Does Public Sector Employment Buffer the Minimum Wage Effects?*

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Abstract

This paper investigates the impact of a minimum wage policy in a labor market with a private and a public sector. For that purpose, we develop a two-sector search and matching model with minimum wage and heterogeneous workers in their human capital. We structurally estimate the model using data for Chile, a country with a large fraction of employment in the public sector and a binding minimum wage. Counterfactual analysis shows that institutional features of public sector employment reduce labor market frictions and mitigate the negative effect of the minimum wage on unemployment and welfare.

Keywords: Search frictions, public sector employment, minimum wage.
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1 Introduction

There are two interesting facts of labor markets in developing economies: first, the public sector accounts for a large fraction of employment (Mizala et al., 2011); and second, there is a

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large mass of workers earning wages around the minimum wage levels (Maloney and Mendez, 2004; Boeri et al., 2008; Boeri, 2012). The Chilean labor market is particularly interesting because its public sector is a large employer and the wages distributions in both the public and the private sectors have a large density around the minimum wage. The minimum wage in Chile is particularly relevant compared with other OECD countries[1]. Chile has a national minimum wage that applies to all workers between 18 and 65 years and it is adjusted once a year. Based on the sample of prime-age full-time urban employed male workers used in this paper, 13.5% of the workers are employed in the public sector. In addition, the minimum wage seems to be binding, as 31% and 18% of those employed in the private and the public sectors, respectively, earn up to 1.2 minimum wages.

This suggests that increases in the minimum wage not only have a direct impact on the wage bill in both sectors, but also affect employment in both sectors differently, if public sector vacancies are filled according to rules different from those applying to the private sector. Therefore, a question that arises is: To what extent does the existence of a public sector employer affect the impact of the minimum wage in the labor market? In particular, how would the minimum wage policy affect the labor market outcomes in an economy with private and public sector jobs? To explore these questions, we develop a search and matching model with private and public sector employment and a minimum wage policy. We then structurally estimate the model to match the Chilean data and perform different counterfactual and policy experiments in order to understand the main mechanisms driving our results.

Specifically, we introduce a minimum wage policy (Flinn, 2006, 2011) in a labor market model with private and public sectors and heterogeneous workers in their human capital level. In the model the labor market is segmented by human capital groups and search is random within each human capital segment. We assume that productivity is match specific. In other words, there is a productivity draw from a distribution of productivity when two parties meet in the private or the public sector. Depending on the productivity draw and the minimum wage, the match is realized or not and wages are eventually determined. If the minimum wage is binding but the productivity draw is such that it is in the interest of the parties to match, then the worker is paid the minimum wage. The match is not formed for low enough productivity levels, and the minimum wage is not binding and wages are determined by Nash Bargaining for high enough productivity levels. In the public sector the minimum productivity requirement is an exogenous policy parameter that can differ from

[1]See OECD (2018) report on minimum wages in OECD countries.

the minimum wage. We also follow the ideas of Gomes (2015) and Albrecht et al. (2017) to assume that the public sector wages can pay a premium over the private sector wages. A free entry condition determines private sector vacancies and public sector vacancies are determined according to an employment target in the public sector.

We estimate our model by maximum likelihood methods using Chilean data from the National Socio-Economic Characterization Survey (CASEN) of 2013 and the Social Protection Survey (SPS) of 2009-2015. We follow the standard identification strategies of Flinn and Heckman (1982) and Flinn (2006) to estimate a search model with endogenous contact rates using only supply side data. The estimation is performed in two steps and uses the fact that the model can be decoupled in two parts, the supply and the demand sides. We do this since we can exploit the fact that the only link in the model between both sides of the market are the contact rates.

The estimation results indicate that in the Chilean labor market workers meet with private sector vacancies more frequently than those of the public sector, that the public sector premium favors more unskilled workers, and that the hiring standards are by far less restrictive in the public sector than in the private sector. Our policy and counterfactual experiments suggest that a larger minimum wage increases low skilled workers' incentives to accept jobs in the public sector, where the hiring requirements and vacancies are not affected by the minimum wage policy and also the wage policy is more generous than in the private sector. As a result, the public sector employment acts as a buffer weakening the negative effects of the minimum wage on unemployment and welfare. Behind these results, we find that the less restrictive hiring rule has a large impact in explaining the buffer effect of public sector employment as we increase the minimum wage. On the contrary, the public sector wage policy reduces this buffer effect of public sector employment. The down side, of course, is that the existence of the public sector negatively affects the private sector productivity as the minimum wage increases.

There is a vast literature on the effects of the minimum wage on the labor market. Neumark and Wascher (2008) provide a thorough review of the literature and conclude that there is a lack of consensus on the employment effects of the minimum wage. This has motivated a resurgence of interest on this topic (Meer and West, 2016; Harasztosi and Lindner, 2019). Regarding the effect of the minimum wage on the public sector, the literature is restricted to a few empirical papers and it is also inconclusive (Lemos, 2007; Gindling and Terrell, 2007, 2009; Alaniz et al., 2011). To the best of our knowledge, there is no literature analyzing the effect of the minimum wage policy in an economy with a large employer like the public sector.

A few papers introduce public sector employment in search and matching models. Burdett (2011) and Bradley et al. (2017), develop search models with on-the-job search à la Burdett and Mortensen (1998) and public sector employment. Quadrini and Trigari (2007), Michaillat (2014), Gomes (2015), Albrecht et al. (2017), Gomes (2018) and Chassamboulli and Gomes (2018) use instead Diamond-Mortensen-Pissarides type models. None of these papers consider the effects of a minimum wage policy in a labor market with private and government sectors.

Our paper is related to Albrecht et al. (2017), a model with public and private sectors and a continuum of worker types. While they focus on the effects of public sector employment policies on the labor market, we focus instead on how the public sector affects the impact of the minimum wage policy on labor market outcomes. Additionally, we assume search markets are segmented by human capital groups, i.e. formal education levels. In this aspect, our model has some features of Chassamboulli and Gomes (2018), who also model a labor market with private firms and a public sector, where two types of workers search for jobs in markets segmented by education levels. While their paper focuses on the analysis of education decisions in the context of hiring and wage setting practices of the labor market, we focus on the impact of the minimum wage and assume an exogenous type distribution of workers. Like in Albrecht et al. (2017), Chassamboulli and Gomes (2018) and Gomes (2018) we assume public sector employment policies are exogenous.

The paper is organized as follows. In the next section, we present the model and characterize the equilibrium. In section 3, we discuss the estimation procedure and the identification strategy. We also present the estimation results and evaluate the model fit. Section 4 presents the results of policy and counterfactual experiments. Finally section 5 concludes.

2 The Model

The model used in this paper extends the basic Diamond, Mortensen and Pissarides model (DMP model, thereafter), like Pissarides (2000), in two directions. First, there are two sectors, the private and the public sectors. Private sector firms create vacancies and look for workers, and once a vacancy is filled a bargained wage is paid to the worker. On the contrary, in the public sector the government adjusts vacancies to reach a constant public employment target and workers are paid according to a premium over the private sector bargained wage. The second extension consists of introducing a legal minimum wage as in

Flinn (2006), which imposes a restriction to the bargaining process in both sectors.

2.1 Environment

Time is continuous and the economy is populated by a unit mass of workers, which are heterogeneous in their (observable) human capital levels h. We assume that there are H types of workers with an exogenous mass $\kappa(h)$ of type h workers, such that $\sum_{h=1}^{H} \kappa(h) = 1$. We also assume that there are no transitions across worker groups and that there are H segmented labor markets, one for each type of worker. The search process is random in all markets and only unemployed workers search for a job. We define the proportion of unemployed workers who are type h as $\eta(h)$. While unemployed, workers receive a flow value of $z(h)$, which can be interpreted as the utility (or disutility) of leisure, net of any unemployment benefits. Finally, agents discount the future at rate ρ.

There are two sectors in the economy, the private (p) and the public (g) sectors. Private sector firms and the government randomly search for workers in each human capital specific market and a match specific productivity is realized when they meet (ex-post heterogeneity). This productivity level is a draw from an exogenous distribution $x \sim G(x|h)$. It is constant for the duration of the job if both parties reach an agreement, and measures the quality of a match between a particular worker and its potential employee. While searching for workers, private sector firms pay a cost $c(h)$. This cost is zero for public sector vacancies.

Search frictions in each market are characterized by a constant returns to scale matching function $Q(v(h), u(h))$, where $u(h)$ is the unemployment rate and $v(h) = v_p(h) + v_g(h)$ is the total number of vacancies for h workers. On one hand, the number of public sector vacancies $v_g(h)$ is determined by the government to reach a public sector employment target; the implicit assumption is that the government has labor requirements of different worker types. On the other hand, the number of private sector vacancies $v_p(h)$ is endogenously determined by a standard free entry condition. Defining the h-th market tightness as $\theta(h) = \frac{v(h)}{u(h)}$ and the probability of meeting a private employer as $\phi(h) = \frac{v_p(h)}{v_p(h)+v_g(h)}$, we can characterize the arrival rates of prospective employers as $\alpha^p(h) = \phi(h)q(\theta(h))$ and $\alpha^g(h) = (1 - \phi(h))q(\theta(h))$ for the private and the public sectors, respectively. Additionally, the arrival rate of prospective employees in the h-th market is $\vartheta(h) = \frac{q(\theta(h))}{\theta(h)}$. Finally, job destruction is exogenous and happens at rates $\delta_p(h)$ and $\delta_g(h)$ in the private and the public sectors, respectively.

2.2 Value Functions

At any point in time, a type h worker can be in one of the following three states: unemployed, working for a private sector firm (private sector job) or working for the government (public sector job). Let $U(h)$ denote the value of unemployment for a type h worker, $N_p(x,h)$ denote the value of employment for a type h worker in a private sector job with match specific productivity x, and $N_g(x,h)$ denote the analogous of the previous value but for the case of a worker employed in a public sector job. Therefore, the flow value of an unemployed worker is given by

$$\rho U(h) = z(h) + \alpha^p(h) \int \max[N_p(x,h) - U(h), 0] dG(x|h) + \alpha^g(h) \int \max[N_g(x,h) - U(h), 0] dG(x|h). \tag{1}$$

While unemployed, type h workers receive a (dis)utility $z(h)$ and private and public sector jobs arrive at Poisson rates $\alpha^p(h)$ and $\alpha^g(h)$, respectively. If a private sector job arrives, a match specific productivity is realized and the job is formed if $N_p(x,h) > U(h)$. Analogously, if a public sector job arrives, the match is formed if $N_g(x,h) > U(h)$. The flow value of a type h worker employed in a sector s job with current productivity x can then be written as

$$\rho N_s(x,h) = w_s(x,h) + \delta_s(h)\left[U(h) - N_s(x,h)\right], \quad s = p, g. \tag{2}$$

In equation (2), the employee receives a wage rate $w_s(x,h)$ and a termination shock arrives at Poisson rate δ_s with $s = p, g$, with its consequent capital loss of $U(h) - N_s(x,h)$.

Private sector firms create vacancies, which can be filled or unfilled at any point in time. The production process occurs only if the vacancy is filled. Denoting the value of a filled and an unfilled vacancy as $J_p(x,h)$ and $V_p(h)$, respectively, we can write the flow value of a private sector job filled by a type h worker with current productivity x as

$$\rho J_p(x,h) = x - w_p(x,h) + \delta_p(h)\left[V_p(h) - J_p(x,h)\right]. \tag{3}$$

Productive matches generate a flow output per worker x and firms pay a wage rate $w_p(x,h)$. If the termination shock occurs, the vacancy becomes unfilled and there is a capital loss of $V_p(h) - J_p(x,h)$ to the firm. At this point, firms start their search process again. In turn, the flow value of an unfilled vacancy in the private sector is

$$\rho V_p(h) = -c(h) + \vartheta(h) \int \max[J_p(x,h) - V_p(h), 0] dG(x|h). \tag{4}$$

Firms with unfilled vacancies searching for workers pay a flow cost $c(h)$. The contact rate for firms in any h market occurs at Poisson rate $\vartheta(h)$ and a match is formed only if for any match specific productivity x we have that $J_p(x,h) > V_p(h)$.

Finally, in the case of the public sector we assume that the government has an employment rate target in each h market $e_g(h)$ and chooses the number of vacancies $v_g(h)$ to reach that goal. Therefore, the endogenous number of public sector vacancies will depend on the rest of the equilibrium objects of the model.[2]

2.3 Wages Determination

Wages in the private sector are determined by Nash Bargaining. Following Flinn (2006), the mandatory minimum wage (m) is incorporated as a side constraint in the worker-firm bargaining problem.[3] Therefore, wages are the solution of the following problem:

$$w_p(x,h) = \arg\max_{w\geq m} \left[N_p(x,h) - U(h)\right]^{\beta} \left[J_p(x,h) - V_p(h)\right]^{1-\beta}$$

where β is interpreted as the bargaining power of the worker.[4] The solution of the problem, ignoring the side constraint, is the standard wage equation, where workers are paid a weighted average (according to the bargaining power) between the match productivity and their outside option (the unemployment flow value):

$$w_p(x,h) = \beta x + (1-\beta)\rho U(h).$$

Under this wage rule, the productivity that would imply that the worker is paid exactly the minimum wage m is:

$$\widetilde{x}_p(h) = \frac{m - (1-\beta)\rho U(h)}{\beta}.$$

It is possible to identify two cases. On one hand, when $\widetilde{x}_p(h) \leq m$ it holds that $m \leq \rho U(h)$; therefore, all matches would generate wage offers higher than m and the solution to the constrained problem is the same as the unconstrained one. That is, the minimum wage

[2]Table A.1 in Appendix A.1 summarizes the notation of the value functions and the flow values in the different states of the labor market.

