Does Public Sector Employment Buffer the Minimum Wage Effects?*

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Abstract

This paper studies the impact of a minimum wage policy in a labor market with a private and a public sector. 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.
JEL Codes: C51, J45, J64.

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). Second, there is a large proportion of workers earning wages around the minimum wage levels (Maloney and

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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's national minimum wage applies to all workers between 18 and 65 years and 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 sector, respectively, earn up to 1.2 minimum wages.

This suggests that increases in the minimum wage do 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 that differ from those applied in 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 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 to understand the main mechanisms driving our results.

Specifically, we introduce a minimum wage policy (Flinn, 2006, 2011) in a two-sector, public and private, labor market model with endogenous heterogeneity in workers' 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, when two parties meet there is a productivity draw from a distribution of productivity. Depending on the productivity draw and the minimum wage, the match is realized or not and wages are eventually determined. On the one hand, if the minimum wage is binding but the productivity draw is such that it is in the interest of the parties to make the match, the worker is paid the minimum wage. On the other hand, if productivity is low enough, then the match is not formed; while if it is high enough, then the minimum wage is not binding and wages are determined by Nash Bargaining. In the public sector, the minimum productivity requirement is an exogenous policy parameter that can differ from the minimum wage. We also follow the ideas of Gomes (2015) and Albrecht

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

et al. (2019) to assume that the public sector can pay a wage premium over the private sector wages. A free entry condition determines private sector vacancies, while public sector vacancies are determined according to an exogenous 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. Since the model can be decoupled in two parts, the supply and the demand sides, the estimation is performed in two steps. This is done by exploiting the fact that the only link in the model between both sides of the market are the contact rates.

The estimation results indicate that workers in the Chilean labor market encounter private sector vacancies more frequently than they do public sector vacancies, the public sector premium favors unskilled workers, and 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 where the wage policy is more generous than in the private sector. As a result, public sector employment acts as a buffer, weakening the negative effects of the minimum wage on unemployment and welfare. Among the different institutional factors of the public sector, we find that the less restrictive hiring rule largely explains 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 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 in this topic (Meer and West, 2016; Harasztosi and Lindner, 2019). For the case of Chile, Silva (2017) analyzes the interaction between labor protection in the form of firing costs and the minimum wage in a similar setting as this paper. Regarding the effect of the minimum wage in 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. (2019), Gomes (2018), Chassamboulli and Gomes (2019) and Chassamboulli and Gomes (2021) 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 public sectors.

As mentioned, our paper is related to Albrecht et al. (2019), who develop a model with public and private sectors and a continuum of worker types to analyze the effects of public sector employment policies. However, we instead focus on how the public sector affects the impact of the minimum wage policy on labor market outcomes in a model where search markets are endogenously segmented by human capital groups, i.e. formal education levels. In this aspect, our model has some features of Chassamboulli and Gomes (2019), 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. As in Albrecht et al. (2019), Gomes (2018), and Chassamboulli and Gomes (2019), we assume that 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, and section 5 compares the main results with those of two model extensions. Finally, section 6 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 three directions. First, the model considers two sectors, private and public. Private sector firms create vacancies and search for workers; once a vacancy is filled a bargained wage is paid to the worker. In the public sector, the government adjusts vacancies to reach a constant public employment target and workers are paid according to a different 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. Finally, the model incorporates human capital investments prior to entering the labor market, in line with Bobba et al. (2017).

2.1 Environment

Time is continuous and the economy is populated by a unit mass of agents. Similar to Bobba et al. (2017) and Chassamboulli and Gomes (2019), we assume that before entering the labor market, agents make an irrevocable decision about their human capital investments. That is, they decide which schooling level they want to acquire among the $h = 1, ..., H$ possible levels. Acquiring the schooling level h has a cost $\sigma(h) \sim T(\sigma|h)$, which summarizes any costs associated with acquiring an additional schooling level (from $h-1$ to h).[2] Once schooling decisions are made, agents enter the labor market and search for a job within their own schooling sub-market. There will be a mass $\kappa(h)$ of type h workers, such that $\sum_{h=1}^{H} \kappa(h) = 1$. In the labor market, the search process is random in all sub-markets and only unemployed workers search for a job. The proportion of unemployed workers, who are type h, is defined 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 it measures the quality of a match between a particular worker and its potential employer. 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 the 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

[2]We normalize the cost of the first schooling level to zero, that is $\sigma(1) = 0$.

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 sector, 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 sector, respectively.

2.2 Value Functions

The net value for an agent of having the schooling level h is $S(h) = U(h) - \sigma(h)$, where $U(h)$ is the value of unemployment for a type h worker. Acquiring the educational level h allows the agent to search for a job in the h-th sub-market. We assume that there are no jumps in schooling levels; that is, agents decide to acquire a schooling level h conditional on having acquired a level $h-1$. Therefore, as long as $S(h) \geq S(h-1)$, it will be worth it for the agent to acquire the additional level of schooling.

Once in the labor market, 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 $N_p(x,h)$ 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 the public sector. Therefore, the flow value of an unemployed worker is given by

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

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, then 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, then 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

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

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 $c(h)$. Meetings for firms in any h market occur 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.[3]

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.[4] Therefore, wages are the solution of the following problem:

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

[3]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.

[4]An alternative wage determination scheme considered in the literature is wage posting (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 was not significant, as in the Brazilian labor market (see Engbom and Moser, 2018).

where β is interpreted as the bargaining power of the worker.[5] 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 the 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 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.[6] 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:

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

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 $\varphi(x,h)$, which could be either positive or negative, relative to 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, $\nu(h)$ is a

[5]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.

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

parameter that captures a potentially different weight of productivity on public sector wages, and $\bar{x}$ is the average productivity. This wage setting specification is flexible enough to match the different dispersion of public and private sector wages observed in the data. 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 as that in Albrecht et al. (2019). 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 that for the 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 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:

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

These wage schedules are graphically shown in Figure 1 for the cases $\lambda(h) > 0$ 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 sub-market h: (i) the minimum wage is not binding, and (ii) the minimum wage is binding. Both cases are discussed in this section.

2.4.1 Schooling Decision

Since acquiring additional schooling requires an investment $\sigma(h)$ and there are no jumps in schooling levels (this is an ordered discrete choice), the agent sequentially solves, starting with the first schooling level, the following problem:

$$h-1: \max\left\{U(h-1)-\sigma(h-1), U(h)-\sigma(h)\right\}.$$

The optimal decision rule for each schooling level h has a reservation value property and is characterized by:

$$\begin{aligned}
\sigma^*(2) &: U(1) = U(2)-\sigma^*(2) \\
\sigma^*(3) &: U(2)-\sigma^*(2) = U(3)-\sigma^*(3) \\
&\vdots \\
\sigma^*(h) &: U(h-1)-\sigma^*(h-1) = U(h)-\sigma^*(h)
\end{aligned} \tag{7}$$

where only agents with $\sigma(h) \leq \sigma^*(h)$ acquire the schooling level h. Since $U(h)-\sigma(h)$ is decreasing in $\sigma(h)$, and $U(h-1)-\sigma^*(h-1)$ does not vary with $\sigma(h)$, there is a unique $\sigma^*(h)$ for each h and they can be computed sequentially.

2.4.2 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:

$$x_p^*(h) = \rho U(h). \tag{8}$$

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:

$$x_g^*(h) = \frac{\beta\rho U(h) - [\lambda(h)+\nu(h)\bar{x}]}{\beta-\nu(h)}. \tag{9}$$

If $\lambda(h) < -\nu(h)\left[\rho U(h)+\bar{x}\right]$, then $x_g^*(h) < x_p^*(h)$; that is, the productivity requirements in the private sector are more stringent.[7] 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 $w_g(x,h)$ it is possible to rewrite equation (1) as:

$$\begin{aligned}
\rho U(h) &= z(h) + \frac{\alpha^p(h)\beta}{\rho+\delta_p(h)}\int_{\rho U(h)}[x-\rho U(h)]dG(x|h) \\
&+ \frac{\alpha^g(h)}{\rho+\delta_g(h)}\int_{\frac{\beta\rho U(h)-[\lambda(h)+\nu(h)\bar{x}]}{\beta-\nu(h)}}\left[[\lambda(h)+\nu(h)\bar{x}]+[\beta-\nu(h)]\,x-\beta\rho U(h)\right]dG(x|h).
\end{aligned} \tag{10}$$

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

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 the definitions of $N_p(x,h)$, $N_g(x,h)$, $w_p(x,h)$ and $w_g(x,h)$, this condition (also referred to as the free entry condition) implies:

$$c = \frac{\vartheta(h)\,(1-\beta)}{\rho + \delta_p(h)} \int_{\rho U(h)} [x - \rho U(h)]\, dG(x|h) \tag{11}$$

