

Labor Market Responses to Payroll Tax Subsidies

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Abstract

In a high tax, high minimum wage labor market like France, payroll subsidies can reduce the minimum labor cost and expand employment opportunities for the low-skilled. Effects of these subsidies go beyond the directly affected. A particular concern is that high quality jobs may be replaced with lower quality ones, which hurts the employment opportunities of highly skilled workers and is costly for the aggregate productivity. We quantify the direct and indirect effects payroll tax subsidies using an equilibrium search-and-matching model estimated from the French administrative data. We find that concentrating payroll subsidies to minimum wage jobs has distributional advantages, but it has negative effects as job creation from low-productivity firms makes it harder for high-productivity workers to find suitable employment. Using our framework, we are able to determine which jobs should benefit from payroll subsidies. We also note that the nominal incidence of a tax subsidy affects equilibrium outcomes when a statutory minimum wage is present. However, our simulation shows that, when combined with an appropriate minimum wage reduction, an employee subsidy has similar effects as an employer subsidy.

1 Introduction

In France, heavy payroll tax burdens and a high statutory minimum wage lead to concerns that no employment opportunity is available for low skilled workers. Since the 1990s, policy makers have

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introduced a series of payroll tax reductions for low-wage work in an effort to boost job creation. Effects of such policies have been widely studied, but previous research has mainly focused on those who are directly targeted by the tax reductions.¹ Nevertheless, empirical evidence suggests that the effects on individuals who are not directly targeted can be substantial and undesirable.² In particular, a concern over the French low-wage tax reductions is that high-productivity jobs may be replaced with less productive ones, hurting employment opportunities of the those who are not directly targeted and pulling down the aggregate production.³

In this paper, we quantify the equilibrium effects on job opportunities for workers within and beyond the direct reach of tax reductions. To do so, we develop a search-and matching model in which workers and firms who are endowed with respectively different levels of productivity. Search frictions lead to mismatch, and a statutory minimum wage restricts the set of firms with whom a worker can match and carry out production. Low-wage payroll subsidies allow previously unviable jobs to become viable, which can trigger responses from both labor supply and demand. In particular, low-productivity firms may create additional jobs. While these jobs are welcomed by some individuals, they may negatively affect those looking for better employment opportunities as these opportunities become harder to find when the low-productivity jobs disproportionately make up the pool of job offers.

We have two objectives. Our main objective is to understand the implications of expanding the wage coverage of payroll subsidies. In the past decades, France has implemented low-wage payroll subsidy programs with increasingly broader coverage. The implications of the coverage broadness are not well understood. A program that strongly subsidizes minimum-wage jobs may have distributional advantages, but it may lower the employment rate of high-productivity workers and have negative consequences for the aggregate production output, particularly when workers and firms are complementary in production. This is the efficiency-equity trade-off involved in determining the optimal wage coverage of a tax reduction policy.

Despite a voluminous literature on the effects of tax reduction programs, only a few studies consider effects of payroll subsidies that go beyond the population that is directly affected. Recently, Chéron et al. (2008) and Shephard (2016) consider tax reduction policies in equilibrium search models, but they do not capture the efficiency-equity trade-off that is central to our analysis. Chéron et al. (2008)

¹For example, see Kramarz and Philippon (2001) and Bunel and L'Horty (2012). More generally, most studies in the empirical literature of tax reduction evaluations ignore the tax incidence on firms by assuming a perfectly elastic labor demand. This has led Hotz and Scholz (2003) and Nichols and Rothstein (2015) to conclude that the incidence effect is under-studied in the literature on the EITC program, a tax credit program in the U.S..

²For example, Rothstein (2008) and Leigh (2010) find that the EITC program in the U.S. leads to decreases in wages for low-productivity workers who do not participate in the program. Azmat (2006) find similar effects from the WFTC program in the UK.

³In a report to the Council of Economic Analysis in France, Malinvaud (1998) suggests that low-wage subsidies may have negative productivity consequences. For empirical evidence, see Crépon and Desplatz (2003).

study a wage-posting model with ex-ante similar workers and on-the-job search. Aggregate productivity is determined by firms' decision to invest in workers' specific human capital. Their model implies a strictly negative relationship between the quantity and quality of jobs: more vacancies lead to faster worker turnover, which in turn leads to lower human capital investments. Our model differs from theirs in that we allow for ex-ante productivity heterogeneity in workers. Different tax subsidies may lead to job creation for different workers, and thus an increase in the quantity of jobs does not necessarily imply a decline in the quality. Moreover, the worker heterogeneity allows us to study the distributional aspect of a policy, which is not the focus of Chéron et al.. Shephard (2016) studies the equilibrium effects of the WFTC in the U.K.. In his model, individuals are only heterogeneous in their outside options. This limits the discussion of distributional benefits of a low-wage payroll subsidy as such a policy would expand benefit those with a high outside option, rather than the disadvantaged individuals. In addition, the productivity effects of the WFTC are limited given that the U.K. does not feature the high minimum labor cost problem like France.

Our second objective is motivated by the difference in the nominal incidence between the French payroll tax reductions and the tax credit programs such as the EITC in the U.S. and the WFTC in the U.K..⁴ In France, tax reductions are applied to the employer share of the payroll tax, whereas in the U.S. and the U.K., tax credits are given to workers. While the nominal incidence is irrelevant in most equilibrium models, it would affect the equilibrium outcomes when a statutory minimum wage is present.⁵ Applying tax reductions to employees rather than employers would effectively increase the legal minimum net income from employment; it is often argued by advocates for employee tax reductions to be a way to ensure that workers capture the benefits of tax reductions. Employee tax reductions combined with a lower minimum wage constitute a policy alternative for employer tax reductions. Our objective is then to examine the implications of this alternative policy.

Methodologically, the wage determination structure in our model builds on Cahuc et al. (2006), who assume that wages are set through a combination of employer-employee bargaining and competition between incumbent and poaching firms.⁶ We allow for a non-linear payroll tax and a statutory minimum wage to influence the wage determination. In particular, we assume that a bargained wage allocates fixed shares of net-of-tax match surplus to the worker and the firm, and the worker receives the minimum wage if it is feasible and greater than the bargained wage.⁷ The payroll tax influences wage bargaining because the surplus shared between the employer-employee pair

⁴“EITC” refers to the Earned Income Tax Credit and “WFTC” refers to the Working Family Tax Credit. For institutional details of these programs, see, for example, Hotz and Scholz (2003) and Nichols and Rothstein (2015) on EITC, and Blundell and Hoynes (2004) on WFTC.