[3]An alternative wage determination scheme considered in the literature is wage posting (as in Burdett and Mortensen, 1998). However, with this scheme the equilibrium wage distribution is continuous and rules out mass points, something that is particularly restrictive in our case where there is an important mass of workers earning minimum wage in the Chilean labor market. This would not be problematic if the mass point at the minimum wage were not significant as it is the case in the Brazilian labor market (see Engbom and Moser, 2018).

[4]The Nash bargaining wage equation is equivalent to an outcome of a Bargaining game à la Rubinstein with alternating offers and complete information, in which the disagreement point and the outside option for the worker is the same. In this game, the minimum wage corresponds to a constraint of the offers that can be made.

is not binding because it is lower than the worker's outside option. On the other hand, when $\widetilde{x}_p(h) > m$ the minimum wage is binding and three sub-cases arise. First, in the interval $x \in [m, \widetilde{x}_p(h))$ the offers in the wage equation would be below the minimum wage, and therefore the minimum wage is binding and the firms pay m.[5] Second, for any $x \geq \widetilde{x}_p(h)$ the Nash bargaining wage equation determines the wage. Finally, no match will be formed for productivity draws such that $x < m$. Therefore, the complete wage schedule in the private sector is:

$$w_p(x,h) = \begin{cases} m & if\, x < \widetilde{x}_p(h) \\ \beta x + (1-\beta)\rho U(h) & otherwise \end{cases} \tag{5}$$

For the case of the public sector wages, we tried to keep a structure as simple as possible assuming, as in Gomes (2015), that workers in this sector are paid a premium $\varphi(x,h)$ over the private sector wage such that

$$w_g(x,h) = \varphi(x,h) + w_p(x,h),$$

where we assume that $\varphi(x,h)$ is skill and productivity specific. We further assume that $\varphi(x,h) = \lambda(h) - \nu(h)(x - \bar{x})$, where $\lambda(h)$ is the pure public sector premium, $\nu(h)$ captures the different valuation that the government may have on productivity according to the tasks performed by the public sector employees, and $\bar{x}$ is the average productivity. Considering these assumptions together with the Nash bargaining equation of the private sector, the public sector wage equation can be written as:

$$w_g(x,h) = [\lambda(h) + \nu(h)\bar{x}] + [\beta - \nu(h)]\, x + (1-\beta)\rho U(h).$$

This wage equation has a similar structure to the one assumed by Albrecht et al. (2017). In addition, it is also assumed that the government sets an exogenous minimum productivity level $\underline{x}(h) \geq 0$ as a hiring rule for public sector workers. We can also define the public sector productivity level such that the modified Nash bargained wage equals the minimum wage as:

$$w_g(\widetilde{x}_g(h), h) = m \Rightarrow \widetilde{x}_g(h) = \frac{m - [\lambda(h) + \nu(h)\bar{x}] - (1-\beta)\rho U(h)}{\beta - \nu(h).}$$

In terms of the impact of the mandatory minimum wage, the discussion is similar to the one for private sector workers. That is, the minimum wage is binding only if $\widetilde{x}_g(h) > m$ and three cases arise. First, the government pays m for productivity in the interval $x \in [\underline{x}(h), \widetilde{x}_g(h))$. Second, for any $x \geq \widetilde{x}_g(h)$ the wage equation of the public sector determines

[5] It is not difficult to show that if $\widetilde{x}_p(h) > m$ then $m > \rho U(h)$.

the wage. Finally, no match will be formed for productivity draws such that $x < \underline{x}(h)$. Thus, the complete wage schedule in the public sector is:

$$w_g(x,h) = \begin{cases} m & if\, x < \widetilde{x}_g(h) \\ [\lambda(h) + \nu(h)\bar{x}] + [\beta - \nu(h)]\, x + (1-\beta)\rho U(h) & otherwise \end{cases} \qquad (6)$$

These wage schedules are graphically shown in Figure 1 for the case $\lambda(h) > 0$ and $\nu(h) > 0$. These parameters will be estimated from the data.

2.4 Equilibrium

Depending on the values of the parameters and the size of the mandatory minimum wage, there are two possible cases in equilibrium in each market: (i) the minimum wage is not binding, and (ii) the minimum wage is binding. Both cases are discussed below.

2.4.1 No Binding Minimum Wage

In the case that it is not binding, the minimum wage is irrelevant because workers and firms will match depending on reservation productivities. In the private sector, the reservation productivity $x_p^*(h)$ satisfies $U(h) = N_p(x_p^*(h), h)$. Using wage equation (5) we have:

$$x_p^*(h) = \rho U(h). \qquad (7)$$

In a similar way, the public sector reservation productivity $x_g^*(h)$ satisfies $U(h) = N_g(x_g^*(h), h)$. Using wage equation (6) we have:

$$x_g^*(h) = \frac{\beta\rho U(h) - [\lambda(h) + \nu(h)\bar{x}]}{\beta - \nu(h)}. \qquad (8)$$

If $\lambda(h) < -\nu(h)\,[\rho U(h) + \bar{x}]$, then $x_g^*(h) < x_p^*(h)$; that is, the productivity requirements in the private sector are more stringent[6]. In other words, a "sufficiently" negative pure premium (provided that $\nu(h) > 0$) implies that the public sector has a less restrictive hiring rule (in terms of productivity). Using the reservation values $x_p^*(h)$ and $x_g^*(h)$ and definitions of $N_p(x,h)$, $N_g(x,h)$, $w_p(x,h)$ and $w_p(x,h)$ it is possible to rewrite equation (1) as:

$$\begin{aligned} \rho U(h) \;&=\; z(h) + \frac{\alpha^p(h)\beta}{\rho + \delta_p(h)} \int_{\rho U(h)} [x - \rho U(h)] dG(x|h) \\ &+\; \frac{\alpha^g(h)}{\rho + \delta_g(h)} \int_{\frac{\beta\rho U(h) - [\lambda(h)+\nu(h)\bar{x}]}{\beta - \nu(h)}} \left[[\lambda(h) + \nu(h)\bar{x}] + [\beta - \nu(h)]\, x - \beta\rho U(h)\right] dG(x|h) \end{aligned} \qquad (9)$$

[6]Additionally $x_g^*(h) \geq 0$ impose two restrictions on the wage equation parameters of the public sector: (1) $\beta > \nu(h)$ and (2) $\rho U(h) > \frac{\lambda(h)+\nu(h)\bar{x}}{\beta}$.

Note that these Bellman equations solve for the outside option values $\rho U(h)$, given $\alpha^p(h)$ and $\alpha^g(h)$ (or $\phi(h)$, $\theta(h)$). On the private sector firms' side, profit maximization requires that all rents from job creation in each market should be exhausted such that the value of an unfilled vacancy is zero, that is $V_p(h) = 0$. Using again the reservation values $x_p^*(h)$ and $x_g^*(h)$ and definitions of $N_p(x,h)$, $N_g(x,h)$, $w_p(x,h)$ and $w_p(x,h)$, this condition (also referred to as the free entry condition) implies:

$$c = \frac{\vartheta(h)\,(1-\beta)}{\rho + \delta_p(h)} \int_{\rho U(h)} [x - \rho U(h)]\, dG(x|h) \tag{10}$$

where $\vartheta(h) = \frac{q[\theta(h)]}{\theta(h)}$. This last equation solves for the market tightness, $\theta(h)$, given $\rho U(h)$ (together $\phi(h)$).

2.4.2 Binding Minimum Wage

The case of a binding minimum wage occurs when $x_p^*(h) \leq m$, where $x_p^*(h)$ is the reservation productivity in the non-binding minimum wage case. According to the previous discussion on wage determination, a match will be formed in the private sector if and only if the productivity draw is greater than the minimum wage. If that is the case, workers earn the minimum wage if their productivity is in the interval $[m, \widetilde{x}_p(h))$, with $\widetilde{x}_p(h) = \frac{m-(1-\beta)\rho\tilde{U}(h)}{\beta}$. We use $\rho\tilde{U}(h)$ instead of $\rho U(h)$ to denote the flow unemployment value for the case in which the minimum wage is binding. If productivity is greater than $\widetilde{x}_p(h)$ the wage rate is defined by the Nash bargaining wage equation (the second case in equation 5).

Meanwhile, a match will be formed in the public sector if the match-specific productivity draw is greater than the hiring minimum productivity $\underline{x}(h)$. Public sector minimum wage earners have productivity in the range $[\underline{x}(h), \widetilde{x}_g(h))$, where $\widetilde{x}_g(h) = \frac{m-[\lambda(h)+\nu(h)\bar{x}]-(1-\beta)\rho\tilde{U}(h)}{\beta-\nu(h)}$ is such that $w_g(\widetilde{x}_g(h), h) = m$. For productivity greater than $\widetilde{x}_g(h)$, wages are determined according to the public sector wage equation (the second case in equation 6). It is easy to show that if $\rho\tilde{U}(h) < m$, then $\widetilde{x}_g(h) > x_g^*(h)$.

Regarding $\underline{x}(h)$, we leave this parameter free and estimate its value from the data. Taking into account what we previously described, it is possible to modify the value function of unemployment in the following way:

$$
\begin{aligned}
\rho\tilde{U}(h) = z(h) + \frac{\alpha^p(h)}{\rho+\delta_p(h)} \int_m^{\widetilde{x}_p(h)} \left(m - \rho\tilde{U}(h)\right) dG(x|h) \qquad (11)\\
+ \frac{\alpha^p(h)\beta}{\rho+\delta_p(h)} \int_{\widetilde{x}_p(h)} \left(x - \rho\tilde{U}(h)\right) dG(x|h) + \frac{\alpha^g(h)}{\rho+\delta_g(h)} \int_{\underline{x}(h)}^{\widetilde{x}_g(h)} \left(m - \rho\tilde{U}(h)\right) dG(x|h)\\
+ \frac{\alpha^g(h)}{\rho+\delta_g(h)} \int_{\widetilde{x}_g(h)} \left([\lambda(h) + \nu(h)\bar{x}] + [\beta - \nu(h)]\, x - \beta\rho U(h)\right) dG(x|h)
\end{aligned}
$$

with $\widetilde{x}_p(h) = \frac{m-(1-\beta)\rho\tilde{U}(h)}{\beta}$ and $\widetilde{x}_g(h) = \frac{m-[\lambda(h)+\nu(h)\bar{x}]-(1-\beta)\rho\tilde{U}(h)}{\beta-\nu(h)}$. These Bellman equations solve for $\rho\tilde{U}(h)$, given $\alpha^p(h)$ and $\alpha^g(h)$ (or $\phi(h)$, $\theta(h)$).

The free entry condition is also modified taking into account the fact that the minimum wage is now binding:

$$
c \;=\; \frac{\vartheta(h)}{\rho+\delta_p(h)} \left[\int_m^{\widetilde{x}_p(h)} (x - m)\, dG(x|h) + (1-\beta) \int_{\widetilde{x}_p(h)} \left(x - \rho\tilde{U}(h)\right) dG_h(x|h) \right] \qquad (12)
$$

where $\widetilde{x}_p(h) = \frac{m-(1-\beta)\rho\tilde{U}(h)}{\beta}$ and $\vartheta(h) = \frac{q(\theta(h))}{\theta(h)}$. Therefore, the last equation solves for $\theta(h)$, given $\rho U(h)$ (together with $\phi(h)$).

2.4.3 Steady State Conditions

To close the model we use the notion of steady state equilibrium, that is the in-flows and the out-flows of each state are equalized:

$$
\begin{aligned}
\delta_p(h)e_p(h) &= \phi(h)q(\theta(h))\widetilde{G}(\max\{m, x_p^*(h)\}|h)u(h) \qquad (13)\\
\delta_g(h)e_g(h) &= (1-\phi(h))\, q(\theta(h))\widetilde{G}(\max\{\underline{x}(h), x_g^*(h)\}|h)u(h)\\
u(h) + e_p(h) + e_g(h) &= 1
\end{aligned}
$$

where $\widetilde{G}(\cdot) = 1 - G(\cdot)$. Note that the equations in (13) cover the two cases previously described depending on whether the reservation productivities $x_p^*(h)$ and $x_g^*(h)$ are higher or lower than the hiring rule in the case of binding minimum wage, m and $\underline{x}(h)$ for the private and public sectors, respectively. Solving the above-mentioned system of equations, it is possible to find a closed form solution for the unemployment and the employment rates in both sectors:

$$
\begin{aligned}
u(h) &= \frac{\delta_p(h)\delta_g(h)}{\Xi(h)}\\
e_p(h) &= \frac{\delta_g(h)\phi(h)q(\theta(h))\widetilde{G}(\max\{m, x_p^*(h)\}|h)}{\Xi(h)}\\
e_g(h) &= \frac{\delta_p(h)\,(1-\phi(h))\, q(\theta(h))\widetilde{G}(\max\{\underline{x}(h), x_g^*(h)\}|h)}{\Xi(h)}
\end{aligned}
$$

where

$$\Xi(h) = \delta_p(h)\delta_g(h) + \delta_g(h)\phi(h)q(\theta(h))\widetilde{G}(\max\{m, x_p^*(h)|h\}).$$
$$+ \delta_p(h)\,(1-\phi(h))\,q(\theta(h))\widetilde{G}(\max\{\underline{x}(h), x_g^*(h)\}|h)$$

Finally, the proportion of private sector vacancies can be written as a function of the unemployment rate, the labor market tightness and the vacancy rate in the public sector:

$$\phi(h) = \frac{u(h)\theta(h) - v_g(h)}{u(h)\theta(h)} \tag{14}$$

where $v_g(h)$ is chosen to target a level of $e_g(h)$ in each h market. Using these ingredients, we define the model equilibrium as follows:

Definition. Given a distribution of human capital levels $\{\kappa(h)\}_{h=1}^{H}$, a vector of parameters $(z(h), \rho, \beta, c(h), \delta_p(h), \delta_g(h), \lambda(h), \nu(h), m, \underline{x}(h))$, a matching function $q(\theta(h))$, and probability distribution functions for the productivity $G(x|h)$, a steady-state equilibrium in the economy with private and public sectors and a mandatory minimum wage is a labor market tightness $\theta(h)$ and a proportion of vacancies in the private sector $\phi(h)$, together with the unemployment flow values $\rho U(h)$ (or $\rho\tilde{U}(h)$), the unemployment rate $u(h)$ and the employment rates $e_p(h)$ and $e_g(h)$ for all H markets such that:

(i) Given $\phi(h)$ and $\theta(h)$, and therefore $\alpha^p(h)$ and $\alpha^g(h)$, $\rho U(h)$ solves equation (9) if the minimum wage is not binding and $\rho\tilde{U}(h)$ solves equation (11) if the minimum wage is binding.