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

2.4.3 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, then 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 $\widetilde{x}_p(h)$, then 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:

$$\rho\tilde{U}(h) = z(h) + \frac{\alpha^p(h)}{\rho+\delta_p(h)} \int_m^{\widetilde{x}_p(h)} \left(m - \rho\tilde{U}(h)\right) dG(x|h) \tag{12}$$
$$+ \frac{\alpha^p(h)\beta}{\rho+\delta_p(h)} \int_{\widetilde{x}_p(h)} \left(x - \rho\tilde{U}(h)\right) dG(x|h) + \frac{\alpha^g(h)}{\rho+\delta_g(h)} \int_{\underline{x}(h)}^{\widetilde{x}_g(h)} \left(m - \rho\tilde{U}(h)\right) dG(x|h)$$
$$+ \frac{\alpha^g(h)}{\rho+\delta_g(h)} \int_{\widetilde{x}_g(h)} \left([\lambda(h)+\nu(h)\bar{x}] + [\beta-\nu(h)]\, x - \beta\rho\tilde{U}(h)\right) dG(x|h)$$

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:

$$c = \frac{\vartheta(h)}{\rho+\delta_p(h)} \left[\int_m^{\widetilde{x}_p(h)} (x-m)\, dG(x|h) + (1-\beta) \int_{\widetilde{x}_p(h)} \left(x - \rho\tilde{U}(h)\right) dG_h(x|h) \right] \tag{13}$$

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 $\rho\tilde{U}(h)$ (together with $\phi(h)$).

2.4.4 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 and in each sub-market h are equalized:

$$\begin{aligned} \delta_p(h)e_p(h) &= \phi(h)q(\theta(h))\widetilde{G}(\max\{m, x_p^*(h)\}|h)u(h) \\ \delta_g(h)e_g(h) &= (1-\phi(h))\, q(\theta(h))\widetilde{G}(\max\{\underline{x}(h), x_g^*(h)\}|h)u(h) \\ u(h)+e_p(h)+e_g(h) &= 1 \end{aligned} \tag{14}$$

where $\widetilde{G}(\cdot) = 1 - G(\cdot)$. The equations in (14) 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 the public sector, 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

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

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:

$$\phi(h) = \frac{u(h)\theta(h) - v_g(h)}{u(h)\theta(h)} \tag{15}$$

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 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 $q(\theta(h))$, a probability distribution function for productivity $G(x|h)$, a probability distribution function for the cost of acquiring human capital $T(\sigma|h)$, and an employment rate in the public sector $e_g(h)$, a steady-state equilibrium in the economy with private and public sectors, a mandatory minimum wage, and endogenous schooling decision is a labor market tightness $\theta(h)$, a proportion of vacancies in the private sector $\phi(h)$, and a vacancy rate in the public sector $v_g(h)$, together with the unemployment flow values $\rho U(h)$ (or $\rho\tilde{U}(h)$), the unemployment rate $u(h)$ and the employment rate $e_p(h)$ 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 (10) if the minimum wage is not binding, and $\rho\tilde{U}(h)$ solves equation (12) if the minimum wage is binding.

(ii) Given $\phi(h)$, $\theta(h)$ solves equation (11) if the minimum wage is not binding and equation (13) if the minimum wage is binding, and it is consistent with $\rho U(h)$ (or $\rho\tilde{U}(h)$) obtained in (i).

(iii) $\phi(h)$ and $v_g(h)$ solve the steady state conditions in (14) and equation (15), given the target $e_g(h)$, and are consistent with $\rho U(h)$ (or $\rho\tilde{U}(h)$) and $\theta(h)$ obtained in (i) and (ii).

(iv) Given $\rho U(h)$ (or $\rho\tilde{U}(h)$) obtained in (i), $\sigma^*(1)$,..., $\sigma^*(H)$ solve equations in (7) and determine the distribution $\kappa(h)$ for all $h = 1, ..., H$.

Based on standard arguments, we can show that, for both the binding and the non-binding minimum wage, an equilibrium exists. That is, first, given $\phi(h)$ and $\theta(h)$, the unemployment values are uniquely determined, since the RHS of equations (10) and (12) is decreasing in $\rho U(h)$ and $\rho\tilde{U}(h)$, respectively. Second, for any given value of $\phi(h)$ the free entry condition equations (11) and (13) solve for $\theta(h)$; the RHS of both equations is continuous and a solution exists since the limit is ∞ as $\theta(h) \to 0$ and 0 as $\theta(h) \to \infty$. Finally, the steady state conditions in (14) and equation (15) solve for $\phi(h)$ and $v_g(h)$, together with $u(h)$ and $e_p(h)$, provided that $e_g(h)$ is known.

The prevailing equilibrium in every h market, with or without a 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 is presented in Appendix A.2.

The uniqueness of the equilibrium depends on the functional form assumed for the productivity distributions and the values of the parameters. In the following section, we structurally estimate the model and perform several counterfactual experiments to numerically explore the comparative static properties of the model (see subsection 4.1). This allows us to identity the main mechanisms at work in our model when we change the main labor market policy parameters.

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, as well as the schooling and the labor market decisions. We use the standard identification strategies given by Flinn and Heckman (1982) and Flinn (2006) to identify the primitive parameters of the model. 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-sectional household survey, which is representative at the national level, namely the Socio-Economic Characterization

Survey (CASEN).[8] We use the 2013 survey, which contains information on labor market status, monthly labor income, hours worked, and individual characteristics such as gender, age, and education.

Since the only source of ex-ante heterogeneity is the schooling 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 consider two groups of workers according to their schooling level: skilled workers, defined as workers with at least a university degree; and unskilled workers, defined as those without a university degree. The choice of two schooling groups is based on fit considerations. In particular, we estimated the model under different grouping schemes and combinations (no education, primary education, secondary education, technical degree and university degree or more), and it turned out that the best fit to the aggregated wages distribution by sector was reached by dividing the sample only into two groups, skilled and unskilled. See details in Appendix B.1. Second, in Chile the female participation rate is low (below 50%) compared to their male counterparts (around 75%). Therefore, we use only male participants in the labor market.[9] Third, since the mandatory minimum wage affects different age groups in different ways, we keep 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 between the ages of 25 and 55 years. Finally, we consider only full-time formal employees in both sectors, private 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.[10]

The sample size was further reduced due to problems with the data. On the 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 first five percentiles at the bottom and one percentile at the top of the wages distribution by

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

[9] We present the results of the estimation, using a sample pooling males and females, in a supplementary online appendix. The estimation results are very similar, as will be discussed in the next section.

[10] Informality is less pervasive in Chile compared to other Latin American countries. In particular, including informal wage workers, the informality rate in Chile is only 5,7% when the described sampling criteria is used. Moreover, informality is mainly related to self-employment in Chile. Again, following our sampling criteria, the self-employed represents 16.7% of our expanded sample. The informality rate among the self-employed is 43.4% and it increases to 12% in the expanded sample, including both wage and self-employed workers.

sector, resulting in 6.8% less observations.[11] Thus, after these adjustments, the final sample consists of 17,827 individuals. Dropping a large fraction of the data generates a concern about potential selection effects in the final sample. However, the schooling and labor market states distributions of the workforce in the initial and final sample are very similar.[12] An additional adjustment to the data was necessary because some observations were below the mandatory minimum wage.[13] As in Flinn (2006), 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 and 0.5% of the skilled workers earn the minimum wage in the final sample.[14]

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-sectional 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)[15] as an additional source of information.[16] 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. We do not attempt to estimate the model using wages and durations from the Social Protection Survey because they are self-reported and retrospective, and may, therefore, be subject to large measurement errors. Data from the CASEN survey provides us with a larger sample and more accurate data as the information is self-reported but not retrospective.

To summarize, the data available for the model estimation are: (1) distribution of worker types, given by the indicator variables for skilled and unskilled workers $\{I(h = S), I(h = U)\}$;

[11] Trimming the first five percentiles at the bottom of the wages distributions is a standard cutoff point in the literature, see for example Bowlus (1997) and Flabbi (2010a) in the context of the analysis of gender wage differentials using estimated search models. Additionally, Albrecht et al. (2019) trim the bottom of the wages distribution, more aggressively, to minimize the number of observation below the minimum wage in their calibration strategy.

[12] For details, see the supplementary online appendix.

[13] These observations are probability zero outcomes, conditional on the model.

[14] 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.

[15] 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.

[16] We pooled together three waves of the Social Protection Survey 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.