⁵Gross wage is the wage before employee payroll taxes.

⁶Such wage determination mechanism is first considered in Dey and Flinn (2005), and has been a common assumption in the search-and-matching literature (Bagger and Lentz, 2014; Lise et al., 2013).

⁷Our assumption regarding the minimum wage is borrowed from Flinn (2006) and Mabli and Flinn (2007). While Cahuc et al. (2006) also consider a minimum wage in their appendix, they assume that workers may use the minimum wage as their outside option in their bargaining with the employer.

shrinks with wage.⁸ It also influences the competition between firms because firms compete with the maximum net-of-tax wage that they are able to offer to a worker.

We estimate our model using the simulated method of moments based on French administrative data from the Annual Declaration of Social Data (DADS). Using the estimated model, we first consider employer tax reductions under between 1995 and 1997. Our simulation indicates that vacancies increase by 4.8%, employment increases by 2.5%, and aggregate production increases by 1.2%. However, if we do not allow firms to change their vacancy creation decisions, both employment and aggregate production would have been higher. As the increase in vacancies concentrate in low-productivity firms, it shrinks employment growth by 9% and shrinks aggregate production growth by 18%.

Next, we simulate tax reductions of the same magnitude but assume that they are applied to employees. We find that in order for the employee tax reductions to generate the same increase in the level of employment, the minimum net wage has to be lowered by 12.7%. The combination of employee tax reductions and a lowered minimum wage lead to strikingly similar equilibrium outcomes as the employer tax reductions. The choice between the policy alternatives thus hinges on practicality - with an existing high minimum wage and political pressures against adjusting it downward, offering employer tax reductions is a sensible decision for France.

Finally, we turn to the question of whether an optimal tax reduction policy entails concentrating subsidies to minimum wage jobs or spreading subsidies to a broader wage coverage. In particular, we focus on a family of subsidy programs that grants the highest subsidy to minimum wage jobs. We parametrize the subsidy function with two parameters governing the coverage and the generosity. To compare alternative subsidy programs, we assume that tax revenues that are not used for non-employment benefits are redistributed in a lump-sum transfer. We also adopt a social welfare function parametrization that allow the policy maker to care more about the consumption of the less well-off than others.

We simulate equilibrium welfare of subsidy programs of different levels of coverage and generosity employment with the restriction that the raise the baseline employment to certain levels. Our results indicate that the optimal coverage broadens with the intended employment growth. A subsidy that covers jobs with wage less than 1.3 times the minimum wage is optimal in raising employment in our estimated environment by 2%; to raise employment by 3% or 5%, the optimal coverage threshold becomes 1.7 and 2.1 times the minimum wage respectively. Moreover, of the three employment targets we consider, the most ambitious one results in the highest welfare gain.

In the rest of the paper, we begin by characterizing the equilibrium search and matching model in Section 2. We describe the data in Section 3. We present our estimation strategy and results

⁸We assume that the payroll tax is non-decreasing in the net wage.

in Section 4. In Section 5, we apply our estimated model to studying the equilibrium effects of the payroll subsidies that were implemented between 1995 and 1997. In Section 6, we discuss why the nominal incidence of a payroll subsidy matters, and compare employee subsidies to employer subsidies. In Section 7, we compare the equilibrium effects of different subsidy coverages and look at how different employment goal affect the optimal coverage. Finally, we conclude in Section 8.

2 Model

In this section, we present an equilibrium search-and-matching model in which wages are determined via a similar process as Cahuc et al. (2006) and are subject to a statutory minimum wage and a payroll tax. We begin this section by introducing model assumptions in Subsection 2.1. In Subsection 2.3 we describe the matching and wage determination procedure. We characterize the value functions in Subsection 2.4. We define the steady state equilibrium and derive some equilibrium properties in Subsection 2.5.

2.1 Environment

There is a unit measure of risk-neutral workers who are heterogenous in the productivity level. Let x be the type, or rank, of a worker according to her productivity; without loss of generality, let x be uniformly distributed in the interval $[0, 1]$. The productivity of worker x is $\mathfrak{h}(x)$ with $\mathfrak{h}'(x) > 0$. At each instant, a worker is either employed or non-employed. Non-employed individuals can choose to participate in job search by paying a flow cost of q . If they do so, they are categorized as unemployment and are regarded as a part of the labor force. Otherwise, the individuals are categorized as non-participation and are out of the labor force. The search cost captures the difference between the the discomfort of search and the stigma of not looking for jobs. Let E , U , and N denote the measures of the workers in the three states respectively, with $E + U + N = 1$. Let $u(x)$ denote the measure of unemployed workers of type x such that $\int_x u(x)dx = U$. We assume that all employed workers search on-the-job at zero cost. The difference between on- and off-the-job search is captured by the difference in the search efficiency. We normalize unemployment search efficiency to 1, and let the on-the-job search efficiency be s_1 .⁹ The sum of search intensity is denoted by $\xi = U + s_1 E$. An employed worker receives a wage determined endogenously. A non-employed

⁹A positive on-the-job search cost may induce assortative matching similar to Bagger and Lentz (2014), which will affect the estimated decomposition of wage dispersion. However, since our focus is not on job-to-job transition or wage dispersion, allowing for a positive on-the-job search cost is beyond the scope of this paper.

individual of type x receives flow benefit $B(\mathfrak{h}(x))$. We assume that the benefit is increasing in worker's productivity.¹⁰

There is a continuum of firms that are heterogenous in the productivity level. We define y as the type, or rank, of a firm according to its productivity, and $\mathfrak{p}(y)$ as the productivity of firm y . We assume that y is uniformly distributed over some interval $[0, y_h]$, where y_h is a model parameter to be normalized. Note that it is possible that not all firms are active. Let y_l denote the type of the least productive firm; it is endogenously determined by the minimum wage requirement, taxes, and the most productive worker. Firms choose the number of vacancy to post.¹¹ Let $v(y)$ be the measure of vacancies posted by firm y , and let the total measure of vacancies be $V = \int_0^{y_h} v(y)dy$. The unit price of posting $v(y)$ vacancies is $c(v(y))$. The vacancy cost is positive and strictly increasing, i.e. $c(\cdot) > 0$ and $c'(\cdot) > 0$.