(ii) Given $\phi(h)$, $\theta(h)$ solves equation (10) if the minimum wage is not binding and equation (12) if the minimum wage is binding, and it is consistent with $\rho U(h)$ (or $\rho\tilde{U}(h)$) obtained in (i).

(iii) $\phi(h)$ solves equation (14), using the steady state conditions in (13), and it is consistent with $\rho U(h)$ (or $\rho\tilde{U}(h)$) and $\theta(h)$ obtained in (i) and (ii).

In definition, the prevailing equilibrium in every h market, with or without binding minimum wage, is determined by comparing the flow value of unemployment $\rho U(h)$ in the non-binding minimum wage equilibrium with the mandatory minimum wage m. If $\rho U(h) < m$, then the minimum wage is binding in the market for workers with human capital level h. The solution algorithm directly follows the equilibrium definition and it is presented in Appendix A.2.

3 Estimation

This section describes the data used in the structural estimation of the model, the estimation method and the identification strategy. We estimate the model using maximum likelihood methods exploiting the possibility to decouple the supply and demand sides of the model. To identify the primitive parameters of the model we use the standard identification strategies given by Flinn and Heckman (1982) and Flinn (2006). At the end of this section, we present the estimation results and analyze the fit of the model.

3.1 Data

We estimate the model for the Chilean labor market using a cross-section household survey, which is representative at the national level, namely the Socio-Economic Characterization Survey (CASEN).[7] We use the survey of 2013. In one of the fragments of this survey, people are asked about their labor market status, as well as their monthly labor income and hours worked in the week prior to the survey. Additionally, the survey contains information on individual characteristics such as gender, age and education.

Since the only source of ex-ante heterogeneity is the human capital level and there are no participation decisions in the model, it is necessary to impose a number of restrictions on the sample to ensure, to a certain degree, that those assumptions hold in the data. First, we define two groups of workers according to their human capital levels: skilled workers, defined as workers with at least a university degree; and unskilled workers, defined as those without a university degree.[8] Second, in Chile the female participation rate is low (below 50%) compared to their male counterpart (around 75%). Therefore, in our sample, we use only male participants in the labor market.[9] Third, given that the mandatory minimum wage affects different age groups in the population in different ways, we are interested in keeping in the sample only those who we believe are more likely to be structurally affected by this policy. Consequently, our sample is comprised of males aged between 25 and 55 years. Finally, we consider in our sample only full-time formal employees in both sectors, private

[7]The survey is conducted by the Ministry of Social Development since 1985 with a biennial or triennial frequency.

[8]We estimated the model under different grouping schemes and combinations (no education, primary education, secondary education, technical degree and university degree or more). The best fit to the aggregated wages distribution by sector was reached by separating the sample only into two groups, skilled and unskilled. See details in Appendix B.1.

[9]In Appendix B.3 we present the results of the estimation with a sample that pooled males and females. The estimation results are very similar as it will be discussed in the next section.

and public, who have an explicit job contract; hence, we exclude informal and self-employed workers from our sample. As a result of these data restrictions, the sample is reduced to 25,459 workers.

The sample size was further reduced due to problems with the data. On one hand, individuals with missing information on education, unemployment durations, hours worked or wages were eliminated, resulting in a reduction of 24,8% of the valid sample observations. On the other hand, to avoid the effect of outliers in the estimation we dropped the upper and lower one percentile of the wages distribution by sector, resulting in 6.8% less observations. Thus, after these adjustments, the final sample consists of 17,827 individuals. An additional adjustment to the data was necessary because some observations were below the mandatory minimum wage.[10] As in Flinn (2006) and Silva (2007), for the cases of the United States and Chile, respectively, we impute the minimum wage in the case of those who earn less than the minimum wage (almost 10%). After the imputation, around 21% of the unskilled workers earn minimum wage in the final sample, while less than 0.5% of the skilled workers wages earn minimum wage.[11]

In addition, for the identification strategy (described below) we need information on transitions from unemployment to employment in each sector (private and public). Since CASEN is a cross-section survey, it does not contain that type of information as individuals are observed either employed in the private sector, employed in the public sector or unemployed. To fill this data gap, we use the Social Protection Survey (2009, 2012 and 2015 waves)[12] as an additional source of information.[13] This survey contains longitudinal data on labor market histories (status in the labor market, types of jobs for employed workers, and wages), which allow us to identify the destination sector of individual exits from unemployment spells. It is important to mention that we do not attempt to estimate the model using the Social Protection Survey because the data is not only self-reported but also retrospective, and therefore may be subject to large measurement errors. We use CASEN instead because its sample size is larger and more accurate as the data is self-reported but not retrospective.

To summarize, the data available for the model estimation are: (1) distribution of worker

[10]Note that these observations are probability zero outcomes, conditional on the model.

[11]In Chile, the mandatory minimum wage is defined on a monthly basis. Therefore, we used the legal working week of 45 hours to calculate the hourly minimum wage.

[12]The survey is conducted by the Micro-data Center of the Economics Department at the University of Chile with the participation of academics of the University of Pennsylvania and the University of Michigan.

[13]We pooled together three waves to ensure an adequate sample size and to avoid the data being affected by the political cycles of hiring and firing during elections and changes of government administrations.

types, given by the indicator variables for skilled and unskilled workers $\{I(h=S), I(h=U)\}$; (2) hourly wages in the private and public sectors $\{w_h^p, w_h^g\}$, $h = S, U$; (3) unemployment durations (ongoing) $\{t_h^u, t_h^u\}$, $h = S, U$; and finally (4) the proportion of exits from unemployment to the private and the public sectors, $\{\%_h(u \to e_p), \%_h(u \to e_g)\}$, $h = S, U$.

Table 1 shows selected descriptive statistics of the sample. It is interesting to note that for unskilled workers there is a wage premium (of about 16%) and that the wage distribution in both sectors have a similar dispersion. For skilled workers, instead, the average wage is 2% larger in the private sector than in the public sector, and the wage distribution is more spread out in both sectors with respect to unskilled workers. Also, the public sector has a larger fraction of skilled workers as a proportion of all workers with the same human capital level. In fact, 26% of employed workers in the public sector are skilled, as opposed to less than 10% in the private sector. All these regularities are consistent with the evidence for other countries.[14] Finally, on average, unskilled workers leave the unemployment state quickly and it is more likely for a private sector job to arrive than one from the public sector (this is particularly notorious for unskilled workers).

3.2 Likelihood Function

We use maximum likelihood methods to estimate the model. Therefore, we discuss the contributions to the likelihood function of each piece of information described above. Additionally, since we assume that labor markets are segmented by human capital level, we estimate the model separately for skilled and unskilled workers (in the discussion that follows we drop the conditioning on h to make the notation simpler).

Workers who are unemployed contribute with unemployment duration information and with the proportion of transitions from unemployment to each sector. To find the contribution of this information to the likelihood function, we first define the hazard rate out of unemployment to jobs in each sector. This hazard rate is the probability that a job is created once a worker meets an employer (in the private or in the public sector) and the match specific productivity is acceptable for that employer, that is $\zeta_p = \alpha_p \widetilde{G}\left(\max\left\{x_p^* = \rho U, m\right\}\right)$ and $\zeta_g = \alpha_g \widetilde{G}\left(\max\left\{x_g^* = \frac{\beta\rho U - [\lambda + \nu\bar{x}]}{\beta - \nu}, \underline{x}\right\}\right)$ for the private and public sector, respectively. The total hazard rate out of unemployment is then defined as $\zeta = \zeta_p + \zeta_g$. Conditional on the model, the total hazard rate is constant, which implies that the unemployment duration can be characterized by a negative exponential distribution (Eckstein and van den Berg, 2007). Using these elements together, the contribution to the likelihood function of the duration

[14] see for example Fontaine et al. (2020).

data is the joint distribution of observing the duration t of a worker who is currently in the unemployed status U,

$$f(t, U) = f(t|u)\Pr[U] = \zeta \exp(-\zeta t) u \tag{15}$$

where the unemployment rate is defined as:

$$u = \frac{\delta_p \delta_g}{\delta_p \delta_g + \delta_g \alpha_p \widetilde{G}\left(\max\left\{\rho U, m\right\}\right) + \delta_p \alpha_g \widetilde{G}\left(\max\left\{\frac{\beta\rho U - [\lambda + \nu \bar{x}]}{\beta - \nu}, \underline{x}\right\}\right)}.$$

Using the multi-exit feature of the unemployment state in the model, we write the probability of observing a transition between unemployment and a private sector job in terms of the sectoral hazard rates as $\Pr[U \to E_p] = \frac{\zeta_p}{\zeta_p + \zeta_g}$ (Tejada, 2017).

Workers who are employed contribute with information on wages that are accepted. Therefore, their contributions to the likelihood function, written in terms of the structure of the model, should map productivity distributions to wages distributions through the wages equations (5) and (6) and capture only those matches that are accepted by truncating the resulting wages distributions at the reservation wage. In the case of the private sector, the contribution to the likelihood function for those earning the minimum wage is given by the joint probability of observing a wage equal to the minimum wage for a worker who is currently employed in the private sector, that is $\Pr[w_p = m, E_p] = \Pr[w_p = m|E_p]\Pr[E_p]$. Using the structure of the model we have:

$$\Pr[w_p = m, E_p] = \begin{cases} 0 & if\, m < \rho U \\ \frac{\left[\widetilde{G}(m) - \widetilde{G}\left(\frac{m-(1-\beta)\rho\tilde{U}}{\beta}\right)\right]}{\widetilde{G}(m)} e_p & otherwise. \end{cases} \tag{16}$$

Equation (16) indicates that if the minimum wage is not binding (hence, $m < \rho U$), the mass of workers earning m should be zero, while if the minimum wage is binding the mass of workers with productivity between m and $\tilde{x}_p$ should be counted. In turn, for workers earning more than the minimum wage, the contribution to the likelihood function is given by the joint distribution of observing a wage that is higher than the minimum accepted wage (the minimum wage or the reservation wage depending on the resulting equilibrium) for a worker who is currently employed in the private sector, that is: $f(w_p, w_p > \max\left\{\rho U, m\right\}, E_p) = f(w_p|w_p > \max\left\{\rho U, m\right\}, E_p)\Pr[w_p > \max\left\{\rho U, m\right\}|E_p]\Pr[E_p]$. In terms of the structure of the model we have

$$f(w_p, w_p > \max\left\{\rho U, m\right\}, E_p) = \begin{cases} \frac{\frac{1}{\beta} g\left(\frac{w_p - (1-\beta)\rho U}{\beta}\right)}{\widetilde{G}(\rho U)} e_p & if\, m < \rho U \\ \frac{\frac{1}{\beta} g\left(\frac{w_p - (1-\beta)\rho\tilde{U}}{\beta}\right)}{\widetilde{G}(m)} e_p & otherwise. \end{cases} \tag{17}$$

As previously mentioned, equation (17) defines the accepted wages distribution in terms of the productivity distribution by mapping wages to productivity throughout the Nash wage equation and truncating it at the reservation productivity ρU if the minimum wage is not binding and at m if it is binding. The employment rate e_p in the private sector in equations (16) and (17) is defined as

$$e_p = \frac{\delta_g \alpha_p \widetilde{G}\left(\min\left\{\rho U, m\right\}\right)}{\delta_p \delta_g + \delta_g \alpha_p \widetilde{G}\left(\max\left\{\rho U, m\right\}\right) + \delta_p \alpha_g \widetilde{G}\left(\max\left\{\frac{\beta \rho U - [\lambda + \nu \bar{x}]}{\beta - \nu}, \underline{x}\right\}\right)}.$$

The contribution of wages for those who are currently employed in the public sector follows a similar discussion. As before, for workers earning the minimum wage in the public sector we have $\Pr[w_g = m, E_g] = \Pr[w_g = m|E_g]\Pr[E_g]$. Using the structure of the model, it becomes:

$$\Pr[w_g = m, E_g] = \begin{cases} 0 & if\, m < \rho U \\ \frac{\left[\widetilde{G}(\underline{x}) - \widetilde{G}\left(\frac{m - [\lambda + \nu \bar{x}] - (1-\beta)\rho \tilde{U}}{\beta - \nu}\right)\right]}{\widetilde{G}(\underline{x})} e_g & otherwise. \end{cases} \tag{18}$$