(2) hourly wages in the private and the public sectors $\{w_h^p, w_h^g\}$, $h = S, U$; (3) unemployment durations (ongoing) $\{t_S^u, t_U^u\}$; and (4) the proportion of exits from unemployment to the private and the public sectors, $\{\%_h(u \to e_p), \%_h(u \to e_g)\}$, $h = S, U$.

Selected descriptive statistics of the sample, in Table 1, shows that there is a public sector wage premium (of about 16%) for unskilled workers and that the wages 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 wages distribution is more spread out than the unskilled wages distribution in both sectors. Also, the public sector has a larger fraction of skilled workers as a proportion of all workers with the same schooling level. In fact, 26% of the skilled workers are employed in the public sector, as opposed to less than 10% of the unskilled who work in that sector. As a result, the skilled employment ratio is 30% in the public sector and only 11% in the private sector. All these regularities are consistent with the evidence found for other countries.[17] Finally, on average, unskilled workers leave the unemployment state quickly and private sector job offers are more likely to arrive than public sector ones.

3.2 Likelihood Function

We use maximum likelihood methods to estimate the model. Hence, 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 schooling levels and that schooling decisions only affect labor market outcomes through the participation in one of the segmented markets, we estimate the model separately for skilled and unskilled workers (we drop the conditioning on h to make the notation simpler in the discussion that follows).

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 the 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, implying that the unemployment duration can be characterized by a negative exponential distribution (Eckstein and van den Berg, 2007).

[17] See for example Fontaine et al. (2020).

Using these elements together, the contribution to the likelihood function of the duration data is the joint distribution of observing the duration t of a worker who is currently in the unemployed status U,

$$f(t,U) = f(t|u)\Pr[U] = \zeta\exp(-\zeta t)u \tag{16}$$

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).

Employed workers contribute with information on accepted wages. 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:

$$\Pr[w_p = m, E_p] = \begin{cases} 0 & if\, m < \rho U \\ \frac{\left[\widetilde{G}(m)-\widetilde{G}\left(\frac{m-(1-\beta)\rho\tilde{U}}{\beta}\right)\right]}{\widetilde{G}(m)}e_p & otherwise. \end{cases} \tag{17}$$

Equation (17) indicates that if the minimum wage is not binding (hence, $m < \rho U$), then the mass of workers earning m should be zero; while if the minimum wage is binding, then 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

$$f(w_p, w_p > \max\left\{\rho U, m\right\}, E_p) = \begin{cases} \frac{\frac{1}{\beta}g\left(\frac{w_p-(1-\beta)\rho U}{\beta}\right)}{\widetilde{G}(\rho U)}e_p & if\, m < \rho U \\ \frac{\frac{1}{\beta}g\left(\frac{w_p-(1-\beta)\rho\tilde{U}}{\beta}\right)}{\widetilde{G}(m)}e_p & otherwise. \end{cases} \tag{18}$$

As previously mentioned, equation (18) 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) or at m (if it is binding). The employment rate e_p in the private sector in equations (17) and (18) 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:

$$\Pr[w_g = m, E_g] = \begin{cases} 0 & if\, m < \rho U \\ \frac{\left[\widetilde{G}(\underline{x}) - \widetilde{G}\left(\frac{m - [\lambda + \nu \bar{x}] - (1-\beta)\rho \tilde{U}}{\beta - \nu}\right)\right]}{\widetilde{G}(\underline{x})} e_g & otherwise. \end{cases} \tag{19}$$

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:

$$f(w_g, w_g > \max\left\{\rho U, m\right\}, E_g) = \begin{cases} \frac{\frac{1}{\beta - \nu} g\left(\frac{w_g - [\lambda + \nu \bar{x}] - (1-\beta)\rho U}{\beta - \nu}\right)}{\widetilde{G}\left(\frac{\beta \rho U - [\lambda + \nu \bar{x}]}{\beta - \nu}\right)} e_g & if\, m < \rho U \\ \frac{\frac{1}{\beta - \nu} g\left(\frac{w_g - [\lambda + \nu \bar{x}] - (1-\beta)\rho \tilde{U}}{\beta - \nu}\right)}{\widetilde{G}(\underline{x})} e_g & otherwise. \end{cases} \tag{20}$$

where, as before, the employment rate in the public sector in equations (19) and (20) 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 this assumption, the parameter space that defines the likelihood contributions in equations (16) to (20) is therefore

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

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 (11) or (13), for the non-binding and binding minimum wage case, respectively. Additionally, we 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 (10) and (12) in the non-binding and binding minimum wage case, respectively. For details, see the identification discussion below.

Putting together all the contributions in equations (16) to (20), we can write the likelihood function (expressed in logarithms) as:

$$\begin{aligned} \ln \mathcal{L}(\Theta; t, w_p, w_g) = & \sum_{i \in U} \ln f(t_i, u) + \sum_{i \in E_p} I_{[w_{i,p}=m]} \ln \Pr[w_p = m, E_p] \\ & + \sum_{i \in E_p} I_{[w_{i,p}>m]} \ln f(w_p, w_p > \max\{\rho U, m\}, E_p) \\ & + \sum_{i \in E_g} I_{[w_{i,g}=m]} \ln \Pr[w_g = m, E_g] \\ & + \sum_{i \in E_g} I_{[w_{i,g}>m]} \ln f(w_g, w_g > \max\{\rho U, m\}, E_g) \end{aligned} \tag{21}$$

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 (21) 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 a non-binding minimum wage is better than its counterpart with a 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-sectional 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 three stages. The first is related to the identification of the parameters in the likelihood function, that is, α_p, α_g, δ_p, δ_g, λ, ν, μ_x, σ_x, and ρU (or $\rho\tilde{U}$ and $\underline{x}$). 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.[18] The third is related with the identification of the distributions parameters of the cost of acquiring human capital.

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, 2010a, 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 z (which underlines 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, the wages data makes it possible to recover the productivity distribution parameters by mapping productivity to wages, using 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

[18] Decoupling the model in the supply and the 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.

family meet this condition.[19] Finally, it is important that the truncation point (the flow value of unemployment) is fixed in the estimation in order to meet the regularity conditions of the maximum likelihood estimator. In this case, a consistent estimator of the flow value of unemployment (which is the reservation wage) is the minimum observed wage.

In a model with a binding minimum wage, 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, $\Pr[U \rightarrow E_p] = \frac{\zeta_p}{\zeta_p + \zeta_g}$, 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 termination 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 $g(x) = \frac{1}{\sigma} g_0 \left(\frac{\ln(x) - \mu_x}{\sigma_x} \right)$ where $g_0(\cdot) \sim N(0, 1)$.

One the one hand, if the minimum wage is not binding, then 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 $\rho U =$

[19] The recoverability condition is satisfied if the original distribution can be completely recovered from a truncated version with known truncation point.

$x_p^* = w_p^* = \min\{w_p^o\}$. Second, the distribution of (the logarithm of) wages, obtained by mapping productivity to wages using the productivity distribution and the wage equation in the private sector, can be written in terms of its location and scale as:

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

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:

$$\begin{aligned} \mu_p^o &= (1-\beta)\rho U + \beta\mu_x \\ \sigma_p^o &= \beta\sigma_x. \end{aligned}$$

The parameters μ_x and σ_x 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:

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

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:

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

Since ρU, μ_x and σ_x 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 the 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:

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

which 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:

$$\begin{aligned}\mu_p^o &= (1-\beta)\rho\tilde{U} + \beta\mu_x \\ \sigma_p^o &= \beta\sigma_x.\end{aligned}$$

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_x, σ_x. Therefore, an additional piece of information is necessary. As in Flinn (2006), the mass of workers earning the minimum wage, written in terms of the model as

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

provides 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_x and σ_x.

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

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

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, once again, can be written as

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

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_x and σ_x 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 knowing the function $Q(\cdot)$ 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 is, empirically, not a good approximation since it generates implausible levels and durations of unemployment. 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 (11) or (13) depending on the case. Additionally, once all the above parameters are identified, v_g can be recovered using equation (15), 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 (10) if the minimum wage is not binding or in equation (12) if it is binding.