When a vacancy is filled, the firm collects the production output $F(\mathfrak{h}, \mathfrak{p})$, pays net wage to the worker, and pays taxes $T(w)$ to a government sector. We assume that the production output is increasing in both worker and firm productivities: $F_{\mathfrak{h}}(\mathfrak{h}, \mathfrak{p}) > 0$ and $F_{\mathfrak{p}}(\mathfrak{h}, \mathfrak{p}) > 0$ for all $\mathfrak{h}$ and $\mathfrak{p}$. Moreover, we assume free disposal of production output. Formally, in a match (x, y) , the firm can choose any level of output $f \in [0, F(\mathfrak{h}(x), \mathfrak{p}(y))]$.

The measure of matches between a pair (x, y) is given by $h(x, y)$. We have $E = \int_0^{y_h} \int_0^1 h(x, y) dx dy$. A match may be destroyed by nature at rate δ , or destroyed endogenously if a worker transitions to another firm.

Search is random. The measure of realized meetings depends on the sum of search intensity ξ and the sum of vacancies V . Let $M(\xi, V)$ be a constant-return to scale meeting technology that maps ξ and V to the flow measure of meetings. For convenience, we define $\kappa \equiv \frac{M(\xi, V)}{\xi V}$. The rates of meeting a vacancy of rank y for an unemployed and an employed worker are, respectively, $\kappa v(y)$ and $s_1 \kappa v(y)$. The rates that a vacancy meets an unemployed and employed worker of rank x are, respectively, $\kappa u(x)$ and $s_1 \kappa \int_0^{y_h} h(x, y) dy$.

2.2 Policies

We consider two labor market policies. The first is a statutory wage floor on the net wage, w_{min} . The second is a payroll tax $T(w)$ collected on the net wage w . To ensure the existence and uniqueness of wage bargaining solutions, we assume that the tax schedule is continuous and monotonically increasing in the net wage. The assumptions allow for a flexible specification of the tax function

¹⁰As we will explain later, we consider $B(\mathfrak{h}(x))$ as the non-employment transfers which in practice is linked to the individual's previous wage. It is thus plausible to have $B' > 0$.

¹¹As common in the search literature, we do not consider potential interactions between jobs within the same firm.

$T(\cdot)$, which accommodates the possibility of kinks in the tax schedule and non-monotonicity in the marginal tax rate, both of which are common in the tax system we consider for our empirical applications.

We model the policies in terms of the net wage because it is what affects individual utility. In practice, the payroll tax (social security contributions in France) is shared between employers and employees, and rather than a minimum net wage, the actual minimum wage requirement is a wage floor on the gross wage, which is the sum of net wage and the employee portion of the payroll tax. Nevertheless, in a steady state equilibrium, the institutional environment in our model is effectively identical to the one in practice because the nominal incidence of the payroll tax does not affect equilibrium outcomes. This is because we derive our minimum net wage, w_{min} , from the minimum gross wage by deducting the employee payroll tax. Without changes to the tax schedule or other policy changes, the net and gross wage floors are equivalent.

It should be noted that when the tax schedule changes, whether the change is made to the employer or the employee share of the payroll tax has different implications for equilibrium outcomes. We will return to the nominal incidence of tax changes in Section 6.

2.3 Match Formation, Wage Determination, and Job-to-Job Transitions

At the core of our model is the interactions between workers and firms when a bilateral meeting takes place. When an unemployed worker and a vacancy meet, they determine whether or not to form a match and the wage at which the match would proceed. When an employed worker and a vacancy meet, the process first involves a competition between the incumbent and the poaching firm, which is followed by a negotiation between the winner of the competition and the worker. If the winner happens to be the poaching firm, the worker would make a job-to-job transition. The minimum wage and taxes influence these processes in significant ways, which we will discuss in detail below.

2.3.1 Match between an unemployed worker and a job

When an unemployed worker x meets a vacancy y , there are two steps in determining whether to match and what the wage is. In the first step, the worker-firm pair determine a “bargained” wage ϕ which effectively allocates α share of the net-of-tax match surplus to the worker and $(1 - \alpha)$ to the firm.¹² If such ϕ exists, the pair proceeds to the second step, in which the pair compares ϕ to

¹²We choose the proportional bargaining scheme rather than the Nash bargaining scheme because we wish to accommodate a flexible specification for the tax function that may contain kinks and non-monotonicity in the marginal

w_{min} . If $\phi \geq w_{min}$, the pair forms a match at wage $\phi_u(x, y)$. If $\phi_u(x, y) < w_{min}$, a match is only formed if the net surplus is positive at w_{min} , in which case the match wage is equal to w_{min} .

Formally, let $W_n(x)$ denote the value of non-employment for worker x , $W_e(w, x, y)$ denote the value of employment for worker x who is paid wage w in job y , $J_u(y)$ denote the value of an unfilled vacancy from firm y , and $J_f(w, x, y)$ denote the value of a filled job from firm y employing worker x at wage w . The net surplus of a match is defined by

$$S(w, x, y) = W_e(w, x, y) - W_n(x) + J_f(w, x, y) - J_u(y) \quad (1)$$

The bargaining power of workers and firms are α and $1 - \alpha$, respectively. The bargained wage ϕ must satisfy the following system

$$\begin{cases} W_e(\phi, x, y) - W_n(x) = \alpha S(\phi, x, y) \\ S(\phi, x, y) \geq 0 \end{cases} \quad (2)$$

Definition 1. A match is viable if ϕ that solves 2 exists and either of the following holds:

1. $\phi \geq w_{min}$, or
2. $\phi < w_{min}$, $W_e(w_{min}, x, y) - W_n(x) \geq 0$ and $J_f(w_{min}, x, y) - J_u(y) \geq 0$.

Let $\mathcal{A}_u(x) \subseteq [0, y_h]$ be the subset of firms such that an unemployed worker x is willing form a viable match with. If a match is viable, the match wage is $\phi_u(x, y) = \max\{\phi, w_{min}\}$; this is the wage at which the match proceeds.