Additionally, those workers in the public sector earning more than the minimum wage contribute with $f(w_g, w_g > \max\left\{\rho U, m\right\}, E_g) = f(w_g | w_g > \max\left\{\rho U, m\right\}, E_g)\Pr[w_g > \max\left\{\rho U, m\right\}|E_g]\Pr[E_g]$. Using the productivity distribution, the map between productivity and public sector wages, and defining those who have an acceptable productivity (higher than the reservation productivity in the public sector $x_g^* = \frac{\beta \rho U - [\lambda + \nu \bar{x}]}{\beta - \nu}$ if the minimum wage is not binding and higher than $\underline{x}$ if it is binding) we have:

$$f(w_g, w_g > \max\left\{\rho U, m\right\}, E_g) = \begin{cases} \frac{\frac{1}{\beta - \nu} g\left(\frac{w_g - [\lambda + \nu \bar{x}] - (1-\beta)\rho U}{\beta - \nu}\right)}{\widetilde{G}\left(\frac{\beta \rho U - [\lambda + \nu \bar{x}]}{\beta - \nu}\right)} e_g & if\, m < \rho U \\ \frac{\frac{1}{\beta - \nu} g\left(\frac{w_g - [\lambda + \nu \bar{x}] - (1-\beta)\rho \tilde{U}}{\beta - \nu}\right)}{\widetilde{G}(\underline{x})} e_g & otherwise. \end{cases} \tag{19}$$

where, as before, the employment rate in the public sector in equations (18) and (19) is defined as

$$e_g = \frac{\delta_p \alpha_g \widetilde{G}\left(\max\left\{\frac{\beta \rho U - [\lambda + \nu \bar{x}]}{\beta - \nu}, \underline{x}\right\}\right)}{\delta_p \delta_g + \delta_g \alpha_p \widetilde{G}\left(\max\left\{\rho U, m\right\}\right) + \delta_p \alpha_g \widetilde{G}\left(\max\left\{\frac{\beta \rho U - [\lambda + \nu \bar{x}]}{\beta - \nu}, \underline{x}\right\}\right)}.$$

We complete the discussion of the contributions to the likelihood function by assuming that the productivity x follows a log-normal distribution with parameters μ_x and σ_x (see Eckstein and van den Berg, 2007). With the latter assumption, the parameter space that defines the likelihood contributions in equations (15) to (19) is therefore

$$\Theta \quad = \quad \begin{cases} \alpha_p, \alpha_g, \delta_p, \delta_g, \lambda, \nu, \mu_x, \sigma_x, \rho U & if\, m < \rho U \\ \alpha_p, \alpha_g, \delta_p, \delta_g, \lambda, \nu, \mu_x, \sigma_x, \rho\tilde{U}, \underline{x} & otherwise. \end{cases}$$

Note that the set Θ is comprised of primitive parameters (the termination rates (δ_p, δ_g) and productivity distribution (μ_x, σ_x)), policy parameters (public sector wages (λ, ν) and hiring rule $\underline{x}$), and endogenous variables (the arrival rates of meeting (α_p, α_g) and unemployment flow value ρU / $\rho\tilde{U}$) that affect only the supply side of the model. In fact, the only links between the likelihood function and the demand side of the model are the arrival rates of meetings between workers and employers. Therefore, as in Flinn (2006) we estimate (α_p, α_g) as fixed parameters using only supply side data and we recover primitive parameters of the demand side using the matching function and the free entry condition given in equations (10) or (12), for the non-binding and binding minimum wage case, respectively. Additionally, we also estimate the unemployment flow value ρU / $\rho\tilde{U}$ as fixed parameters and we recover the unemployment flow (dis)utility using the Bellman equation that characterizes the unemployment flow value, defined in equations (9) and (11) in the non-binding and binding minimum wage case, respectively. For details, see the identification discussion below.

Putting together all the contributions in equations (15) to (19), we can write the likelihood function (expressed in logarithms) as:

$$\begin{aligned} \ln \mathcal{L}(\Theta; t, w_p, w_g) = & \sum_{i \in U} \ln f(t_i, u) + \sum_{i \in E_p} I_{[w_{i,p}=m]} \ln \Pr[w_p = m, E_p] \\ & + \sum_{i \in E_p} I_{[w_{i,p}>m]} \ln f(w_p, w_p > \max\{\rho U, m\}, E_p) \\ & + \sum_{i \in E_g} I_{[w_{i,g}=m]} \ln \Pr[w_g = m, E_g] \\ & + \sum_{i \in E_g} I_{[w_{i,g}>m]} \ln f(w_g, w_g > \max\{\rho U, m\}, E_g) \end{aligned} \tag{20}$$

where $I_{[condition]}$ is an indicator variable that takes the value of 1 if the condition on wages is satisfied and zero otherwise. The likelihood function (20) is maximized choosing Θ and subject to $\Pr[U \to E_p] = \frac{\zeta_p}{\zeta_p + \zeta_g}$. To determine whether the minimum wage is binding or not (that is, if $m \geq \rho U$) we use a loglikelihood ratio test. That is, we test the null hypothesis of $\Pr[w_p = m, E_p] = 0$, and therefore $m < \rho U$, by assessing whether the goodness of fit of the equilibrium with non-binding minimum wage is better than its counterpart with binding minimum wage. The complete specification of the likelihood in both cases, with and without a binding minimum wage, is presented in Appendix B.2.

3.3 Identification

The identification strategy follows the standard arguments of Flinn and Heckman (1982) and Flinn (2006) to identify a search model with only supply side cross section data, in our case unemployment duration, transitions from unemployment to private and public sector jobs, and wages in both the public and the private sectors. Additionally, the identification strategy has two stages. The first is related to the identification of the parameters in the likelihood function, that is, s α_p, α_g, δ_p, δ_g, λ, ν, μ_x, σ_x, and ρU (or $\rho\tilde{U}$ and $\underline{x}$); and the second is related to the identification (recovery) of the demand side parameters, that is, c, θ and ϕ, and of the flow (dis)utility in the unemployment state, z.[15]

It is important to mention that we do not attempt to estimate the Nash bargaining power parameter (β) and the discount rate (ρ), but instead we set them exogenously. Eckstein and Wolpin (1995) and Flinn (2006) point out that β cannot be identified under credible assumptions without demand side information. We use $\beta = 0.5$, which is a common assumption in the applied literature when the discount rate is the same for workers and firms (see Flabbi, 2010, for a detailed discussion). In the case of ρ, even though it enters in the likelihood as part of ρU, it is not possible to separately identify ρ and U, as well as all the remaining parameters (Eckstein and van den Berg, 2007). Therefore, for the particular case of Chile, we let ρ equal an annualized discount rate of 6.7% (see for example Fuenzalida and Mongrut, 2010).

In the first stage, the key idea in Flinn and Heckman (1982) is to use unemployment duration data to identify the hazard rate out of unemployment and to recover the parameters that govern the dynamics of the model, that is the arrival and terminations rates, such that the steady state conditions of the model hold. Additionally, with the wages data it is possible to recover the productivity distribution parameters by mapping productivity to wages, throughout the wage equations, and recover the original wages distribution from its truncated version (at the reservation wage). The condition required to make that possible is called the *recoverability condition* and the distributions that belong to the location-scale family meet this condition.[16] Finally, the truncation point (the flow value of unemployment),

[15]Decoupling the model in the supply and demand sides is useful for two reasons. First, it makes the identification clearer and allows us to apply standard identification conditions used in the literature. Second, it reduces the parameter space in the numerical maximization of the likelihood function, also reducing the computational burden and increasing the precision of the optimization algorithm. At the same time, it is equivalent to maximize the likelihood functions over the whole spectrum of primitive parameters, subject to the equilibrium conditions of the model

[16]The recoverability condition is satisfied if the original distribution can be completely recovered from a

is required to be fixed in the estimation in order to meet the regularity conditions of the maximum likelihood estimator. A consistent estimator of the flow value of unemployment (which is the reservation wage) in this case is the minimum observed wage.

In a model with a binding minimum wage instead, as in Flinn (2006), the truncation point is fixed and equal to the legal minimum wage. Therefore, the flow value of unemployment can be estimated with all the other parameters as part of the maximum likelihood estimation. The identification in this case also relies on the information contained in the proportion of workers who earn the minimum wage.

In our case, the identification of the mobility parameters of the model follows exactly the classic Flinn and Heckman (1982) strategy described above. Indeed, the maximum likelihood estimator of the hazard rate out of unemployment (ζ) is the average duration observed in the data. Since we observe and fix the proportion of transitions from unemployment to the private sector, $\Pr[U \to E_p] = \frac{\zeta_p}{\zeta_p+\zeta_g}$, we can directly recover the intensity of transitions ζ_p and ζ_g. Given the productivity distribution and the reservations values, these hazard rates out of unemployment identify the arrival rates of meetings α_p and α_g. Additionally, the terminations rates (δ_p and δ_g) are identified using the hazard rates out of unemployment and the steady state equilibrium conditions. That is, given the flows from unemployment to both sectors, which are implicit in the hazard rates out of unemployment, the termination rates determining flows from employment to unemployment should be such that the unemployment and employment rates are constant in both sectors. This identification result holds when the minimum wage is binding and when it is not.

In the case of the identification of the productivity distribution and the reservation values, it is necessary to distinguish between the models with and without a binding minimum wage. The assumption that is common in both cases is that the productivity follows a log-normal distribution. Since the distribution belongs to the family of log location-scale distributions, it satisfies the recoverability condition and the density can be written in terms of its location and scale as $g(x) = \frac{1}{\sigma} g_0\left(\frac{\ln(x)-\mu}{\sigma}\right)$ where $g_0(\cdot) \sim N(0,1)$.

One one hand, if the minimum wage is not binding, the identification strategy of the remaining parameters is as follows. First, the strongly consistent estimator of the reservation wage, which in the model is equal to the reservation productivity in the private sector and the flow value of unemployment, is the minimum observed wage, that is $\rho U = x_p^* = w_p^* = \min\{w_p^o\}$. Second, the distribution of (the logarithm of) wages, obtained by mapping productivity to wages using the productivity distribution and the wage equation in the

truncated version with known truncation point.

private sector, can be written in terms of its location and scale as

$$\frac{1}{\sigma\beta}g_0\left(\frac{\ln(w_p)-(1-\beta)\rho U-\beta\mu}{\beta\sigma}\right).$$

Given the recoverability condition, the location and the scale of the observed distribution of (the logarithm of) wages in the private sector identify μ_p^o and σ_p^o, which in turn can be mapped directly to the parameters of the productivity distributions as:

$$\mu_p^o=(1-\beta)\rho U+\beta\mu$$
$$\sigma_p^o=\beta\sigma.$$

The parameters μ and σ are identified since ρU is identified and β is set exogenously. In the same way, we can write the distribution of (the logarithm of) wages in the public sector in terms of its location and scale as:

$$\frac{1}{(\beta-\nu)\sigma}g_0\left(\frac{\ln(w_g)-[\lambda+\nu\bar{x}]-(1-\beta)\rho U-(\beta-\nu)\mu}{(\beta-\nu)\sigma}\right).$$

As before, the location and the scale of the observed distribution of (the logarithm of) wages in the public sector identify μ_g^o and σ_g^o, which can be mapped directly to the parameters of the model as follows:

$$\begin{aligned}\mu_g^o &= [\lambda+\nu\bar{x}]+(1-\beta)\rho U+(\beta-\nu)\mu\\ \sigma_g^o &= (\beta-\nu)\sigma.\end{aligned}$$

Since ρU, μ and σ are identified from the private sector wages data, μ_g^o and σ_g^o contain enough information to identify the parameters λ and ν. This completes the parameter identification discussion of the first stage in the case of non binding minimum wage equilibrium.

On the other hand, if the minimum wage is binding, the minimum observed wage (which is the minimum wage) can no longer be an estimator of the flow value of unemployment $\rho\tilde{U}$. This occurs since, by construction, the flow value of unemployment is lower than the minimum wage in the model. As before, we write the distribution of (the logarithm of) wages in the private sector in terms if its location and scale as

$$\frac{1}{\beta\sigma}g_0\left(\frac{\ln(w_p)-(1-\beta)\rho\tilde{U}-\beta\mu}{\beta\sigma}\right),$$

which once again allows us to map the location and the scale, identified with the observed distribution of (the logarithm of) wages in the private sector, to the parameter of the productivity distribution as:

$$\mu_p^o=(1-\beta)\rho\tilde{U}+\beta\mu$$
$$\sigma_p^o=\beta\sigma.$$

Even though μ_p^o and σ_p^o are identified, these do not provide enough information to recover the three parameters $\rho\tilde{U}$, μ, σ. Therefore, an additional piece of information is necessary. As in Flinn (2006), the mass of workers earning minimum wage, written in terms of the model as

$$\Pr[w_p = m|E_p] = \frac{\left[\widetilde{G}\left(m\right) - \widetilde{G}\left(\frac{m-(1-\beta)\rho\tilde{U}}{\beta}\right)\right]}{\widetilde{G}\left(m\right)},$$

provide the additional information needed to pin down all the parameters. Indeed, given that m and β are fixed, the observed proportion of workers earning the minimum wage combined with μ_p^o and σ_p^o from the private sector wages distribution, allow us to recover $\rho\tilde{U}$, μ and σ.