Finally, we are constrained in terms of the number of schooling decision parameters we can identify since the only piece of information available in the data is the distribution of schooling types. In the case of two types of schooling level, skilled and unskilled, we can only identify one parameter.[20] To be concrete, recall from the equilibrium of the model that

[20] In general, for H schooling types, it is possible to identify $H-1$ parameters.

in the case of two types of schooling level, the reservation value for the cost of acquiring education satisfies $\sigma^*(2) = U(2) - U(1)$. Therefore, the probability of observing a type 1 (unskilled) worker is $1 - T(\sigma^*(2)|2)$. This means that in order to directly identify the distribution $T(\cdot|2)$ from the proportion of unskilled workers, the distribution has to have one parameter and be invertible with respect to that parameter. We follow the literature and use a negative exponential distribution, which satisfies these conditions, with parameter $\varphi(2)$ (see for example Bobba et al., 2017; Flabbi, 2010b). In particular, under this assumption, the proportion of unskilled workers can be written as:

$$\kappa(1) = \Pr[h = 1] = \Pr[\sigma(2) > \sigma^*(2)] = e^{-\varphi(2)\sigma^*(2)}$$

and therefore, the parameter $\varphi(2)$ can be estimated as:

$$\hat{\varphi}(2) = -\frac{\kappa(1)}{\sigma^*(2)},$$

which actually corresponds to the likelihood estimator of the unique parameter of a negative exponential distribution (Flabbi, 2010b).[21]

3.4 Estimation Results

Table 2 shows the estimated parameters for the supply and the 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 the public sectors are reported in the first two rows. In the case of the private sector, the estimates indicate that a meeting occurs every 2 and 4.5 months, on average, for unskilled and skilled workers, respectively. Meetings occur far less frequently in the public sector, with every 50 and 10 months, on average, for unskilled and skilled workers, respectively. The estimated values for termination rates, presented in rows three and four, imply that the average duration of a job in the

[21] For the general case of H schooling levels, we write:

$$\begin{aligned}\Pr[h = \tilde{h} - 1] &= \prod_{i=1}^{\tilde{h}-1} \Pr[\sigma(j) \leq \sigma^*(j)] \Pr[\sigma(\tilde{h}) > \sigma^*(\tilde{h})] \\ &= \prod_{i=1}^{\tilde{h}-1} T(\sigma^*(j)|j) \left[1 - T(\sigma^*(\tilde{h})|\tilde{h})\right]\end{aligned}$$

and therefore, if $T(\sigma(j)|h)$ has only one unknown parameter and having computed $\sigma^*(h)$, the parameters of each of these distributions are sequentially estimated starting from the proportion of the first (the lowest) schooling level.

private and the public sectors are approximately 21 and 58 months, respectively, for unskilled workers. For skilled workers the average duration of a job is around 40-43 months in both sectors.[22]

Rows five and six of Table 2 present the location and the scale parameters of the productivity distribution by skill level.[23] 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 show 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 for skilled workers is almost three times higher, in absolute value, than their unskilled counterparts. This occurs for two reasons. First, in terms of the interpretation 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

[22]This same pattern is found in the data. Indeed, according to the transitions from employment to unemployment, computed using the Social Protection Survey (SPS) for a three-year period, we find that the proportion of exits from the private sector to unemployment are 20% higher than those from the public sector for the case of unskilled workers, while for the skilled workers that difference is less than 4%. This pattern of the gap in termination rates across sectors and schooling levels (that is, separation rates across sectors are larger for less educated workers) is also found by Fontaine et al. (2020) for the United States, the United Kingdom, France and Spain.

[23]In the model and the estimations we set the parameters of the productivity distribution to be the same across sectors. This is a key assumption for our identification strategy. To verify whether there are considerable gains in terms of fit when we drop this assumption, we estimate the model with different location and scale parameters for the productivity distributions. The LR test of the null hypotheses of equality in the location and the scale parameters cannot be rejected at any reasonable significance level for both schooling groups. This means that our wage equation specification is flexible enough to accommodate differences in the wages distributions across sectors. See the supplementary online appendix for details.

with respect to the average productivity, are rewarded 0.1 for unskilled workers, while these deviations are penalized 0.03 in the case of skilled workers. To have an idea of the magnitude of these wage premiums, for a skilled and unskilled worker who are 20% less productive than the average, the total premium in the public sector is 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, skilled and unskilled workers who are 20% more productive than the average obtain 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. When this productivity is compared to the legal minimum wage (the minimum accepted productivity in the private sector) it indicates that the public sector hires workers who would not be hired in the private sector, given their productivity. This is particularly true for unskilled workers. Indeed, at the bottom of the productivity distribution, the unskilled workers' probability of being hired in the public sector is around 10% higher than being hired in the private sector, conditional on a job offer arrival. On the contrary, this sectoral difference in hiring 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. In this economy, for every vacancy there are six skilled workers looking to fill that vacancy. In the case of unskilled workers, for every vacancy there are only three workers looking to fill it. This result is explained by the fact that the observed average unemployment duration in the data is higher for high skilled workers (see Table 3, row 4). Finally, the private sector search cost is around 19 times the skilled workers' average wage and around 9 times the unskilled workers' average wage.

Finally, the bootstrap standard errors of the estimated parameters show that the estimation is quite precise for almost all parameters, except for the minimum accepted productivity in the public sector, the flow (dis)utility, and the vacancy cost, all for skilled workers.[24] Also, the LR test, presented in the bottom panel of Table 2, tells us to reject the null hypothesis that the best fit to the data occurs with the model without a binding minimum wage, at any

[24]We use bootstrap to calculate the standard errors because having a large mass of unskilled workers earning the minimum wage introduces problems when numerically computing the Hessian of the likelihood function. This problem does not occur for skilled workers. However, to maintain consistency with the method across schooling groups we use bootstrap for both types of workers.

acceptable significance level and for both skilled and unskilled workers. Of course, the null hypothesis is rejected 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 observations are worth mentioning. First, the overall fit of the model is very good, in particular for the moments related with the labor market status and the wages distributions. Second, four moments of particular interest, given the findings discussed in subsection 3.1, 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, the model adequately captures the majority of mass observed in the data. Finally, in terms of the wages distributions, the simulated densities in Figure 2 maintain the shapes of those obtained from the data. This is remarkable given that we only use 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. Excluding women from our sample implies that we eliminate around 40% and 50% of the total unskilled and skilled workers observations, respectively. Hence, we also estimated the model pooling men and women and the detailed estimation results can be found in a supplementary online appendix. We observed that, in general, the estimation results are similar, in terms of magnitude, to those in Table 2. Also, the estimated productivity distribution is skewed more to the right and less disperse when considering men and women in the sample. The average productivity is 18% lower for both types of 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 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. Finally, 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 66% 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 3.5 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 in Table 2, we consider the impact of different labor market policies on 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 increasing the minimum wage in the benchmark economy with the corresponding effects in an economy without the public sector. We further analyze how the specific features of the public sector employment policy interact with minimum wage increases by separately removing differences in hiring standards and in wage setting rules in both sectors. In both cases, the comparison is with respect to an economy without the public sector. In all these experiments, we assume that the estimated vacancy rate, that is the rate consistent with observed employment in the public sector, is the one necessary to provide a certain level of a public good. Hence, we keep it fixed. As a consequence, we let public sector employment adjust to policy changes.[25]

We report the effects of each counterfactual and policy experiment 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, considering the distribution of workers in the steady-state equilibrium of the model, the productivity distribution, and the values of each state of the labor market (Flinn, 2006). In particular, the welfare function for a type h worker, in the binding minimum wage case, is:

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

Since the productivity distribution in the model is the same for both sectors, we assume implicitly that the private and the public sectors share the same technology and produce the

[25]We also performed the counterfactual experiments maintaining the public sector employment constant. The results are very similar for all labor market outcomes considered in figures 3 to 6. In particular, the impact of increasing the minimum wage on both, the unemployment and the employment rate in the private sector, are attenuated when the public sector exists. In the case of the latter, since the employment rate in the public sector is fixed, the role of the public sector hiring rule is eliminated. The complete set of results can be found in a supplementary online appendix.

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

$$W = \sum_{h=1}^{H} \kappa(h) W(h). \tag{22}$$

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 the 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. In fact, the market tightness (θ) decreases from 0.323 to 0.302, generating lower contact rates in the private sector 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. The private sector employment rate decreases by more than one percentage point, while the public sector employment rate increases by 0.5 percentage points. The incidence of the minimum wage increases largely from 19% to 28% in the private sector, and from 12% to 22% 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 for unskilled workers. This effect is dominated by a composition effect. That is, the higher minimum productivity requirement induced by the higher minimum wage, is more than compensated with the reduction in unskilled employment in the private sector. The welfare effect of the minimum wage is largely negative for those workers, reducing our welfare measure (W_U) by nearly 7%, from 28.5 to 26.6.

The minimum wage policy also has an impact on schooling decisions. Since the unemployment effects are larger than the greater expected wage effect, the value of unemployment in the unskilled market falls, while that for skilled workers is almost unchanged. As a result, the difference between $U(2) - U(1)$ increases and so does the cut-off education cost $\sigma^*(2)$.