2.3.2 Meeting between an employed worker and an outside firm

When an employed worker x meets a vacancy from a poaching firm, the incumbent firm and the poaching firm compete over the worker. We first introduce the “best match wage” $\bar{\phi}(x, y)$, defined to be the wage the firm y can offer to worker x that maximizes her value in employment:

$$\bar{\phi}(x, y) = \arg \max_w W_e(w, x, y)$$

tax rate. Under Nash bargaining, multiple equilibria may exist if the marginal tax rate is not continuously increasing. Nash and proportional bargaining yield the same results if the payroll tax does not depend on wage; with a tax that depend on labor income, match surplus is not perfectly transferrable between workers and firms and thus the two schemes diverge (l'Haridon et al., 2013; Jacquet et al., 2014). See Appendix A for more details.

such that

$$J_f(w, x, y) - J_u(y) \geq 0.$$

Firm y wins y' if and only if $W_e(\bar{\phi}(x, y), x, y) \geq W_e(\bar{\phi}(x, y'), x, y')$. Note that the value of employment consists a current component, which is the wage, and a continuation component, which is the present value of discounted future utilities. At the best match wage, the only possible future events are exogenous separations or job-to-job transitions to a better firm. The former is independent of the current match. The latter can only be higher for the winning firm y due to the free-disposal assumption. This is because the free-disposal assumption states that a more productive firm y can choose to act as being type $y' < y$ by disposing of the extra match outputs. Since firm y can always afford to pay any wage firm y' pays to the worker, it can behave as if it were y' in future wage competitions and negotiations. Therefore, if $\partial W_e(w, x, y)/\partial w \geq 0$ for all w, x, y , the condition for firm y to win y' is equivalent to $\bar{\phi}(x, y) \geq \bar{\phi}(x, y')$.

The wage negotiation only commences if the poaching firm can make the worker better-off compared to her current state, i.e. $W_e(\bar{\phi}(x, y_1), x, y_1) \geq W_e(w_0, x, y_0)$ where a subscript 0 indicates the incumbent firm and a subscript 1 indicates the poaching firm. This condition implies that the poacher can always afford to pay w_{min} . If the poacher is the winning firm, it can offer a higher “best match wage” than the incumbent, which is paying at least the minimum wage. If the poacher is the losing firm, by definition of the “best match wage”, we have $W_e(\bar{\phi}(x, y_1), x, y_1) \geq W_e(w_0, x, y_1)$. Therefore, if $\partial W_e(w, x, y)/\partial w \geq 0$, we must have $\bar{\phi}(x, y_1) \geq w_0$. Again, since wages in existing matches must be above the minimum wage, we have $\bar{\phi}(x, y_1) \geq w_{min}$.

The pair (x, y) negotiates a wage if, compared to the current value of employment, the worker can be made better off in firm y' at wage $\bar{\phi}(x, y')$. In other words, a wage bargaining initiates if $W_e(\bar{\phi}(x, y'), x, y') \geq W_e(w_0, x, y_0)$ where w_0 is the current wage and y_0 is the incumbent firm. If wage bargaining is not initiated, the worker remains in firm y_0 at wage w_0 .

In the wage bargaining, the worker uses the best value at the losing firm $W_e(\bar{\phi}(x, y'), x, y')$ as her new outside option. The net surplus of the match between employed worker x and firm y is

$$S_e(w, x, y, y') = W_e(w, x, y) - W_e(\bar{\phi}(x, y'), x, y') + J_f(w, x, y) - J_u(y) \quad (3)$$

The bargained wage ϕ must solve the following system:

$$\begin{cases} W_e(\phi, x, y) - W_e(\bar{\phi}(x, y'), x, y') = \alpha S_e(\phi, x, y, y') \\ S_e(\phi, x, y, y') \geq 0 \end{cases} \quad (4)$$

If ϕ exists, the next step is to compare it with w_{min} . Since that both the incumbent and the poacher can afford to pay w_{min} , the minimum wage does not change the destination firm.

The match wage is $\phi_e(x, y, y') = \max\{\phi, w_{min}\}$. First consider the case when the winning firm is the incumbent ($y_0 = y$). Since $W_e(\bar{\phi}(x, y_1), x, y_1) \geq W_e(w_0, x, y_0)$, the bargained wage ϕ is greater than the original wage w_0 . Therefore, the worker receives a wage increase without leaving the firm. If the winning firm is the poacher ($y_0 \neq y'$), the worker makes a job-to-job transition.

We define two useful sets. First, let $\mathcal{A}_{e1}(x, y_0) \subseteq [0, y_h]$ be the subset of firms that can win firm y_0 over worker x ; this is the subset of firms that can poach the worker from a match (x, y_0) . Then, let $\mathcal{A}_{e2}(w_0, x, y_0) \subseteq [0, y_h]$ be the subset of firms not in the subset $\mathcal{A}_{e1}(x, y_0)$, but can make the worker strictly better-off than her current state. This is the subset of firms that can trigger a wage negotiation for the match (x, y_0) .

2.4 Value functions

2.4.1 Non-employed workers

The value function for non-employment is

$$rW_n(x) = \max_{s \in \{0,1\}} \left\{ B(h(x)) - sq + s\kappa \int_{y' \in \mathcal{A}_u(x)} [W_e(\phi_u(x, y'), x, y') - W_n(x)] v(y') dy' \right\} \quad (5)$$

Let $s(x)$ denote the optimal search decision of a non-employed worker. The worker is unemployed if $s(x) = 1$ and non-participating if $s(x) = 0$. Note that since worker productivity is time-invariant, the model does not generate transitions in and out of the labor force.

2.4.2 Employed workers

The value function for employment is

$$\begin{aligned}
& [r + \delta + s_1 \kappa V] W_e(w, x, y) = w + \delta W_n(x) \\
& + s_1 \kappa \int_{y' \in \mathcal{A}_{e1}(x, y)} W_e(\phi_e(x, y', y), x, y') v(y') dy' \\
& + s_1 \kappa \int_{y' \in \mathcal{A}_{e2}(w, x, y)} W_e(\phi_e(x, y, y'), x, y) v(y') dy' \\
& + s_1 \kappa \int_{y \in [y_l, y_h] \setminus \{\mathcal{A}_{e1}(x, y) \cup \mathcal{A}_{e2}(w, x, y)\}} W_e(w, x, y) v(y') dy'
\end{aligned} \tag{6}$$

Proposition 2. For all $w \geq w_{min}$, x and y , $\partial W_e(w, x, y) / \partial w > 0$. Moreover, $\lim_{w \rightarrow -\infty} W_e(w, x, y) = -\infty$ and $\lim_{w \rightarrow \infty} W_e(w, x, y) = \infty$.