Finally, the distribution of (the logarithm of) wages in the public sector, in terms of its location and scale, can be written as:

$$\frac{1}{(\beta-\nu)\sigma} g_0 \left(\frac{\ln(w_g) - [\lambda + \nu\bar{x}] - (1-\beta)\rho\tilde{U} - (\beta-\nu)\mu}{(\beta-\nu)\sigma} \right).$$

The mapping of the location and scale identified from the observed distribution of (the logarithm of) wages in the public sector μ_g^o and σ_g^o to the parameters of the model can, once again, be written as

$$\begin{aligned}
\mu_g^o &= [\lambda + \nu\bar{x}] + (1-\beta)\rho\tilde{U} + (\beta-\nu)\mu \\
\sigma_g^o &= (\beta-\nu)\sigma,
\end{aligned}$$

to which we can add information on the mass of workers earning the minimum wage in the public sector and write:

$$\Pr[w_g = m|E_g] = \frac{\left[\widetilde{G}\left(\underline{x}\right) - \widetilde{G}\left(\frac{m-[\lambda+\nu\bar{x}]-(1-\beta)\rho\tilde{U}}{\beta-\nu}\right)\right]}{\widetilde{G}\left(\underline{x}\right)}.$$

Since $\rho\tilde{U}$, μ and σ are identified from the private sector data and β is fixed, we are able to identify λ, ν and $\underline{x}$. This completes the parameter identification discussion of the first stage in the case of a binding minimum wage equilibrium.

The second stage corresponds to the estimation of the demand side parameters, which builds on the estimated values of the contact rates (α_p and α_g) from the first stage. Without information on vacancies, v_p and v_g, we cannot identify any additional parameter in the matching function $Q(\cdot)$. This is relevant in this context because we know that the $Q(\cdot)$ function is a sufficient condition to recover and identify all the remaining parameters of the demand side of the model.

We can follow two approaches to identify the matching function. The first approach, proposed by Flinn (2006), consists of using a matching function that does not contain any unknown parameters, like the exponential matching function $Q(u, v) = v(1 - e^{-u/v})$. The second approach consists of using external sources to obtain estimates of the parameter γ of a Cobb-Douglas matching function $Q(u, v) = u^{1-\gamma}v^{\gamma}$. According to Petrongolo and Pissarides (2001), the Cobb-Douglas matching function has had empirical success, while the exponential matching function generates implausible levels and duration of unemployment, and hence is not, empirically, a good approximation. However, the drawback of the Cobb-Douglas function is the lack of micro-foundations and the use of external estimates. In our estimations, we give more weight to fit the data, and follow the second approach, setting $\gamma = 0.625$, which is based on a recent estimation for Chile by Kirchner and Tranamil (2016).

Once the matching function is known, the market tightness θ and the proportion of private sector vacancies ϕ can be recovered from the solution to the following system of equations:

$$\begin{aligned}\alpha_w^p &= \phi\theta^{\gamma} \\ \alpha_w^g &= (1-\phi)\theta^{\gamma}\end{aligned}$$

We are able to recover the search cost c by combining θ, the estimates from the supply side and the free entry condition, and equation (10) or (12) depending on the case. Additionally, once all the above parameters are identified, v_g can be recovered using equation (14), that is, $v_g = (1-\phi)u\theta$. Finally, the flow (dis)utility in the unemployment state can be recovered by using all the estimated parameters and solving for z in equation (9) if the minimum wage is not binding or in equation (11) if it is binding.

3.4 Estimation Results

Table 2 shows the estimated parameters for the supply and demand sides of the market. Also, the parameters that are fixed in the estimation are presented in the table for reference. The arrival rates of meetings by skill level for the private and public sectors are reported in the first two rows. In the case of the private sector, the estimates indicate that a meeting occurs, on average, every 2 and 4.5 months for skilled and unskilled workers, respectively. In the case of the public sector, in turn, the meetings occur far less frequently, that is, on average, every 50 and 10 months for skilled and unskilled workers, respectively. The estimated values for termination rates, presented in rows three and four, imply that the average duration of a job in the private and the public sectors are approximately 21 and 59 months, respectively, for unskilled workers. For skilled workers the average duration of a job is around 59 months in both sectors.

Rows five and six of Table 2 present the location and the scale parameters of the productivity distribution by skill level. Given the log-normality assumption, the average productivity implied in those estimates are 17.88 USD and 5.27 USD per hour for skilled and unskilled workers, respectively. These results indicate that skilled workers are on average more than three times more productive than unskilled workers. Moreover, the standard deviations indicate that the productivity distributions are substantially more spread out for skilled than for unskilled workers (14.15 and 4.05, respectively).

The flow value and the flow (dis)utility of unemployment are presented in rows seven and eight. The flow value of unemployment for both, skilled and unskilled workers, is lower than the legal minimum wage (1.7978 USD per hour), which is consistent with the equilibrium in which the minimum wage is binding. The flow (dis)utility is almost three times higher, in absolute value, for skilled workers with respect to their unskilled counterparts. This occurs for two reasons. First, in terms of the interpretations of this parameter, the opportunity cost of searching for a job is higher for skilled workers. Second, as Hornstein et al. (2011) show, the higher the dispersion in the wages distributions, the lower (more negative) the flow (dis)utility has to be.

The public sector wage premium parameters λ and ν, are presented in rows nine and ten of Table 2, respectively. They indicate that unskilled workers earn around 0.8 USD per hour more in the public sector regardless of their productivity, while skilled workers have no pure premium at all. Furthermore, positive unit deviations of the workers' productivity with respect to the average productivity, are awarded by 0.1 for unskilled workers, while these deviations are penalized by 0.03 in the case of skilled workers. To have an idea of the magnitude of these wage premiums, take a skilled and unskilled worker who is 20% less productive than the average, then the total premium in the public sector would be 0.1 and 0.7 USD per hour, respectively, representing 1.5% and 30% of the average wage in the public sector. On the contrary, a skilled and unskilled worker who is 20% more productive than the average obtains a premium of -0.1 and 0.9 USD per hour, respectively, representing -1.5% and 45% of the average wage in the public sector. From these results, it is clear that unskilled workers benefit more from the public sector wage schedule.

Row eleven shows the estimated minimum accepted productivity in the public sector, which when compared to the legal minimum wage (the minimum accepted productivity in private sector), indicates that the public sector hires workers who, given their productivity, would not be hired in the private sector. This is particularly true for unskilled workers. Indeed, in the bottom of the productivity distribution, the increase in the probability of being hired in the public sector with respect to the private sector, conditional on the arrival of both job offers, is around 10% for unskilled workers. On the contrary, the difference in probabilities is not significant for skilled workers.

The demand side parameters, shown in rows twelve to fourteen of Table 2, indicate that 70% and 96% of the unfilled vacancies are private sector vacancies for skilled and unskilled workers, respectively. Also, the market is relatively tighter for skilled workers, because in this economy for every vacancy there are six skilled workers looking to fill that vacancy, while in the case of unskilled workers for every vacancy there are only three workers looking to fill it. Finally, the search cost is around 19 times the skilled workers' average wage and around 9 times the unskilled workers' average wage, both in the private sector.

Finally, the bootstrap standard errors of the estimated parameters show that the estimation is quite precise for all parameters, with the only exception of the minimum accepted productivity in the public sector, the flow (dis)utility and the vacancy cost for skilled workers. Also, the LR test, presented in the bottom panel of Table 2, indicates rejection of the null hypothesis that the best fit to the data occurs with the model without a binding minimum wage, at any acceptable significance level and for both skilled and unskilled workers. Of course, the null hypothesis is rejected much more easily in the case of the unskilled workers.

To assess the fit of the estimates, Table 3 compares the predictions obtained by simulating the model and its data sample counterparts. Three comments are worth mentioning. First, it is notorious that the overall fit of the model is very good and this is particularly true for the moments related with the labor market status and the wages distributions. Second, four moments of particular interest, given the findings discussed in the Data Section, are the ratio between the average wages of the public and the private sectors and the mass of workers earning the minimum wage in both the private and the public sectors. In the former case, the model accurately estimates and captures the fact that, on average, skilled workers earn more in the private sector while unskilled workers earn more in the public sector. For the latter case, in turn, the model adequately captures the majority of mass observed in the data. Finally, in terms of the wages distributions, it can be observed that the simulated densities in Figure 2 exactly preserve the shapes as those obtained from the data and this is remarkable given that we use only two groups of workers for the estimation.

As we mentioned previously, to avoid selection problems due to the low female participation rate observed in Chile, our estimation sample is composed of only male workers. Not including women in our sample implies that we eliminate around 40% and 50% of the total unskilled and skilled workers, respectively. For this reason we have also estimated the model pooling men and women; the results are presented in Table B.3 of the Appendix. Note that the magnitude of the estimated parameters are, in general, similar to those presented in Table 2. Two differences stand out and are worth mentioning. First, the estimated productivity distribution is more right skewed and less disperse when considering men and women in the sample. Indeed, the average productivity is 18% lower for both skilled and unskilled workers, while the standard deviation is 5.6% and 19% lower for skilled and unskilled workers, respectively. Since the estimation of the productivity distribution relies heavily on the wages data, these differences are a consequence of wages distributions also characterized by lower average wages and lower standard deviation of wages when women are included in the sample (compare wages in Table 1 with those in Table B.2). Second, the minimum productivity requirements for hiring in the public sector are also considerably lower when including both men and women in the sample. For unskilled workers, the productivity requirement is only 60% of that estimated with only men workers, while for skilled workers this requirement is around 40% of that corresponding to only male workers. This is explained by a higher incidence of the minimum wage in the public sector when including women in the sample (around 3 percentage points more).

4 Policy and Counterfactual Experiments

In order to analyze the main mechanisms operating in our modeled economy, this section presents four different counterfactual experiments adjusting key parameters of the model. Starting from the benchmark economy, with the estimated parameters of Table 2, we consider the impact of different labor market policies in the main variables of the model. Specifically, we analyze the effects of an increase in the minimum wage, of shutting down the public sector employment, of equalizing hiring standards (rules) between the private and the public sectors, and of equalizing the wage schedules between the private and the public sectors. Additionally, we compare the effects of minimum wage increases in the benchmark economy with the same effects but in an economy without a public sector. We further analyze how the specific features of the public sector employment policy interacts with minimum wage increases by separately shutting down differences in hiring standards and in wage setting rules in both sectors. The comparison is always with respect to an economy without a public sector. It is important to mention that throughout these experiments we assume that the estimated vacancy level, that is the level consistent with observed employment in the public sector, is what is necessary to maintain a certain level of a public good. Hence, we keep it fixed. As a consequence, the level of public sector employment is the variable that is adjusted to policy changes.

We report the effects of each of the described counterfactual and policy experiments on the unemployment dynamics variables (weighted average of the two markets), the labor market states variables, accepted wages, the minimum wage incidence and output. Additionally, to evaluate welfare effects we construct a welfare measure by exploiting the distribution of workers in the steady-state equilibrium of the model and the values of each state of the labor market (Flinn, 2006). In particular, the welfare function for a type h worker, when the minimum wage is not binding, is:

$$W(h) = u(h)U(h) + e_p(h)\int_{x_p^*(h)} N_p(x,h)dG(x|h) + e_g(h)\int_{x_g^*(h)} N_g(x,h)dG(x|h)$$

while in the case in which the minimum wage is binding it is:

$$W(h) = u(h)U(h) + e_p(h)\int_{m} N_p(x,h)dG(x|h) + e_g\int_{\underline{x}} N_g(x,h)dG(x|h)$$

The total welfare function W can be calculated directly using the distribution of type h workers over the population, that is:

$$W = \sum_{h=1}^{H} \kappa(h)W(h) \tag{21}$$

4.1 Individual Policy and Counterfactual Experiments

Increasing the minimum wage

In the first experiment, we increase the minimum wage m by 20%. The results are presented in the second column of Table 4. Most of the impact of this policy is, as expected, in the market of unskilled workers, where the minimum wage is more binding. On one hand, a higher minimum wage implies a higher wage floor for employed workers, which in turn increases the average accepted wages. On the other hand, given that the minimum productivity requirements in the private sector increase with the minimum wage, firms create fewer vacancies. Indeed, the market tightness (θ) decreases from 0.323 to 0.305, generating lower contact rates and increasing the unemployment duration. Also, since the number of vacancies and the hiring rule in the public sector are not affected by the minimum wage, the contact rate for public sector jobs is almost unchanged.

The overall unemployment rate increases from 0.086 to 0.093, while private sector employment decreases by almost one percentage point and public sector employment increases by 0.2 percentage points. The incidence of the minimum wage increases largely from 19% to 29% in the private sector, and from 12% to 23% in the public sector. With the increase in the minimum wage, a larger proportion of workers not qualifying for private sector jobs accept job offers from the public sector at wage m, a sector where the minimum productivity requirements ($\underline{x}$) are particularly low in the unskilled workers' market (see Table 2). Finally, the impact of a higher minimum wage on aggregate productivity is negative. This effect is dominated by a composition effect. That is, the higher minimum productivity requirement, associated with a higher minimum wage, is more than compensated with the reduction in employment in the private sector. Finally, the welfare effect of the minimum wage is largely negative, reducing our welfare measure (W) by more than 4% from 38.8 to 37.2.