Given $\hat{\varphi}(2)$, this implies that $\kappa(1)$ decreases and the workforce education composition improves. In other words, the greater expected returns from participating in the skilled market leads to a higher fraction of workers in that market. This composition effect determines a low negative impact of the minimum wage on aggregate welfare, despite the large effects among unskilled workers mentioned above.

Shutting down the public sector

In the second counterfactual experiment, we compute the equilibrium in an economy without 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 in the private sector. This, in turn, leads to more vacancy creation in the private sector, and also to a higher market tightness (θ) and contact rate of vacancies. However, because of the stricter hiring productivity requirements in the private sector, it is more difficult for workers to be hired in this economy, leaving the average unemployment duration unchanged with respect to the benchmark 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, skilled workers' unemployment rate slightly declines from 0.069 to 0.067. Accepted wages are almost unchanged, and the incidence of the minimum wage increases slightly from 18.9% to 19.4% in the private sector. As expected, the output in the private sector increases greatly due to the increased supply of workers in that sector. However, unskilled workers' welfare falls mainly due to the increase in their unemployment rate. In terms of schooling decisions, the no public sector economy has a better skill composition of the workforce. Removing the public sector causes a smaller reduction of the skilled unemployment value compared to the unskilled value, and hence the cut-off cost for acquiring education increases. Loosing the generous wage and hiring policies from the public sector harms more the unskilled workers, as well as the returns of belonging in the unskilled market. Despite this favorable composition effect, the aggregate welfare decreases.

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 for these workers in the public sector reduces their employment in the sector by one percentage point. This 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, welfare, and human capital compositions are almost unchanged.

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 $\nu = 0$. 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. This small quantitative effect relates to the low impact of wages on vacancies in the public sector. That is, given the very low job destruction rate among the unskilled in that sector, the change in public sector vacancies is very small and so is the transmission to the private sector. On the other hand, as expected, public sector wages for unskilled workers are greatly reduced, and therefore the incidence of the minimum wage largely increases in the public sector. Productivity and education composition are 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 without public sector employment, as we vary the minimum wage. Additionally, we look at the extent to 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 for this result 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. 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 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 the 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 compute the ratio between the unemployment rate of the economy with equal hiring rules across sectors, $\underline{x} = m$, and the one with no public sector, $e_g = 0$, for different values of the minimum wage (dashed line in the top panel of Figure 3). In this case, the relative difference in unemployment rates is slightly smaller and it slightly decreases with the minimum wage. This means that removing differences between the hiring rules in the sectors increases unemployment for all the range of values of m considered. Moreover, the effect of the less restrictive hiring rule has a larger impact in explaining the buffer effect of public sector employment as we increase the minimum wage. Finally, when comparing the unemployment rate of an economy with a public sector and the same wage schedules across sectors ($\lambda = 0$ and $\nu = 0$) with an economy without the public sector (dotted line in the top panel of Figure 3), we find that the relative differences in unemployment rates are larger and they increase with the minimum wage. This suggests that the public sector wage policy reduces the buffer effect of public sector employment. This happens 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 very similar in magnitude for the different economies considered and for different values of the minimum wage. However, in line with the results regarding unemployment, unemployment duration tends to be slightly 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 three different public sector economies for different values of the minimum wage. As before, the horizontal axis graphs the ratios between the variables in the three different economies to those in an economy without the public sector. In panel (a), the private sector employment is, as expected, greater in an economy without a public sector than in an economy with a public sector employer. This difference increases as 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, in the economy with no differences between the hiring rules in the sectors, private sector employment increases relative to that in the benchmark economy. This suggests that the lower hiring requirement in the public sector in the benchmark economy is an important determinant of the lower private sector employment rate, 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 smaller in the benchmark economy than in the economy without the public sector, $e_g = 0$. This difference is quite large for low levels of the minimum wage and almost disappear for high enough levels of m. This mainly occurs because of the public sector wage policy, which particularly benefits unskilled workers. If there were no differences in wage schedules, the incidence of the minimum wage would be closer to the one in the economy without the 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. If instead the hiring rules in the sectors were the same, the aggregate incidence of the minimum wage would not change by much.

Productivity and Welfare

In Figure 5, panels (a) and (b), respectively, we show the relative values of productivity in the private sector and the total welfare in an economy with public sector employment, with respect to an economy without the public sector. At the observed minimum wage, private sector productivity in the benchmark economy is around 81% of the corresponding level in the economy without the public sector. This ratio decreases with the minimum wage. On the one hand, we find that with no differences between the hiring rules in the sectors, the productivity differences with respect to the economy without the public sector would get reduced, especially for high levels of the minimum wage. Indeed, in the benchmark economy, the differences between hiring rules in the public and the private sectors are smaller for low values of the minimum wage; the productivity differences are also smaller. As the differences in hiring standards increase with the minimum wage, the productivity differences also increase. We also find that if the wage setting rules in the sectors were the same, then the productivity differences would also get reduced. In any case, increasing the minimum wage amplifies the productivity differences between the economy, with and without a public sector.

Finally, welfare is larger with a public sector employer than without it. This relative welfare gain does not vary greatly with the minimum wage. This implies that the standard negative employment effects of the minimum wage in the private sector are more than compensated by the frictions reducing effects of the public sector employment. When analyzing the contribution of the different features of public sector employment to the welfare gain, we observe that both the hiring rule and the wage setting rule are relevant. If wage schedules were the same in the two sectors, then the welfare differences in the economy without the public sector would almost disappear. Furthermore, if hiring rules were the same across sectors, then the welfare differences in the economy without the public sector would be smaller, specifically for high levels of the minimum wage. This means that with a low minimum wage, the difference between hiring rules in the public and the private sectors is low. Therefore, the more generous wage policy in the public sector makes the job more attractive for workers. The wage policy in the public sector also matters for high values of the minimum wage. However, the lower hiring standards in the public sector also have an important role in attracting workers.

Schooling Decision

As observed in Table 4, the benchmark economy has a larger fraction of unskilled workers compared to the economy without the public sector. As shown in Figure 6, this feature is more pronounced for larger values of the minimum wage, despite the fact that the increase in m leads to a reduction in the proportion of unskilled workers, $\kappa(1)$, in the benchmark economy (see Table 4). Thus, increasing the minimum wage improves the skill composition by more in the economy without the public sector than in the benchmark economy. In explaining this pattern, the contribution of the public sector hiring rule is very small for low levels of the minimum wage, but large for higher values of it. Additionally, the public sector wage schedule seems to have an important role in explaining the worse skill composition of the benchmark economy for all the values of the minimum wage in the figure. The worse skill composition is associated to a smaller difference between the unemployment values of both worker types, $U(2)-U(1)$. This, in turn, determines a lower reservation value for $\sigma^*(2)$, the minimum required education cost to access the high type market. Relative to the economy without the public sector, this difference in unemployment values is smaller and decreases with the minimum wage. Both the lower productivity standards and the wage rule in the public sector disproportionately increase the unemployment value for the unskilled workers, and these effects are increasing with the minimum wage.

5 Model Extensions

In this section, we show the results of our counterfactual experiments under two extensions of the model, namely allowing for endogenous search effort and introducing payroll taxes to fund the government wage bill. In the former case, it is possible that a worker would optimally search for jobs with different intensities, depending on the sector, because the hiring, termination and wage conditions are different between the private and public sectors. In the latter case, a higher minimum wage increases wages in both the private and the public sectors, making it necessary to incorporate an aggregate public sector budget constraint. In this section, we briefly describe the main ideas of both extensions and discuss how the counterfactual results compare with those found in subsection 4.2.[26]

In the first extension, we introduce optimal search effort decisions in the unemployment state as in Mortensen (1986). Specifically, in each sub-market h, we normalize the search effort for private sector jobs to 1 and let the search intensity for public sector jobs be an endogenous variable $s(h)$. Additionally, we assume that exerting effort is costly, making the net flow utility of unemployed workers equal to $z(h)-\frac{s(h)^2}{2}$ in equation (1).[27] At the same time, making more effort increases the likelihood of meeting a public sector vacancy by affecting the arrival rate of these types of jobs, $\alpha^g(h)s(h)$. In this setup, as it is standard, the level of $s(h)$ is set to maximize the value of unemployment in each sub-market h, and the hazard rate out of unemployment to public sector jobs becomes $\alpha^g(h)s(h)\widetilde{G}(\max\{\underline{x}(h), x_g^*(h)\}|h)$. The rest of the model remains the same.

In the second extension, we introduce a standard payroll tax paid by the worker to partially fund the public sector wage bill (see for example Pissarides, 2000). Specifically, the after tax wage rate in the sub-market h is $w_s(x,h)(1-\tau)$ in equation 2, where τ is the

[26]A detailed exposition of both extensions can be found in a supplementary online appendix.