Proof. We give a heuristic proof for the above proposition. Wage affects the value of employment both directly, through the current consumption, and in the continuation value, when the worker meets a poaching firm that cannot win the incumbent. The direct effect is necessarily a positive one as the marginal consumption equals the marginal increase in wage. We only need to examine the continuation effect. Consider an infinitesimal change in wage dw . At any $w > w_{min}$, we have:

$$\begin{aligned}
& (r + \delta + s_1 \kappa V) [W_e(w, x, y) - W_e(w - dw, x, y)] = 1 \\
& + s_1 \kappa [W_e(w, x, y) - W_e(\phi_e(x, y, y^*), x, y)] \int_{d\mathcal{A}_{e2}(w, x, y)} v(y') dy'
\end{aligned}$$

where y^* is some element of $d\mathcal{A}_{e2}(w, x, y) = \{y' : W_e(w - dw, x, y) < W_e(\phi_e(x, y'), x, y') < W_e(w, x, y)\}$. Therefore, $[W_e(w, x, y) - W_e(\phi_e(x, y, y^*), x, y)] > 0$. This implies that $W_e(w, x, y) - W_e(w - dw, x, y) > 0$, and thus the partial derivative $\partial W_e(w, x, y) / \partial w > 0$. $\square$

2.4.3 Filled position

The value function of a filled position is

$$\begin{aligned}
& (r + \delta + s_1 \kappa V) J_f(w, x, y) = F(h(x), p(y)) - w - T(w) + \delta J_u(y) \\
& + s_1 \kappa \int_{y' \in \mathcal{A}_{e1}(x, y)} J_u(y) v(y') dy' \\
& + s_1 \kappa \int_{y' \in \mathcal{A}_{e2}(w, x, y)} J_f(\phi_e(x, y', y), x, y) v(y') dy' \\
& + s_1 \kappa \int_{y' \in [y_l, y_h] \setminus \{\mathcal{A}_{e1}(x, y) \cup \mathcal{A}_{e2}(w, x, y)\}} J_f(w, x, y) v(y') dy'
\end{aligned} \tag{7}$$

Proposition 3. For all x and y , $\frac{\partial J_f(w, x, y)}{\partial w} < 0$. Moreover, $\lim_{w \rightarrow -\infty} J_f(w, x, y) = +\infty$ and $\lim_{w \rightarrow \infty} J_f(w, x, y) = -\infty$.

A heuristic proof of this proposition follows that of Proposition 2.

2.4.4 Vacancy

Let $\mathcal{B}_u(y) = \{x : s(x) = 1 \text{ and } y \in \mathcal{A}_u(x)\}$ be the set of unemployed worker x such that firm y can form a match with, and let $\mathcal{B}_e(y) = \{(x, y') : s(x) = 1 \text{ and } y \in \mathcal{A}_{e1}(x, y')\}$ be the set of matches that the firm y can successfully poach the worker from.

Following Lise and Robin (2017), assume a competitive intermediary who sells matching opportunity to firms at price $c(v)$ per unit of vacancy. The present value of a vacancy is

$$rJ_u(y) = -c(v(y)) + \kappa\{I_u(y) + I_e(y)\}$$

where

$$\begin{aligned} I_u(y) &= \int_{x \in \mathcal{B}_u(y)} s(x)[J_f(\phi_u(x, y), x, y) - J_u(y)]u(x)dx \\ I_e(y) &= \iint_{(x, y') \in \mathcal{B}_e(y)} s_1[J_f(\phi_e(x, y, y'), x, y) - J_u(y)]h(x, y')dy'dx \end{aligned}$$

At equilibrium, the free-entry condition holds such that the value of a vacancy $J_u(y) = 0$. For any give y , if $\mathcal{B}_u(y) = \emptyset$ and $\mathcal{B}_e(y) = \emptyset$, the firm is not able to form any matches with any worker participating in the labor force, and thus the firm would stay inactive by choosing $v(y) = 0$. Otherwise, we have

$$c(v(y)) = \kappa[I_u(y) + I_e(y)] \tag{8}$$

which gives the vacancy distribution.

2.5 Equilibrium

2.5.1 Steady state conditions on the distribution of workers.

If $s(x) = 0$, worker x is always out of the labor force, so that $h(x, y) = 0$ and $u(x) = 0$. Otherwise, if $s(x) = 1$, the steady state levels of $h(x, y)$ and $u(x)$ are determined by equating inflows with outflows.

The outflow from type (x, y) matches are due to exogenous separations at rate δ , and voluntary job-to-job transitions. The inflow into type (x, y) matches are due to unemployed workers x matching with firm y , or employed worker moving to firm y . The steady state condition for $h(x, y)$ is the following.

$$h(x, y) = \frac{v(y)[\kappa u(x) + s_1 \kappa \int_{y': (x, y') \in \mathcal{B}_e(y)} h(x, y') dy']}{(\delta + s_1 \kappa \int_{y' \in \mathcal{A}_{e1}(x, y)} v(y') dy')} \quad (9)$$

The outflow from unemployment is due to job finding. The inflow is due to exogenous separation. The stationary measure of employed workers $u(x)$ is given as follows

$$u(x) = \frac{\delta}{\delta + \kappa \int_{y' \in \mathcal{A}_u(x)} v(y') dy'} \quad (10)$$

2.5.2 Uniqueness of wage

Given Propositions 2 and 3, it is easy to show that bargained wages satisfying the systems 2 and 4 are unique if they exist.