Shutting down the public sector

In the second counterfactual experiment, we compute the equilibrium in an economy with no public sector employment. The results are reported in the third column of Table 4. Shutting down the public sector largely increases the supply of workers available to work in the private sector. This, in turn, leads to more vacancy creation in the private sector, and so to a higher market tightness (θ) and contact rate of vacancies, which reduces unemployment duration. However, because of the stricter hiring productivity requirements in the private sector, it is more difficult for workers to get hired in this economy. Even though in the benchmark, skilled workers are over represented in the public sector, setting $e_g = 0$ mostly harms unskilled workers, whose unemployment rate increases by half percentage point from 0.088 to 0.093. Instead, the unemployment rate slightly declines from 0.069 to 0.067 for skilled workers. Accepted wages are almost unchanged, and the incidence of the minimum wage increases slightly from 18.9% to 19.7% in the private sector. As expected, the output in the private sector increases greatly due to the increased supply of workers in that sector, but welfare falls because of the increase in the unemployment rate for unskilled workers.

Same hiring rule in both sectors

In the third counterfactual experiment, reported in the fourth column of Table 4, we match the hiring productivity requirement in the public sector to that in the private sector. That is, we increase $\underline{x}$ from 0.2069 in the unskilled workers' market and 1.0661 in the skilled workers' market to the minimum wage (m) in both of them. Most of the equilibrium variables are unaffected by this change and there is no effect on skilled workers, for whom the minimum wage is almost not binding. The impact is visible for unskilled workers. The higher productivity requirement in the public sector for these workers reduces their employment in the public sector by one percentage point, which is compensated by a similar increase in employment in the private sector. Accepted wages for public sector workers become higher and there is a large reduction in the fraction of public sector workers earning the minimum wage. This is a result of the increased productivity requirements and the generous wage schedule in the public sector. Output and welfare decrease slightly, mainly because of the reduced overall employment.

Same wage policy in both sectors

In the last experiment, we match the wage schedule between the public and the private sectors by setting $\lambda = 0$ and $\nu = 0$. That is, we consider a case in which there is no pure public sector wage premium and a different weight on productivity in the wage rule. The results are reported in the last column of Table 4. The unemployment dynamics and labor market state variables are almost unaffected by this change in the wage policy in the public sector. There is a slight reduction in the unemployment rate and in the unemployment duration due to the lower expected wages associated to the erosion of the public sector wage premium. Indeed, public sector wages for unskilled workers are greatly reduced, and therefore the incidence of the minimum wage largely increases. Productivity is mostly unaffected but welfare for unskilled workers declines significantly due to the less generous wage policy in the public sector. As a consequence, aggregate welfare decreases.

4.2 Policy Interactions with the Minimum Wage

In this subsection, we analyze how the most relevant endogenous variables in an economy with public sector employment compare to their counterparts in an economy with no public sector employment as we vary the minimum wage. Additionally, we look at the extent at which the different characteristics of the public sector interact with the impact of the minimum wage. In doing so, we simulate the model for different values of the minimum wage in the range of 0.9 and 2.6 US dollars per hour, that is 50% below and above its benchmark value (1.7978 US dollars per hour). Overall, the results in this subsection indicate that the existence of a public sector employer, with low productivity requirements and a generous wage policy for unskilled workers, is welfare improving for the modeled economy. The main reason is that the public sector reduces frictions in the labor market, making it easier for workers to find jobs. Of course, in the real world running a public sector is costly, and therefore the implicit assumption behind our results is that the costs of having a public sector match up with the benefits of the public goods that it provides.

Unemployment

In panel (a) of Figure 3 we show, with a solid line, the ratio between the unemployment rate in the benchmark economy and the unemployment rate in the economy without a public sector for different values of the minimum wage. The vertical line is the observed value of the minimum wage at the benchmark. There are two interesting findings in this figure. First, and consistent with Table 4, unemployment is lower in the benchmark economy than in the economy without public sector. Second, as we increase the minimum wage, the buffer effect of the public sector on unemployment increases, and the ratio of unemployment rates shown in Figure 3 decreases.

We also compare the unemployment rate in an economy with public sector but no differences in hiring rules between the sectors with that in an economy without public sector employment (dashed line in the top panel of Figure 3). In this case the relative difference in unemployment rates is slightly smaller and it does not vary with minimum wage. This suggests that a less restrictive hiring rule has a large impact in explaining the buffer effect of public sector employment as we increase the minimum wage. Finally, in comparing an economy with public sector but no differences in wage schedules across sectors with an economy with no public sector (dotted line in the top panel of Figure 3), we find that the relative differences in unemployment rates are larger and they decrease significantly with the minimum wage. This suggests that the public sector wage policy reduces the buffer effect of public sector employment. This effect decreases with the minimum wage because, all else equal, higher expected public sector wages increase the value of unemployment.

In panel (b) of Figure 3 we perform a similar exercise for the average unemployment duration. The results are similar in magnitude for the different economies considered and for different values of the minimum wage. However, it is worth mentioning that, in line with the results regarding unemployment, unemployment duration tends to be lower due to the lower minimum productivity requirements in the public sector and it would be even lower if the public sector had the same wage policy as the private sector.

Employment and Minimum Wage Incidence

In Figure 4, we explore how employment and the incidence of the minimum wage in the private sector behave in different economies for different values of the minimum wage. As before, the horizontal axis graphs the ratios between the variables in the different economies to those in an economy with no public sector. Notice in panel (a) that private sector employment is, as expected, greater in an economy without public sector than in an economy with a public sector employer, This difference remains almost constant when the minimum wage increases (solid line). The public sector wage schedule has basically no impact on those differences in private sector employment rates (dotted line). On the contrary, the ratio of private sector employment in the economy with no differences in hiring rules, relative to an economy without public sector, increases with the minimum wage. This suggests that the lower hiring requirement in the public sector, in the benchmark economy, becomes an important determinant of the lower weight of the private sector employment in total employment as the minimum wage increases.

In panel (b) of Figure 4, we consider how the relative incidence of the minimum wage in the private sector varies with m. First, the incidence of the minimum wage is greater in the economy without public sector than in its counterpart with a public sector employer, and the relative differences between these two cases is decreasing in m. This occurs because the hiring rule in the public sector requires productivity levels that are lower than the minimum wage. If there were no differences in wage schedules the incidence of the minimum wage would be similar between the economies with and without a public sector. This means that the more generous the public sector wage policy is, the lower the incidence of the minimum wage. As the minimum wage increases, this effect tends to be smaller.

Productivity and Welfare

In Figure 5, panels (a) and (b) respectively, we show the relative values of productivity in the private sector and total welfare in an economy with public sector employment with respect to an economy without public sector. Productivity in the private sector is larger in an economy without public sector and this difference is increasing with the minimum wage. This occurs because the higher minimum productivity requirements are associated to a larger minimum wage and the less strict hiring rule of the public sector that makes a better pool of unemployed for the private sector. Indeed, for low values of the minimum wage, the differences in hiring rules in the public and private sectors are smaller, and therefore the productivity differences are also small. As the differences in hiring standards increase with the minimum wage, the productivity differences also increase.

Finally, welfare is larger with a public sector employer than without it. This relative welfare gain increases with m as the benefit of reducing the labor market frictions of the public sector are magnified when the minimum wage exerts its standard negative employment effects in the private sector. When inspecting the contribution of the different features of public sector employment to this welfare gains, we notice that both the hiring rule and the wage setting rule are relevant. For low values of the minimum wage, the wage setting rule is more relevant in determining the welfare gain of the public sector. Instead, the hiring rule is the main determinant of the public sector welfare gain for high values of the minimum wage. That is, with a low minimum wage, the difference in hiring rules between the public and the private sectors is low, and therefore it is the more generous wage policy in the public sector which make it attractive for workers. For high values of the minimum wage, the wage policy in the public sector does matter too but the lower hiring standards in the public sector also have an important role to make it attractive for workers.

5 Concluding Remarks

This paper develops a search and matching model with a public and a private sector and a mandatory minimum wage. The model is estimated for skilled and unskilled workers using recent data for Chile, an economy with a large fraction of public sector workers and a binding minimum wage. The estimation results indicate that in the Chilean labor market workers meet with private sector vacancies more frequently than those of the public sector, that the public sector premium favors more unskilled workers, and that the hiring standards are by far less restrictive in the public sector than in the private sector. We also perform several policy and counterfactual experiments. We find that the public sector employment acts as a buffer weakening the negative effects of the minimum wage on unemployment and welfare. Behind these results, we find that the less restrictive hiring rule has a large impact in explaining the buffer effect of public sector employment as we increase the minimum wage. On the contrary, the public sector wage policy reduces this buffer effect of public sector employment. The down side, of course, is that the existence of the public sector negatively affects the private sector productivity as the minimum wage increases. Finally, it is important to mention that as we only focus on the effect of the public sector on the dynamics of the labor market, we ignore the role of the public sector as a public good provider with a budget constraint. In this context, the implicit assumption in our framework is that the costs of having a public sector match up with the benefits of the public goods that it provides.

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Figure 1: Wage Schedules in the Private and the Public Sectors

