $A =$

[31]Estimated by Menzio and Shi [2011].

0.27. And the on-the-job search intensity picked to match the employment-employment rate from the data decreases from $s = 0.91$ to $s = 0.88$. The non-target employment distribution across δ's also remains very similar and close to the data, and the equilibrium wages in the new calibration are also very similar to the old ones.

Table 10: Results of Calibrations Using Different Matching Elasticity ζ.

Parameter	$\zeta = 0.5$	$\zeta = 0.6$	Data
A	0.27	0.25	
s	0.88	0.91	
θ	2.46	2.37	
ve	1.31	1.28	
e	0.89	0.89	0.89
ce	0.11	0.11	0.11
EE	0.01	0.01	0.01
$\underline{d\tilde{N}'s}$			
0.01	95.3%	95.9%	95.1%
0.02	2.0%	1.7%	2.5%
0.03	1.1%	1.0%	1.3%
0.05	1.3%	1.1%	0.9%
0.08	0.4%	0.3%	0.3%
$\underline{w's}$			
0.01	0.94	0.92	
0.02	0.65	0.64	
0.03	0.60	0.59	
0.05	0.55	0.54	
0.08	0.49	0.48	
$mean(w)$	0.920	0.910	
$std(w)$	0.006	0.005	