Consider the case for the bargaining between an unemployed worker and a firm. The bargained wage ϕ satisfies the following:

$$W_e(\phi, x, y) - W_n(x) = \frac{\alpha}{1 - \alpha} [J_f(\phi, x, y) - J_u(y)]. \quad (11)$$

The left hand side $W_e(\phi, x, y) - W_n(x)$ monotonically increases in ϕ whereas $J_f(\phi, x, y) - J_u(y)$ is monotonically decreases. Moreover, as $\phi \rightarrow -\infty$, the left hand side goes to $-\infty$ whereas the right hand side goes to ∞ . As $\phi \rightarrow \infty$, the left hand side goes to ∞ whereas the right hand side goes to $-\infty$. Therefore, there is always a unique solution Eq. 11. If the solution to Eq. 11 makes the net surplus S positive, a unique solution exists. Similar arguments can be made for the bargained wage between an employed worker and the winning firm of the firm competition.

2.5.3 Characterizations of $\mathcal{A}_u$, $\mathcal{A}_{e1}$, and $\mathcal{A}_{e2}$.

Propositions 2 and 3 also imply that firm y can win firm y' over worker x if and only if $\bar{\phi}(x, y) > \bar{\phi}(x, y')$ (see Section 2.3.2). We take this a step further by showing that the condition is equivalent to $y > y'$. This only requires that $\partial \bar{\phi}(x, y) / \partial y > 0$, which we establish with the following proposition.

Proposition 4. For all x, y , $\partial \bar{\phi}(x, y)/\partial y > 0$.

Proof. In equilibrium, given that $J_u(y) = 0$, it must be that $J_f(\bar{\phi}(x, y), x, y) = 0$. Moreover, we know that $\mathcal{A}_{e2}(\bar{\phi}(x, y), x, y) = \emptyset$. Therefore, substituting w with $\bar{\phi}(x, y)$ in Eq. 7 gives

$$\bar{\phi}(x, y) + T(\bar{\phi}(x, y)) = F(\mathbf{h}(x), \mathbf{p}(y)) \quad (12)$$

Taking the derivative of Eq. 12 with respect to y , we have

$$\frac{\partial \bar{\phi}(x, y)}{\partial y} + T'(\bar{\phi}(x, y)) \frac{\partial \bar{\phi}(x, y)}{\partial y} = \frac{\partial F(\mathbf{h}(x), \mathbf{p}(y))}{\partial y}$$

Rearranging, we have

$$\frac{\partial \bar{\phi}(x, y)}{\partial y} = \frac{\frac{\partial F(\mathbf{h}(x), \mathbf{p}(y))}{\partial y}}{1 + T'(\bar{\phi}(x, y))}$$

By assumption, $\frac{\partial F(\mathbf{h}(x), \mathbf{p}(y))}{\partial y} > 0$ and $T'(\bar{\phi}(x, y)) \geq 0$, thus $\frac{\partial \bar{\phi}(x, y)}{\partial y} > 0$. $\square$

Given the free disposal assumption, the above proposition tells us that, whenever the match (x, y') is viable, the match (x, y) such that $y > y'$ must also be viable. This is because the firm y can always mimic to be of type y' , and it can do so because firm y can always afford to pay $\bar{\phi}(x, y')$. This allows us to define $\mathcal{A}_u(x)$ as a convex interval such that $\mathcal{A}_u(x) = [\underline{y}(x), y_h]$. The lower bound arises from two constraints, both of which are influenced by policies. The first constraint, $y_u(x)$, is the lowest y such that the equations in 2 are satisfied. Here, higher taxes lowers the match surplus and thus endanger the viability of a match.¹³

The second constraint, $y_{min}(x)$, is the lowest y that can afford to pay at least the minimum wage to a worker x . More precise, it is defined by $y_{min}(x) = \arg \min_{y \in [y_l, y_h]} \{y : F(\mathbf{h}(x), \mathbf{p}(y)) \geq w_{min} + T(w_{min})\}$. Clearly, in addition to higher taxes, a higher minimum also endangers match viability. Finally, the lower bound of $\mathcal{A}_u(x)$ is the maximum of the two constraints: $\underline{y}(x) = \max \{y_u(x), y_{min}(x)\}$.

In addition, the lower bound of the firm distribution is defined as

¹³It may be useful to consider the static counterparts of the constraint. In a static environment, the system of equations in 2 becomes

$$\begin{cases} \phi + B(\mathbf{h}(x)) = \alpha [F(\mathbf{h}(x), \mathbf{p}(y)) - T(\phi) - B(\mathbf{h}(x))] \\ F(\mathbf{h}(x), \mathbf{p}(y)) - T(\phi) - B(\mathbf{h}(x)) \geq 0 \end{cases}$$

The static counterpart for the first constraint is $\arg \min_{y \in [y_l, y_h]} \{y : F(\mathbf{h}(x), \mathbf{p}(y)) \geq B(\mathbf{h}(x)) + T(B(\mathbf{h}(x)))\}$, which states that the match productivity must be high enough to pay the worker's non-working income plus taxes. It is clear that higher taxes endanger match viability.

$$y_l = \arg \min_y \{y : \exists x \text{ such that } s(x) = 1 \text{ and } y \geq \underline{y}(x)\}$$

Proposition 4 also implies that all workers make job-to-job transitions toward the firm with a higher y . This allows us to express the sets $\mathcal{A}_{e1}$ and $\mathcal{A}_{e2}$ as convex intervals on $[y_l, y_h]$ such that:

$$\mathcal{A}_{e1}(x, y) = \{y' \in [y_l, y_h] : y' > y\} \quad (13)$$

$$\mathcal{A}_{e2}(w, x, y) = \{y' \in [y_l, y_h] : y > y' > y_0(w, x, y)\} \quad (14)$$

where $y_0(w, x, y)$ is the lowest y' that can trigger a wage renegotiation, i.e. $W_e(y_0(w, x, y), x, y) = W_e(\bar{\phi}(x, y'), x, y')$.

2.5.4 Steady State Equilibrium

The steady state equilibrium is characterized by the distributions $\Phi = \{u(\cdot), h(\cdot, \cdot)\}$, and the decisions $\Psi = \{s(\cdot), \underline{y}(\cdot), \phi_u(\cdot, \cdot), y_0(\cdot, \cdot, \cdot), \phi_e(\cdot, \cdot, \cdot), v(\cdot)\}$ such that

1. Non-employed workers choose the optimal search strategy $s(\cdot)$.
2. Unemployed workers choose the optimal threshold firm type $\underline{y}(\cdot)$.
3. Employed workers choose the optimal threshold firm type $y_0(\cdot, \cdot, \cdot)$ for wage renegotiation. In addition, they move to firms with a higher y .
4. $\phi_u(\cdot, \cdot)$ and $\phi_e(\cdot, \cdot, \cdot)$ specify the wages of matches.
5. There is free entry of firms such that Eq. 8 holds, and $v(\cdot)$ solves the equation.
6. Steady state conditions (Eq. 9, 10) hold.