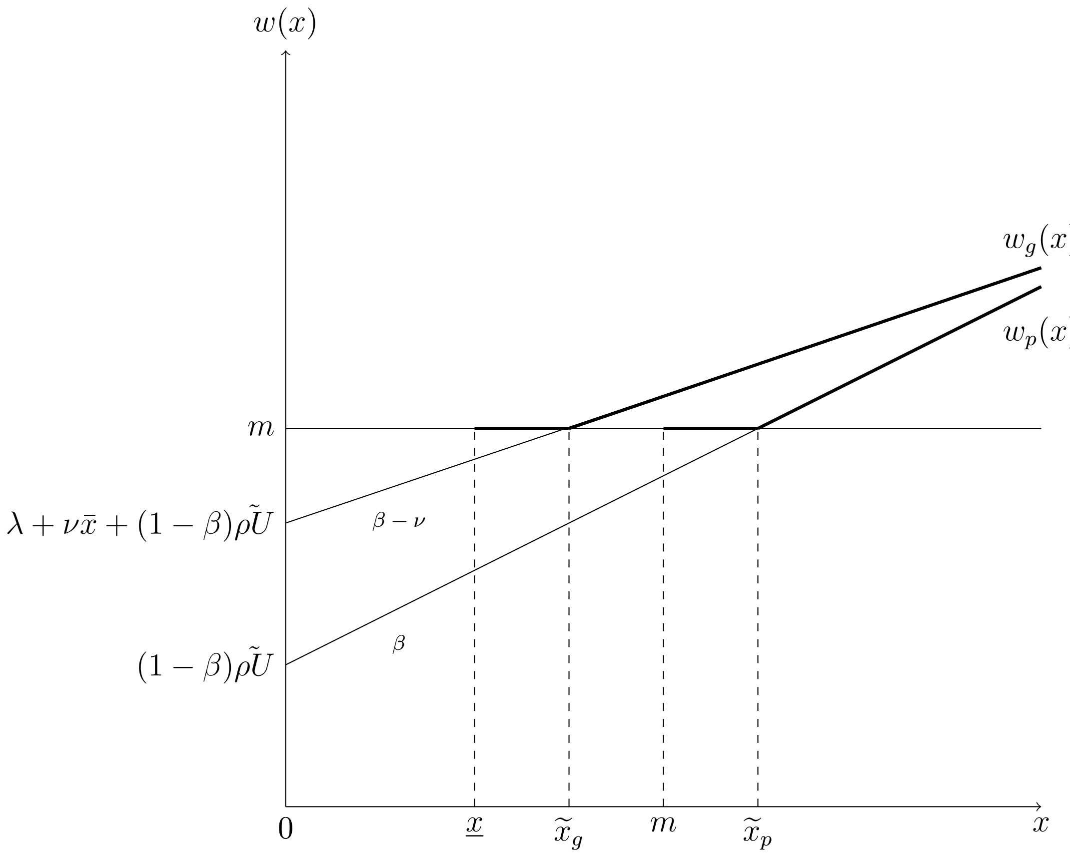


Figure 2: Wage Schedules in the Private and the Public Sectors

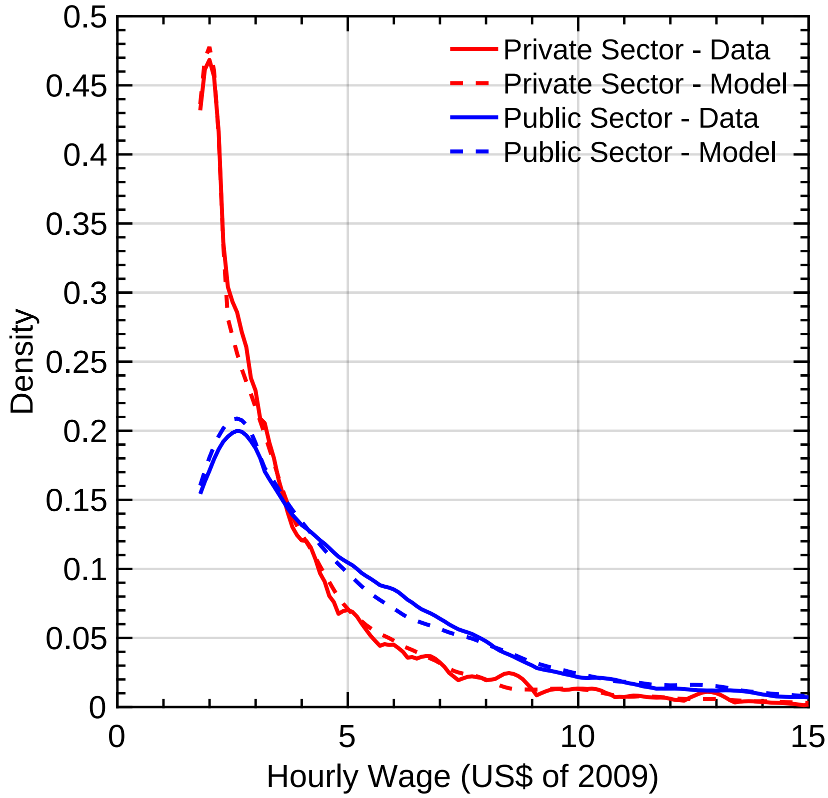
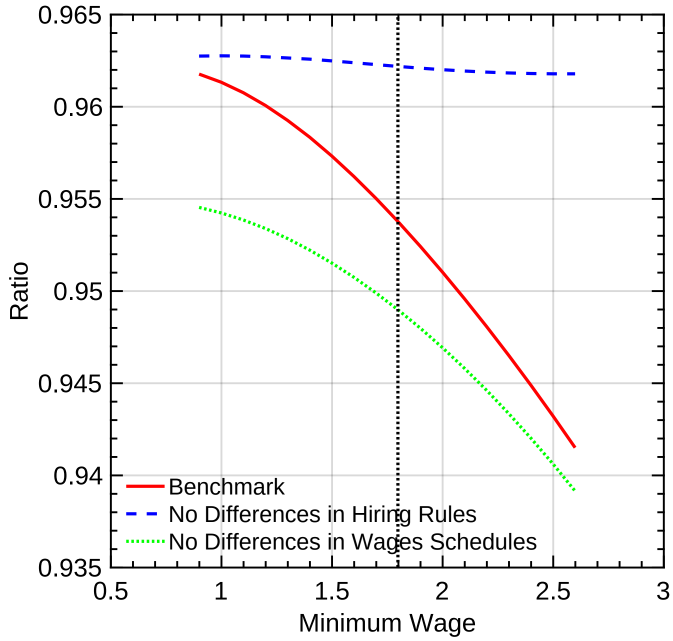
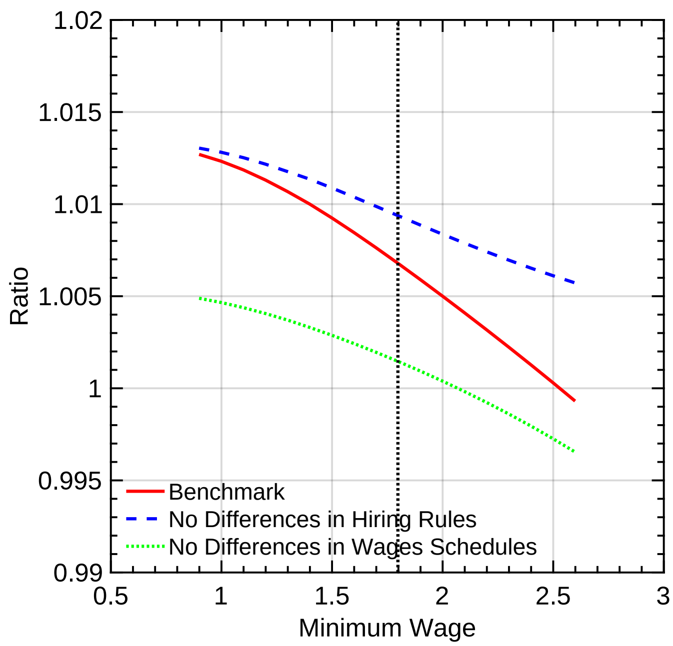


Figure 3: Counterfactual Scenarios: Unemployment



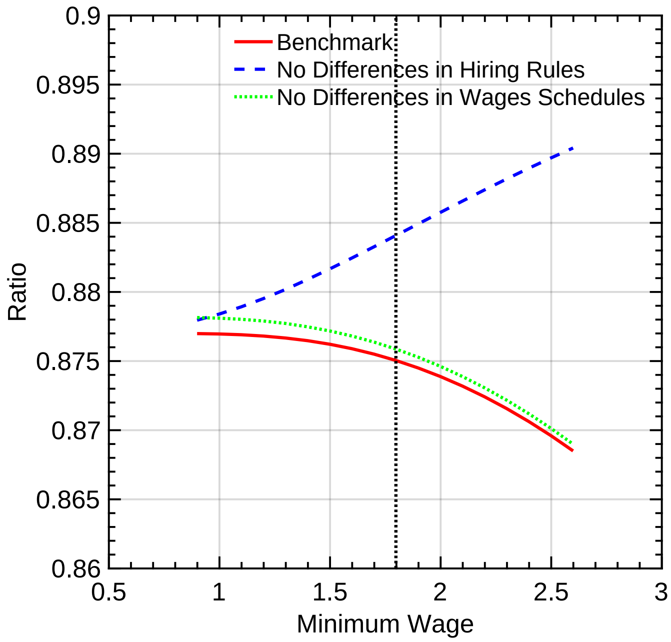
(a) Unemployment Rate



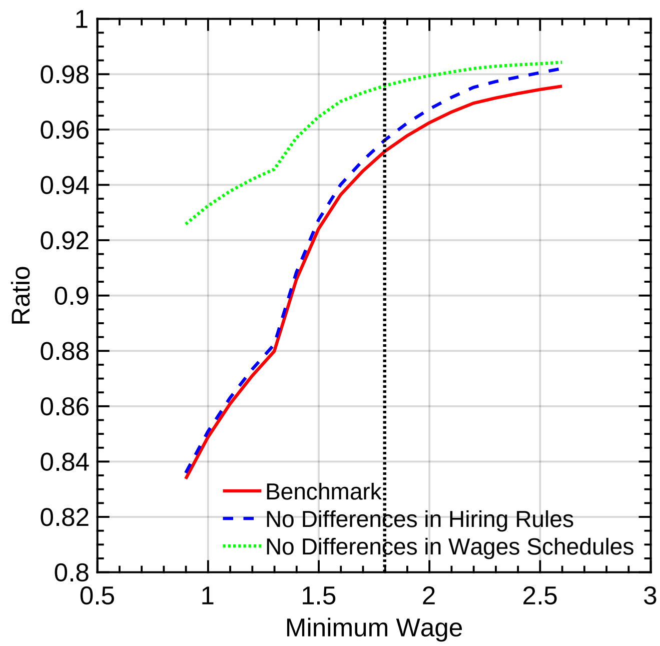
(b) Unemployment Duration

NOTE: The vertical axis corresponds to the ratio between the variable in the described economy and the variable in an economy without the public sector. The vertical line corresponds to the observed value of the minimum wage. All calculations are based on the point estimates of the parameters presented in Table 2 and assume that the public sector maintains the estimated vacancy levels constant.

Figure 4: Counterfactual Scenarios: Employment and Minimum Wage Incidence in the Private Sector



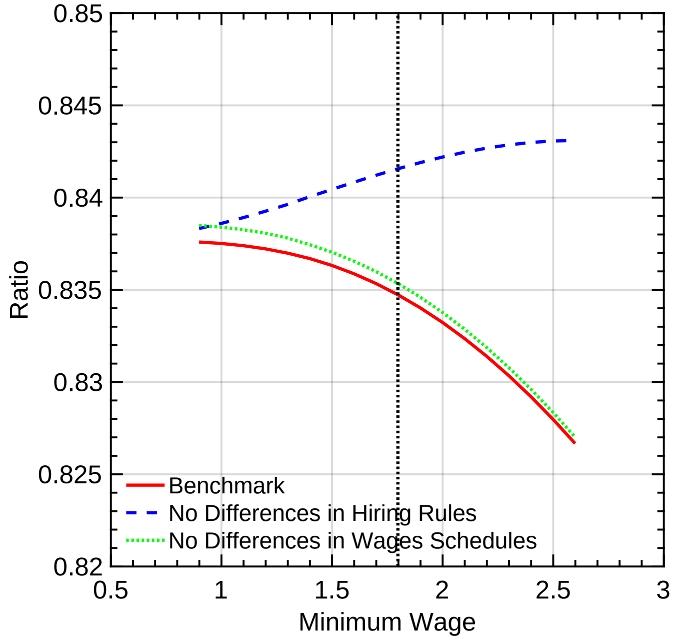
(a) Employment Rate



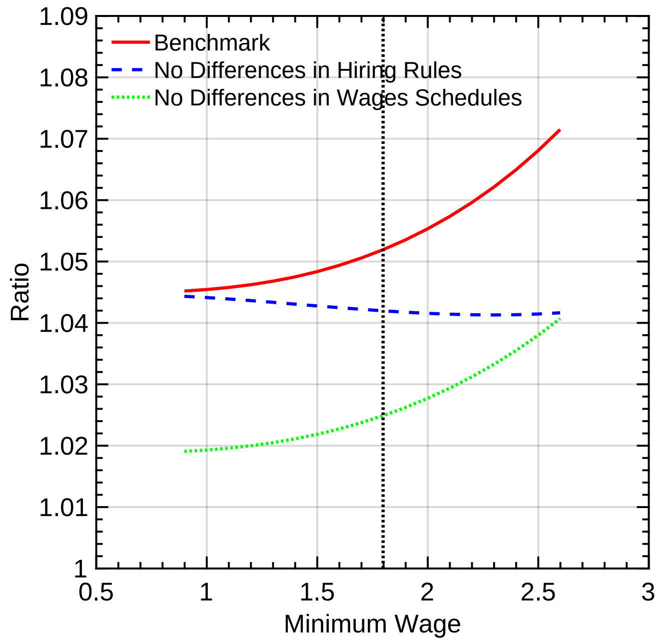
(b) Incidence of the Minimum Wage

NOTE: The vertical axis corresponds to the ratio between the variable in the described economy and the variable in an economy without the public sector. The vertical line corresponds to the observed value of the minimum wage. All calculations are based on the point estimates of the parameters presented in Table 2 and assume that the public sector maintains the estimated vacancy levels constant.

Figure 5: Counterfactual Scenarios: Productivity and Welfare



(a) Productivity in the Private Sector



(b) Welfare Measures

NOTE: The vertical axis corresponds to the ratio between the variable in the described economy and the variable in an economy without the public sector. The vertical line corresponds to the observed value of the minimum wage. All calculations are based on the point estimates of the parameters presented in Table 2 and assume that the public sector maintains the estimated vacancy levels constant.

Table 1: Descriptive Statistics

	Unskilled	Skilled
Hourly Wage - Private Sector (US$/hour)		
Mean	3.2715	9.7449
Standard Deviation	2.0627	7.1478
Minimum	1.7978	1.7978
Hourly Wage - Public Sector (US$/hour)		
Mean	3.7934	9.5513
Standard Deviation	2.3055	6.4097
Minimum	1.7978	1.7978
Ratio of Average Wages	0.8624	1.0203
Unemployment Duration (Months)		
Mean	2.1568	3.0747
Proportion of Transitions $u \to e_p$	0.9598	0.7021
Proportion of Transitions $u \to e_g$	0.0402	0.2979
Unemployment Rate	0.0884	0.0674
Employment in the Private Sector	0.8162	0.6711
Employment in the Public Sector	0.0954	0.2614
Proportion of Workers with $w_p = m$	0.2202	0.0031
Proportion of Workers with $w_g = m$	0.1421	0.0016
Proportion of Workers	0.8653	0.1347

NOTE: Data extracted from CASEN 2013. Wage distributions are trimmed at the top and bottom 1 percentile by sector and are reported in US Dollars of December 2009 (Exchange Rate = 559.67 Pesos/US$).

Table 2: Estimates of the Model Parameters

Parameter	Unskilled		Skilled	
	Coeff.	Standard Error	Coeff.	Standard Error
Estimated Parameters				
α_p	0.4986	0.0188	0.2249	0.0542
α_g	0.0186	0.0008	0.0953	0.0231
δ_p	0.0482	0.0017	0.0230	0.0103
δ_g	0.0173	0.0006	0.0249	0.0122
μ_x	1.4310	0.0213	2.6411	0.0361
σ_x	0.6811	0.0117	0.6971	0.0318
$\rho\tilde{U}$	0.6517	0.0434	1.3467	0.2335
z	-10.1283	0.3153	-27.9024	3.7884
λ	0.8062	0.0768	0.0000	0.1570
ν	-0.1037	0.0184	0.0290	0.0182
$\underline{x}$	0.2069	0.4641	1.0661	1.2687
ϕ	0.9640	0.0008	0.7024	0.0033
θ	0.3483	0.0210	0.1617	0.0694
c	28.6111	1.3984	181.9646	35.7629
Predicted Values				
$E[x]$	5.2748	0.0789	17.8873	0.4753
$SD[x]$	4.0529	0.0610	14.1488	0.9042
Fixed Parameters				
β	0.5000			
ρ	0.0670			
γ	0.6250			
m	1.7978			
Log-Likelihood	-37259		-8975	
LR Test	13224		35	
No. Obs.	15425		2402	

NOTE: Standard errors were calculated using Bootstrap with 1,000 replications. The LR statistic test the null hypothesis that the model without minimum wage has better fit than the model with binding minimum wage.