[27]Without any information in the data about the search process, other than unemployment duration, we assume that the cost function is quadratic.

tax rate and $s = p, g$. Since payroll taxes reduce the value of employment, and hence affect the total surplus of the match, the workers' outside option in the resulting Nash bargained wages is adjusted upwards, and is $\rho U(h)/(1-\tau)$. Given that unemployment is not taxed, the outside option becomes more attractive as τ increases. The tax rate is then chosen endogenously such that the aggregate budget constraint of the public sector holds for all h sub-markets, that is:

$$\tau\left[\sum_{h=1}^{H}\int w_p(x,h)dG(x|h)e_p(h)\right] = (D-\tau)\left[\sum_{h=1}^{H}\int w_g(x,h)dG(x|h)e_g(h)\right]$$

where D is the proportion of the total wage bill funded by these taxes.[28] The rest of the model remains the same.

In Figure 7, we show the counterfactual results of both model extensions for the unemployment rate, the incidence of the minimum wage, productivity in the private sector and welfare. As in the previous section, the figures show the ratios of each labor market outcome in the economy with a public sector relative to the economy without the public sector (with $e_g = 0$). As can be observed in panel (a) of the figure, both endogenous search effort and taxes strengthen the result that the overall unemployment rate with a public sector is lower than in an economy without the public sector. Intuitively, endogenous search for public sector jobs help to reduce search frictions and unemployment relative to the economy with only a private sector (where search is exogenous by assumption). In addition, the economy with taxes has a lower unemployment rate compared to the benchmark economy.

Panel (b) reports the effects of increasing the minimum wage in the model extensions on the incidence of the minimum wage. In the economy with taxes, the minimum wage incidence increases largely, a result that is related with a decrease in the value of unemployment due to the tax. In the case of endogenous search effort, such as in the benchmark economy, the incidence of the minimum wage is lower when there is a public sector compared with the $e_g = 0$ case. In terms of the effects on private sector productivity, panel (c), we observe that while endogenous search effort has a positive impact on observed productivity, taxes reduce productivity in the private sector economy relative to the economy without the public sector. Finally, panel (d) shows that while endogenous search effort is welfare improving, introducing a payroll tax has a large negative impact on welfare. Actually, with taxes, there is a welfare loss from running an economy with a public sector instead of having $e_g = 0$. This result suggests that, as long as we consider the costs of funding a public sector, the

[28]We assume that only a proportion of the total wage bill is financed by payroll taxes to avoid incredible high tax rates. In particular, we choose D to keep τ around 10% in the benchmark case.

welfare gains of having a public sector employer get reduced. Obviously, these costs have to be weighted against the utility of the public sector as a public goods producer, something that we have ignored here.

6 Concluding Remarks

This paper develops a search and matching model with a public and a private sector, a mandatory minimum wage, and endogenous pre-labor market human capital investment. The model is estimated for skilled and unskilled workers using 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 with 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 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 is that the existence of the public sector negatively affects the private sector productivity and generates a larger fraction of unskilled workers, as the minimum wage increases. Finally, since 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. 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

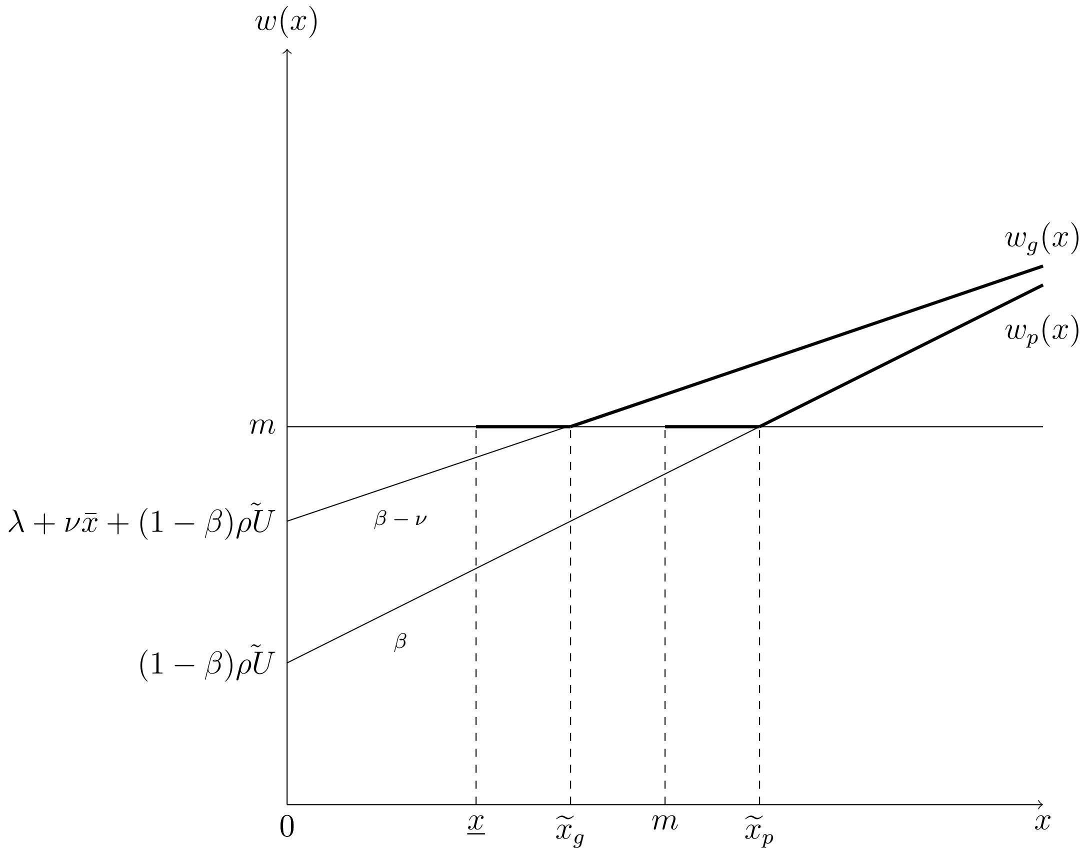


Figure 2: Wage schedules in the private and the public sectors

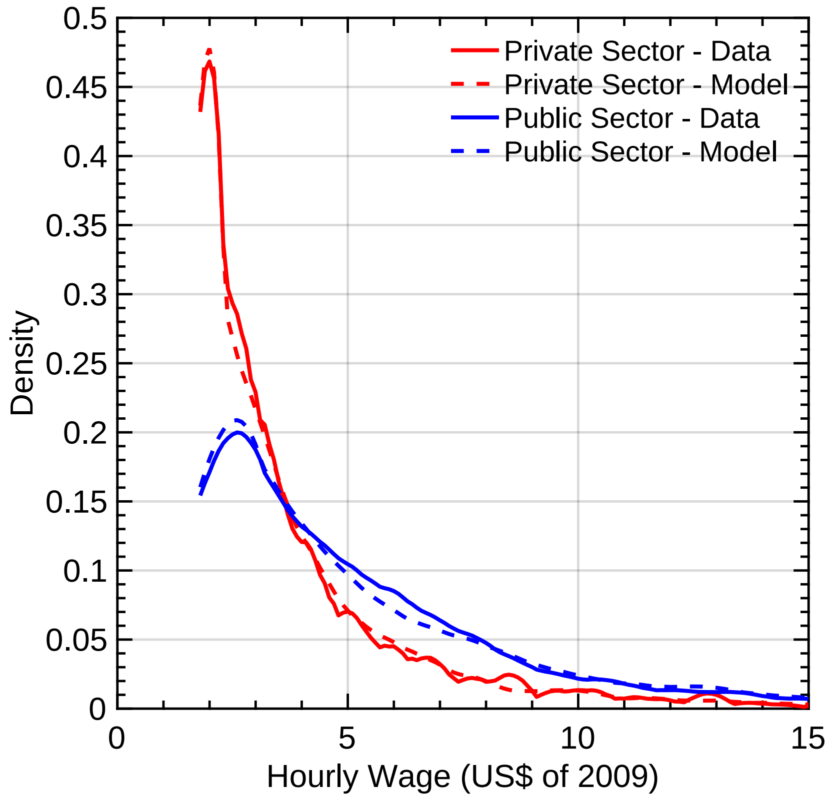
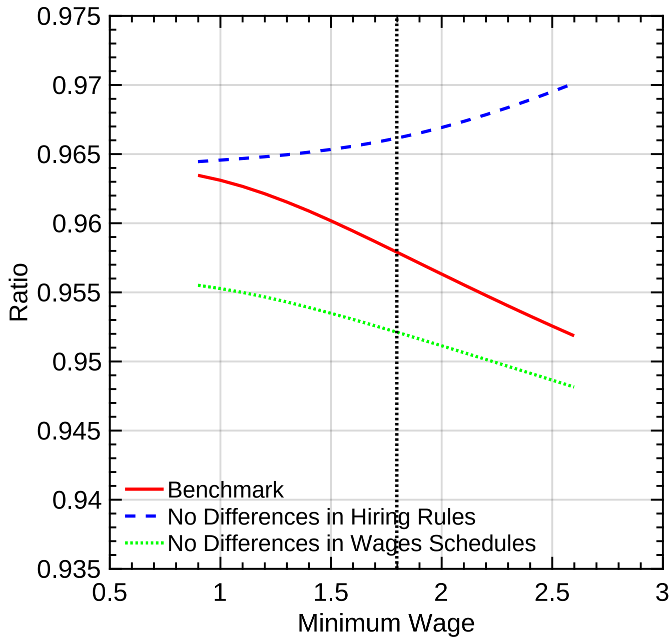
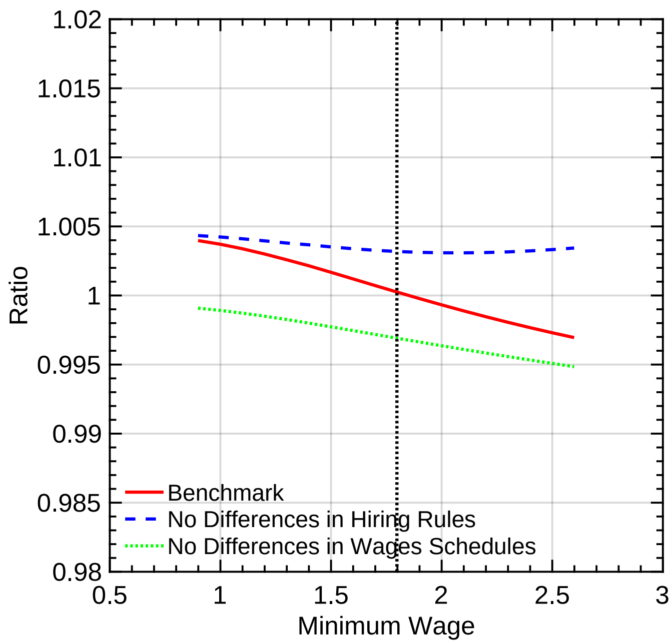