Solving the model relies on iterating the value functions because the surplus function depends on wage due to the presence of labor market policies. The continuation value of the match surplus depends on wages of potential future matches, which can only be solved for if the value functions are known.¹⁴ We describe the procedure to solve for the steady state equilibrium numerically in Appendix B.

¹⁴Because of taxes and the minimum wage, we are unable to derive an analytical wage equation as in Cahuc et al. (2006).

3 Data

Our main source of data is the Annual Declaration of Social Data (DADS), a French administrative data maintained by the French National Statistical Institute (INSEE). The DADS is based on mandatory employer declarations of the earnings of employees who contribute to the social security system. Data in the DADS database are organized into several datasets with different sampling schemes and structures for data security reasons. We access three of them that are relevant for our empirical applications: *panel DADS*, *panel tous salariés*, and *fichier Postes*.

The first two, *panel DADS* and *panel tous salariés* are linked employer-employee datasets, containing employees who were born in Octobers of even-numbered years.¹⁵ The *panel DADS* mainly covers non-public sector workers, while *panel tous salariés* mainly covers public sector workers. We construct our panel data by combining the two DADS panels and merging social security contributions for private sector employees computed by the tax simulator developed by the Institute for Public Policies (TAXIPP). While the panel data contains full employment information on individuals, the individual-level sampling scheme renders it insufficient for observing within-firm wage distributions, which are important for our estimation strategy. We thus compute firm-level wage variables using our third dataset *fichier Postes* (hereafter, POST). POST contains all workers in the employer declarations even though workers are not linked across different job spells. Moreover, firms can be linked between the panel and POST.

Both the panel and POST contain information on the gender and age of workers and characteristics of jobs. We keep men age 30-55, and only focus on those who work mainly in full-time non-executive jobs in the private sector. This relatively homogenous group faces similar social security tax schedules.¹⁶

Individuals may be missing from our data for one of several reasons: unemployment, self-employment, and non-participation. The period that a worker is not observed in the panel will be referred to as a gap spell. We impute the status of individuals in gap spells using the duration of the gap, age of the individual, and the type of job that follows the gap (public or private sector, industry, and occupation). The parameters of the imputation model are estimated based on a similar sample drawn from the French labor force survey *Enquête Emploi* (EE).¹⁷ We furthermore impute non-employment incomes for gap spells by employing a formula that depends on the gross earnings in all jobs during the year that precedes the unemployment spell.¹⁸

¹⁵From 2002 onwards, the dataset contains those born in Octobers of each year.

¹⁶Individuals working primarily in full-time jobs have a relatively weaker taste for non-working time. This frees us from considering the within period decision of consumption and leisure. Although the part-time labor market are more likely low-wage, among men of age 30-55, as much as 84% of the jobs are full-time, and a substantial fraction of these jobs are low-wage.

¹⁷See Appendix C for details on the imputation procedure.

¹⁸See Appendix D for details.

Figure 3.1: Approximated social security contributions (SSC) by net wage, January 1993 to August 1995. The relationship is estimated based on data from the DADS by regressing SSC on net wages using a linear spline model. SSC for each job spell is computed by TAXIPP. We restrict our sample to non-executive, full-time, and private sector jobs.

We took several steps to organize the panel data, which is based on employment and gap spells, into a monthly dataset that contains one observation per individual-month. The details of these steps are described in Appendix E. Wages are inflated to the 2010 price level. To convert between Euros and French francs, we apply the conversion rate of 1 € = 6.55957 FF.

We extract the aggregate labor market statistics used for model estimation from various sources other than the DADS. We do not compute the labor force participation rate and the unemployment rate using the DADS because the dataset does not include non-participants. Instead, we use the rates computed by INSEE using the Labour Force survey. Both rates are computed according to the International Labour Organization (ILO) definitions. According to the ILO, a labor force participant is defined as one who is either employed or unemployed, and an unemployed person is defined as a working age person who has not worked, is available for work, and has actively looked for a job in the previous month or will start a job in the next 3 months. We use the series for men age 25-49 in Metropolitan France. Our vacancy rate is taken from the Employment Orientation Board (*Conseil d'orientation pour l'emploi*).¹⁹ The vacancy rate is defined as the number of vacancies divided by the sum of vacancies and jobs. We use the European vacancy definition, according to which a vacancy is a job to be filled immediately or at short notice, and there must be active search for candidates outside of the concerned firm. We consider non-public sector, non-agricultural vacancies in France.

Finally, we obtain a function the total social security contribution (SSC) in net wages by regressing the SSC on the net wage using a linear spline model. Since SSC is primarily based on individual wages rather than household income, this methods provides us with a good approximation for the SSC. We use data from the period between January 1993 to August 1995 for our steady state estimation because this is a period of relative stability in terms of minimum wage and tax policies. Figure 3.1 shows the approximated SSC for this period. The net statutory minimum wage for this period is 912 in 2010 Euros.

4 Estimation

We estimate model parameters using the Simulated Method of Moments (SMM), which we describe in Subsection 4.1. Identifying the distributions of worker and firm productivities and the com-

¹⁹See Conseil d'Orientation pour l'Emploi (2013).

plementarity between them requires us to recover the ranks x and y of individuals and firms using statistics that are monotone their respective productivities.²⁰ The panel and POST from the DADS are well-suited for this purpose. We discuss the ranking method in Subsection 4.2. Our baseline model is estimated using data from the period between January 1993 and August 1995. This a period of relative stability in terms of minimum wage and tax policies. We describe our identification strategy in Subsection 4.3. Finally, in Subsections 4.4 and 4.5, we present our estimation results and discuss the model fit.