Table 3: Fit of the Model

Statistic	Unskilled		Skilled	
	Data	Model	Data	Model
Labor Market States				
u	0.088	0.088	0.067	0.069
e_p	0.816	0.816	0.671	0.669
e_g	0.095	0.095	0.261	0.262
Exits of Unemployment				
$E[t\|u]$	2.157	2.157	3.075	3.126
$\Pr[u \rightarrow e_p]$	0.960	0.960	0.702	0.702
Accepted Wages				
$E[w\|e_p]$	3.272	3.254	9.745	9.634
$SD[w\|e_p]$	3.793	3.810	9.551	9.615
$E[w\|e_g]$	2.063	1.967	7.148	7.085
$SD[w\|e_g]$	2.306	2.362	6.410	6.680
$E[w\|e_p]/E[w\|e_g]$	0.862	0.854	1.020	1.002
Minimum Wage Incidence				
$\Pr[w_p = m]$	0.220	0.218	0.003	0.003
$\Pr[w_g = m]$	0.142	0.139	0.002	0.000

Table 4: Policy and Counterfactual Experiments

Statistic	Benchmark	Minimum Wage $1.2 \times m$	Public Sect. Employment $e_g = 0$	Public Sect. Hiring Rule $\underline{x} = m$	Public Sect. Wages Rule $\lambda = 0, \nu = 0$
Unemployment Dynamics					
ϕ	0.929	0.930	1.000	0.929	0.929
θ	0.323	0.305	0.330	0.324	0.326
α_p	0.462	0.446	0.497	0.463	0.465
α_g	0.029	0.028	–	0.029	0.029
$E[t\|u]$	2.287	2.490	2.272	2.293	2.275
Labor Market States					
u	0.086	0.093	0.090	0.087	0.085
u_U	0.088	0.097	0.093	0.089	0.088
u_S	0.069	0.069	0.067	0.069	0.069
e_p	0.796	0.787	0.910	0.805	0.797
$e_{U,p}$	0.816	0.806	0.907	0.826	0.817
$e_{S,p}$	0.669	0.669	0.933	0.669	0.669
e_g	0.118	0.120	–	0.109	0.118
$e_{U,g}$	0.095	0.098	–	0.085	0.095
$e_{S,g}$	0.262	0.263	–	0.262	0.262
Accepted Wages					
$E[w\|e_p]$	4.113	4.249	4.104	4.116	4.110
$E[w_U\|e_p]$	3.254	3.411	3.233	3.260	3.252
$E[w_S\|e_p]$	9.634	9.634	9.692	9.617	9.618
$E[w\|e_g]$	4.592	4.626	–	4.811	3.980
$E[w_U\|e_g]$	3.810	3.842	–	4.055	3.096
$E[w_S\|e_g]$	9.615	9.658	–	9.670	9.662
$E[w\|e_p]/E[w\|e_g]$	0.874	0.903	–	0.830	1.043
Minimum Wage Incidence					
$\Pr[w_p = m]$	0.189	0.287	0.197	0.190	0.193
$\Pr[w_g = m]$	0.121	0.226	–	0.034	0.268
Output and Welfare					
y_p	5.235	5.107	6.272	5.278	5.239
$y_{U,p}$	4.187	4.040	4.651	4.236	4.192
$y_{S,p}$	11.965	11.960	16.681	11.972	11.965
y_g	1.068	1.078	–	1.009	1.066
$y_{U,g}$	0.503	0.515	–	0.436	0.501
$y_{S,g}$	4.695	4.695	–	4.687	4.695
W	38.844	37.203	36.926	38.476	37.845
W_U	28.513	26.625	26.157	28.090	27.359
W_S	105.184	105.126	106.082	105.171	105.185

NOTE: In all policy and counterfactual experiments we fixed v_g for each type of worker to the estimated value.

A Additional Material on The Model

A.1 Additional Tables

Table A.1: Model Notation Summary

State	Value Function	Measure	Shock	Flow Utility	Policy Instrument
			Workers (type h)		
Unemployed	$U(h)$	$u(h)$	$\alpha^p(h), \alpha^g(h)$	$z(h)$	–
Private Sector Emp.	$N_p(x,h)$	$e_p(h)$	$\delta_p(h)$	$w_p(x,h)$	–
Public Sector Emp.	$N_g(x,h)$	$e_g(h)$	$\delta_g(h)$	$w_g(x,h)$	–
			Private Sector		
Filled Job	$J_p(x,h)$	$e_p(h)$	$\delta_p(h)$	$x - w_p(x,h)$	–
Vacant Job	$V_p(h)$	$v_p(h)$	$\vartheta(h)$	$-c(h)$	–
			Public Sector		
Filled Job	–	$e_g(h)$	$\delta_g(h)$	$x - w_g(x,h)$	$\lambda(y), \nu(h), m$
Vacant Job	–	$v_g(h)$	–	–	$\underline{x}(h)$

A.2 Solution Algorithm

The solution algorithm involves the following three steps.

1. Guess $\phi(h)$.

   (a) Guess $\theta(h)$

   (b) Compute $\alpha^p(h)$ and $\alpha^g(h)$.

   (c) Find the value of unemployment:

   - Find $\rho U(h)$ iterating equation in (9) if the minimum wage is not binding.
   - Find $\rho U(h)$ iterating equation (11) if the minimum wage is binding.

   (d) Find the labor market tightness

   - Compute $\vartheta(h)$ and find θ solving equation (10) if the minimum wage is not binding.
   - Compute $\vartheta(h)$ and find θ solving equation (12) if the minimum wage is binding.

   (e) Iterate over $\theta(h)$.

2. Find $\phi(h)$ using the steady state conditions in (13) and equation (14).

3. Iterate over $\phi(h)$.

To choose between models (the cases in which the minimum wage is binding or not), solve the case where the minimum wage is not binding first and compare $\rho U(h)$ with m.

- If $\rho U(h) \leq m$ then solve where the minimum wage is binding.
- Otherwise, keep the solution where the minimum wage is not binding.

B Additional Material on the Estimation

B.1 Strategy to Choose Human Capital Groups

We defined an empirical procedure to deal with human capital heterogeneity for the structural estimation of the model. For this procedure, we first define sets of schooling groups that are meaningful. That is, we consider the following education groups: no education or incomplete basic education (lower that 8 year of schooling), complete basic education (between 9 and 12 years), complete secondary education with incomplete technical career (between 13 and 14 years), complete secondary education with incomplete university degree (between 13 and 16 years), and completed university degree (more than 17 years of schooling). We also considered different aggregations of these different schooling groups. Then, we estimated the model for each schooling group defined above by maximum likelihood assuming segmented markets. For each estimated model we simulate wages with the estimated parameters by schooling groups and pooled those wages to find the aggregated wages distributions by sector. These simulated wages distributions are then compared, in mean square error, with the observed wages distributions by deciles. That is, the mean squared error, denoted by MSE, is

$$MSE = \sum_{i=1}^{10} (\bar{w}_i^s(\theta) - \bar{w}_i^o)^2$$

where $\bar{w}_i^s(\theta)$ is the average wage in the decile i calculated using the simulated wages data, given the parameters θ, and $\bar{w}_i^o$ is the average wage in the decile i, calculated using the observed wages. Finally, we chose the schooling groups estimated model that made this MSE as low as possible. The Table B.1 shows the results for various schooling groups. The best fit for the public sector wages distribution is obtained with five schooling groups, while for the private sector it is obtained with 3 schooling groups. Moreover, when the we obtain the best fit in one sector, either the private or the public sectors, the other generates a fit that can be categorized among the worst fits in the table. For this reason we constructed a weighted average MSE using the contribution of each sector to the total employment. The minimum is reached for the weighted average of the MSE when we consider two groups (0.1108): with and without university degree. Note that this weighted average chooses the number of groups corresponding to the second best fit observed for both sectors and that the loss of fit, also for both sectors, is not significantly high with respect to the best bit.

Table B.1: Fit of the Aggregated Wages Distributions

Groups	Years of Schooling	Private Sector	Public Sector	Weighted Average
2	$[0 - 17 - >]$	0.0907	0.2473	0.1108
3	$[0 - 13 - 17 - >]$	0.0639	1.6336	0.2653
3	$[0 - 15 - 17 - >]$	0.1120	3.1115	0.4969
4	$[0 - 9 - 13 - 17 - >]$	0.2911	0.3838	0.3030
4	$[0 - 13 - 15 - 17 - >]$	0.2389	0.7127	0.2997
5	$[0 - 9 - 13 - 15 - 17 - >]$	0.2211	0.2148	0.2203

NOTE: The weighted average of the MSE is calculated using the contribution of each sector to the total employment.

B.2 Complete Likelihood Function

When the minimum wage is not binding, that is $m < \rho U$, the likelihood function is:

$$\begin{aligned}\ln \mathcal{L}(\Theta; t, w_p, w_g) = & \sum_{i \in U} \ln\left[\zeta \exp(-\zeta t_i)\right] + \sum_{i \in U} \ln u \\ & + \sum_{i \in E_p} \ln \left(\frac{\frac{1}{\beta} g\left(\frac{w_{i,p} - (1-\beta)\rho\tilde{U}}{\beta}\right)}{\widetilde{G}(m)} \right) + \sum_{i \in E_p} \ln e_p \\ & + \sum_{i \in E_g} \ln \left(\frac{\frac{1}{\beta-\nu} g\left(\frac{w_g - [\lambda+\nu\bar{x}] - (1-\beta)\rho\tilde{U}}{\beta-\nu}\right)}{\widetilde{G}(\underline{x})} \right) + \sum_{i \in E_g} \ln e_g\end{aligned}$$

In turn, when the minimum wage is binding, that is $m \geq \rho U$, the likelihood function becomes:

$$\begin{aligned}
\ln \mathcal{L}(\Theta; t, w_p, w_g) = & \sum_{i \in U} \ln\left[\zeta \exp(-\zeta t_i)\right] + \sum_{i \in U} \ln u \\
& + \sum_{i \in E_p} I_{[w_{i,p}=m]} \ln\left(\left[\widetilde{G}\left(m\right) - \widetilde{G}\left(\frac{m-(1-\beta)\rho\tilde{U}}{\beta}\right)\right]\right) \\
& + \sum_{i \in E_p} I_{[w_{i,p}>m]} \ln\left(\frac{\frac{1}{\beta} g\left(\frac{w_{i,p}-(1-\beta)\rho\tilde{U}}{\beta}\right)}{\widetilde{G}\left(m\right)}\right) + \sum_{i \in E_p} \ln e_p \\
& + \sum_{i \in E_g} I_{[w_{i,g}=m]} \ln\left(\left[\widetilde{G}\left(\underline{x}\right) - \widetilde{G}\left(\frac{m-[\lambda+\nu\bar{x}]-(1-\beta)\rho\tilde{U}}{\beta-\nu}\right)\right]\right) \\
& + \sum_{i \in E_g} I_{[w_{i,g}>m]} \ln\left(\frac{\frac{1}{\beta-\nu} g\left(\frac{w_g-[\lambda+\nu\bar{x}]-(1-\beta)\rho\tilde{U}}{\beta-\nu}\right)}{\widetilde{G}\left(\underline{x}\right)}\right) + \sum_{i \in E_g} \ln e_g
\end{aligned}$$

B.3 Estimation Pooling Male and Female Workers in the Sample

Table B.2: Descriptive Statistics using Male and Female Workers

	Unskilled	Skilled
Hourly Wage - Private Sector (US$/hour)		
Mean	3.0827	8.7284
Standard Deviation	1.9777	6.4940
Minimum	1.7978	1.7978
Hourly Wage - Public Sector (US$/hour)		
Mean	3.4372	8.1478
Standard Deviation	2.0816	5.3375
Minimum	1.7978	1.7978
Ratio of Average Wages	0.8969	1.0713
Unemployment Duration (Months)		
Mean	2.2115	2.8360
Proportion of Transitions $u \to e_p$	0.9315	0.7531
Proportion of Transitions $u \to e_g$	0.0685	0.2469
Unemployment Rate	0.1059	0.0697
Employment in the Private Sector	0.7584	0.5893
Employment in the Public Sector	0.1357	0.3410
Proportion of Workers with $w_p = m$	0.2615	0.0042
Proportion of Workers with $w_g = m$	0.1692	0.0006
Proportion of Workers	0.8445	0.1555

NOTE: Data extracted from CASEN 2013. Wage distributions are trimmed at the top and bottom 1 percentile by sector and are reported in US Dollars of December 2009 (Exchange Rate = 559.67 Pesos/US$).

Table B.3: Estimates of the Model Parameters using Males and Female Workers

Parameter	Unskilled		Skilled	
	Coeff.	Standard Error	Coeff.	Standard Error
Estimated Parameters				
α_p	0.5278	0.0164	0.2289	0.1025
α_g	0.0310	0.0009	0.0748	0.0346
δ_p	0.0588	0.0016	0.0278	0.0253
δ_g	0.0242	0.0007	0.0161	0.0156
μ_x	1.2107	0.0213	2.4914	0.0390
σ_x	0.7475	0.0104	0.6862	0.0407
$\rho\tilde{U}$	0.7640	0.0267	1.5294	0.2058
z	-7.8839	0.1860	-21.2644	6.4455
λ	0.8112	0.0459	0.0000	0.0090
ν	-0.0756	0.0126	0.0497	0.0187
$\underline{x}$	0.1360	0.1380	0.4375	1.5715
ϕ	0.9446	0.0009	0.7536	0.0027
θ	0.3941	0.0193	0.1486	0.1271
c	19.5298	0.8458	148.2227	49.7534
Predicted Values				
$E[x]$	4.4377	0.0653	15.2844	0.8970
$SD[x]$	3.8396	0.0453	11.8528	1.9197
Fixed Parameters				
β		0.5000		
ρ		0.0670		
γ		0.6250		
m		1.7978		
LogLikelihood	-64708		-17552	
No. Obs.	26344		4850	

NOTE: Standard errors were calculated using Bootstrap with 1,000 replications.