Figure 3: Counterfactual scenarios: Unemployment



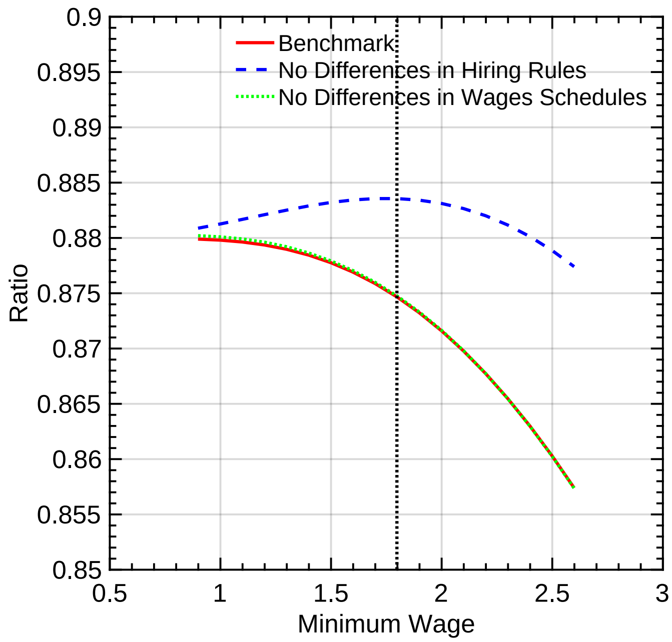
(a) Unemployment rate



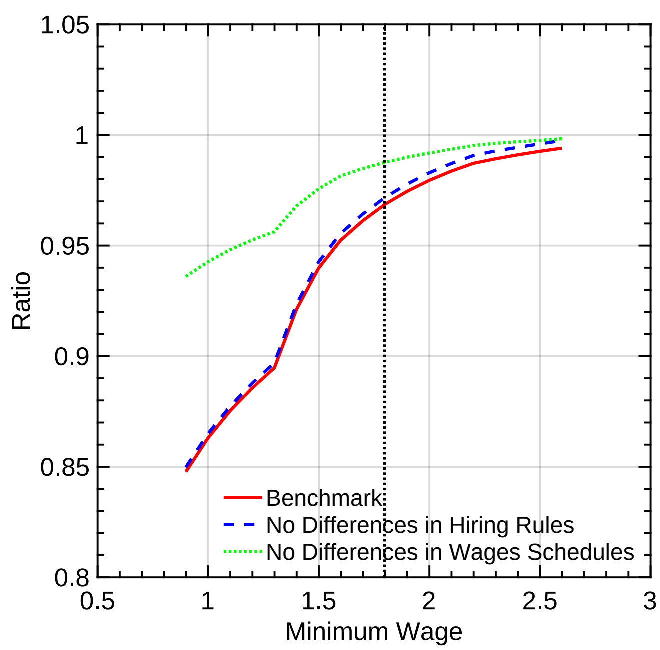
(b) Unemployment duration

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



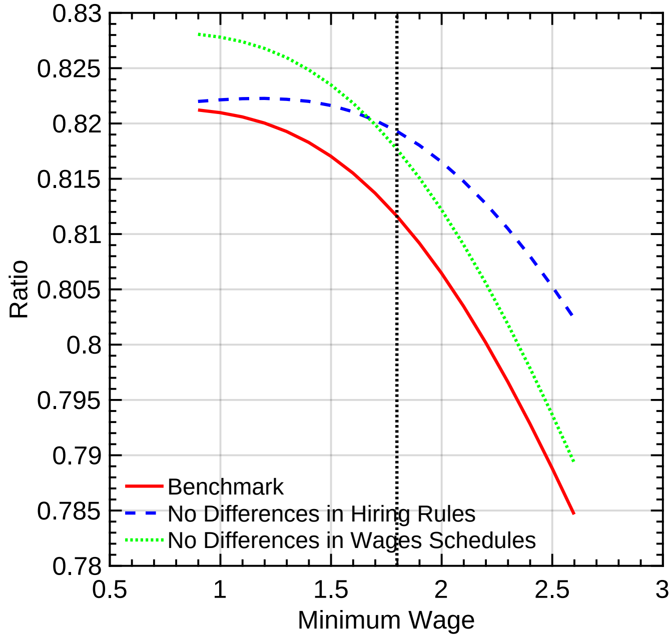
(a) Employment rate



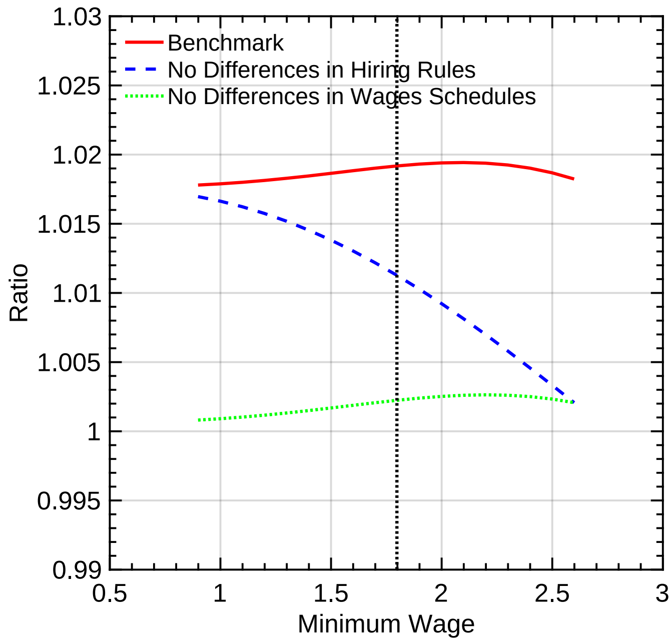
(b) Incidence of the minimum wage

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



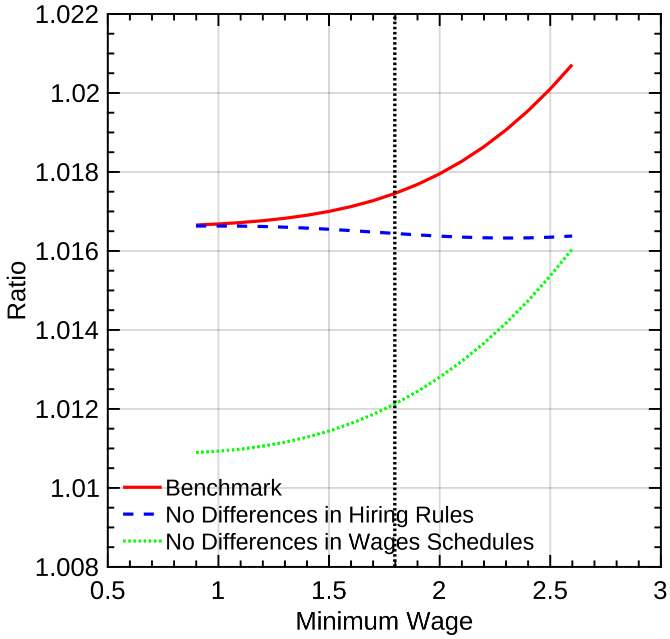
(a) Productivity in the private sector



(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.

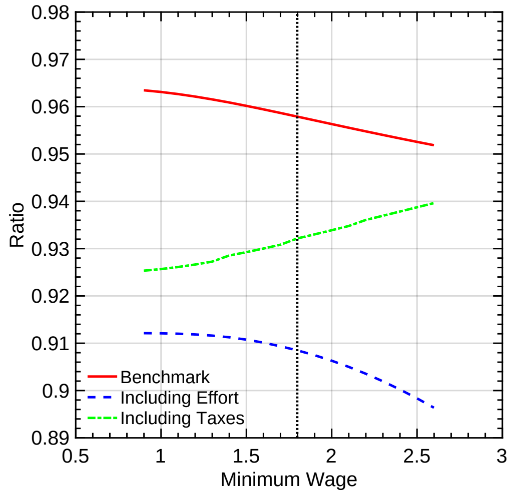
Figure 6: Counterfactual scenarios: Schooling decision



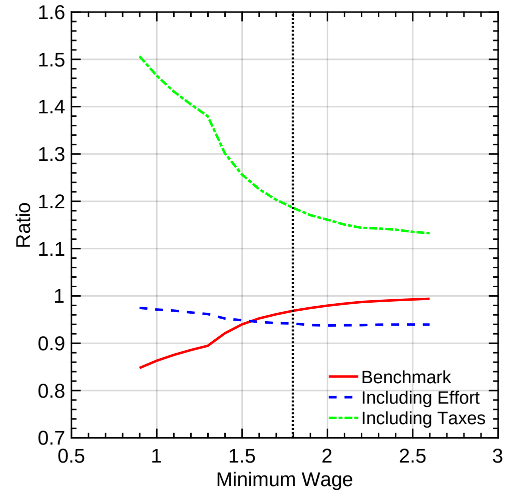
(a) Proportion of unskilled workers

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.

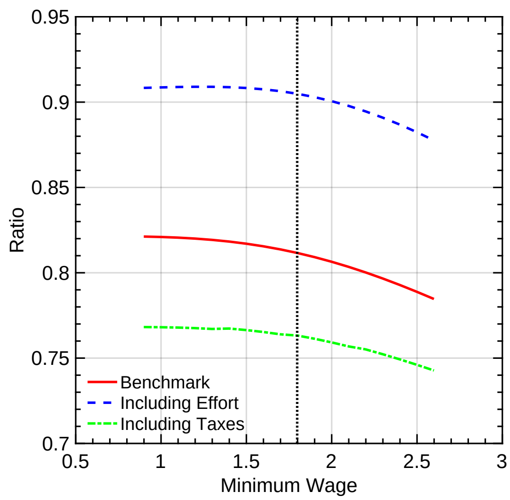
Figure 7: Counterfactual scenarios under model extensions



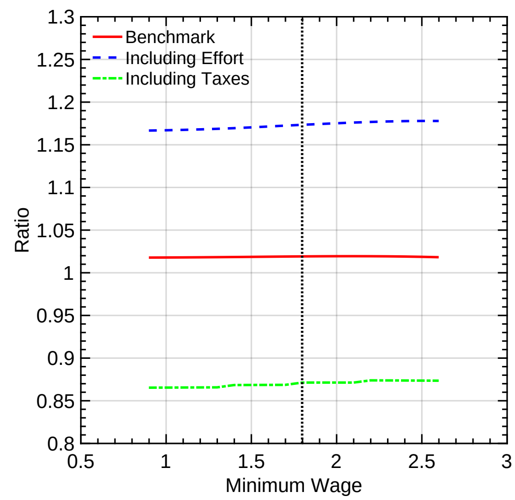
(a) Unemployment rate



(b) Incidence of the minimum wage



(c) Productivity in the private sector



(d) 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 5 percentiles at the bottom and 1 percentile at the top 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
φ	-	-	0.0140	0.0065
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	13225		34	
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
$\Pr[u \to e_p]$	0.960	0.960	0.702	0.702
Accepted Wages				
$E[w\|e_p]$	3.272	3.261	9.745	9.613
$SD[w\|e_p]$	3.793	3.808	9.551	9.574
$E[w\|e_g]$	2.063	1.972	7.148	7.044
$SD[w\|e_g]$	2.306	2.398	6.410	6.572
$E[w\|e_p]/E[w\|e_g]$	0.862	0.856	1.020	1.004
Minimum Wage Incidence				
$\Pr[w_p = m]$	0.220	0.221	0.003	0.003
$\Pr[w_g = m]$	0.142	0.139	0.002	0.000
Human Capital Distribution				
$\Pr[h = U]$	0.865	0.865	0.135	0.135

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	0.925	1.000	0.929	0.928
θ	0.323	0.302	0.327	0.324	0.325
α_p	0.462	0.441	0.494	0.462	0.463
α_g	0.029	0.029	–	0.029	0.029
$E[t\|u]$	2.287	2.505	2.287	2.294	2.280
Labor Market States					
u	0.086	0.093	0.090	0.086	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	0.784	0.910	0.804	0.796
$e_{U,p}$	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	0.123	–	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					
$E[w\|e_p]$	4.117	4.370	4.199	4.122	4.138
$E[w_U\|e_p]$	3.261	3.411	3.233	3.260	3.252
$E[w_S\|e_p]$	9.613	9.634	9.692	9.617	9.618
$E[w\|e_g]$	4.585	4.739	4.665	4.816	4.010
$E[w_U\|e_g]$	3.808	3.842	3.788	4.055	3.096
$E[w_S\|e_g]$	9.574	9.658	9.656	9.670	9.662
$E[w\|e_p]/E[w\|e_g]$	0.876	0.905	0.876	0.830	1.043
Minimum Wage Incidence					
$\Pr[w_p = m]$	0.192	0.280	0.194	0.190	0.192
$\Pr[w_g = m]$	0.121	0.221	0.124	0.034	0.267
Output and Welfare					
y_p	5.235	5.262	6.451	5.285	5.275
$y_{U,p}$	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	1.159	–	1.013	1.085
$y_{U,g}$	0.503	0.515	–	0.436	0.501
$y_{S,g}$	4.695	4.695	–	4.687	4.695
W	38.844	38.730	38.113	38.543	38.198
W_U	28.513	26.625	26.157	28.090	27.359
W_S	105.184	105.126	106.082	105.171	105.185
Human Capital Distribution					
$\Pr[h = U]$	0.865	0.846	0.850	0.864	0.861

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)			
Pre Labor Market	$S(h)$	$\kappa(h)$	–	–	–
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 (10) if the minimum wage is not binding.
   - Find $\rho U(h)$ iterating equation (12) if the minimum wage is binding.

   (d) Find the labor market tightness

   - Compute $\vartheta(h)$ and find θ solving equation (11) if the minimum wage is not binding.
   - Compute $\vartheta(h)$ and find θ solving equation (13) if the minimum wage is binding.

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

2. Find $\phi(h)$ using the steady state conditions in (14) and equation (15).

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

4. Given $U(h)$ for all h, compute $\sigma^*(h)$ and $\kappa(h)$.

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 primary education (lower that 8 year of schooling), complete primary 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 complete 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 we obtain the best fit in one sector, either the private or the public sector, 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 fit.

Table B.1: Fit of the Aggregated Wages Distributions

Groups	Years of Schooling	Private Sector	Public Sector	Weighted Average
2	$[0-17-30]$	0.0907	0.2473	0.1109
3	$[0-13-17-30]$	0.0639	1.6336	0.2660
3	$[0-15-17-30]$	0.1120	3.1115	0.4982
4	$[0-9-13-17-30]$	0.2911	0.3838	0.3030
4	$[0-13-15-17-30]$	0.2389	0.7127	0.2999
5	$[0-9-13-15-17-30]$	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:

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

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

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