4.1 Simulated method of moments

We use the simulated method of moments (SMM) to estimate our model parameters θ . For each set of parameters, we solve the model numerically for the distributions $\Phi = \{u(\cdot), h(\cdot, \cdot)\}$, and the decisions $\Psi = \{s(\cdot), \underline{y}(\cdot), \phi_u(\cdot, \cdot), y_0(\cdot, \cdot, \cdot), \phi_e(\cdot, \cdot, \cdot), v(\cdot)\}$.

We construct our simulated sample to reflect features of the actual data from the DADS sample. We simulate a cohort of 100,000 individuals drawn from the discretized worker productivity distribution with 100 grid points, and 2,000 firms drawn from the discretized firm productivity distribution with 50 grid points. We follow the same selection criteria in ranking firms; the fraction of firms that are ranked and the share of employment accounted for by the ranked firms are similar to those in the DADS.

We consider a discrete time version of our model by aggregating to the month. Since the average sample duration of workers and firms in the DADS sample is around 10 years, we rank the simulated individuals and firms based on 120 months of the simulated data. The moment computation is based on 36 months of data, consistent with our moment computation using the DADS data.

The SMM estimator is

$$\hat{\theta} = \arg \min_{\theta} \{[\hat{m}_{data} - \hat{m}_{sim}(\theta)]' \Omega [\hat{m}_{data} - \hat{m}_{sim}(\theta)]\}$$

where $\hat{m}_{data}$ and $\hat{m}_{sim}(\theta)$ are $M \times 1$ vectors of data and simulated moments respectively, and the weighting matrix Ω is some symmetric non-negative $M \times M$ matrix.

4.2 Worker and Firm Ranks

In order to rank individuals and firms in the data, we use statistics that are monotone in their respective productivity levels according to our model. We consider a finite number of ranks by

²⁰The ranking method has been tested in Hagedorn et al. (2017).

assigning workers and firms into N_{xbin} and N_{ybin} equal-sized ranked bins, such that less productive workers and firms are assigned a lower bin.

4.2.1 Workers

We use three statistics to rank workers: lifetime earnings, and lifetime minimum and maximum wages. In our model, individuals are risk-neutral and make decisions to maximize their discounted lifetime net income. By assumption, both $F(\mathfrak{h}(x), \mathfrak{p}(y))$ and $B(\mathfrak{h}(x))$ increase in worker productivity $\mathfrak{h}(x)$. High- x workers thus have a greater earnings capacity; lifetime earnings accounting for both labor income and non-employment benefits is a statistic that can be used to rank workers in the data. Because workers appear in our sample for various lengths of time, we take the average daily net earnings, including labor income and non-employment transfers.²¹

Lifetime maximum and minimum wages are also monotonically increasing in x . First consider the lifetime maximum wage. Since all workers labor force participants (employed or unemployed workers) are able to form a viable match with the most productive firm and the maximum match wage increases in x ($\partial \bar{\phi}(x, y) / \partial x > 0$), the lifetime maximum wage is a consistent ranking statistic.

Then, consider the lifetime minimum wage. The lowest wage that a worker can attain in a given firm y is $\max\{w_{min}, \phi_u(x, y)\}$ if $y \in \mathcal{A}_u(x)$. If $\underline{y}(x)$, the lower bound of $\mathcal{A}_u(x)$, is weakly increasing in x , the lowest firm productivity that a worker can match with is weakly increasing in x , in which case $\max\{w_{min}, \phi_u(x, y)\}$ must also be weakly increasing in x . $\underline{y}(x)$ may also decrease in x due to the minimum wage constraint - the more productive a worker is, the more likely she can produce enough in a low-productivity firm to cover the minimum labor cost. If this is the case, the lifetime minimum wage that the worker can attain must be w_{min} , which is independent of x .

To compute the ranking statistics for an individual from the panel, we need to observe an extended fraction of her career. For this reason, we use the panel data from the entire period between 1991 to 2008, and exclude individuals for whom we do not have sufficient observations. In Appendix E.2, we describe details on sample selection and the computation of the ranking statistics.

All three statistics allow for global rankings of workers. Because of the presence of sampling or measurement errors, different statistics may lead to conflicting rankings of workers. We aggregate the three rankings in the following way. Since our goal is to assign workers to a finite number of ranked bins, we develop a simple method to aggregate the rankings by iterative bisections. At the

²¹Lifetime earnings that does not account for periods of non-employment may not be consistent with worker productivity because the set of firms with which a worker can form viable matches does not necessarily expand with x : a high- x worker may be more selective because of her higher outside options and spend more time in unemployment, and thus using lifetime labor earnings may under-predict the productivity of high- x workers.

Table 4.1: Ranking statistics of workers by discrete worker bins (b_x). All statistics are monthly in 2010 euros. For each individual, the statistics are computed based on the panel data from the DADS from 1991 to 2008, restricted to men age 30-55 who are primarily employed in non-executive, full-time, private sector jobs. “Lifetime income” refers to the net-of-tax average income per month, accounting for net wage and imputed non-employment benefits. “Lifetime min. wage” and “Lifetime max. wage” refer to the lowest and the highest net wage from employment that an individual obtains while in sample. Individuals are assigned to bins based on the three statistics such that those with higher income and wages are put to a higher bin.

Discrete worker bin (b_x)	Lifetime income	Lifetime min. wage	Lifetime max. wage
1	915.6	328.8	1973.4
2	1177.5	632.1	2160.6
3	1332.6	847.8	2265.3
4	1475.4	1009.8	2324.1
5	1631.4	1179.9	2541.0
6	1828.2	1366.2	2727.6
7	2114.4	1613.4	3151.2
8	2896.2	2146.8	5184.0

end of iteration $n_{xiter} = 1, \dots, N_{xiter}$, workers are assigned to $N_{xbin} = 2^{n_{xiter}}$ ranked bins. We use the lifetime net earnings as the primary statistic as it is measured with the least noise. In cases of disagreement among the three rankings, the mechanism follows the primary statistic unless the other two statistics simultaneously show a strong indication for the alternative. We choose $N_{xiter} = 3$, resulting in $N_{xbin} = 8$ worker bins. Let $b_x = 1, \dots, N_{xbin}$ be the index of the bins. Table 4.1 shows that the average values of all three statistics increase in the discrete worker bin b_x .

4.2.2 Ranking Firms

Ranking firms using our DADS panel is nearly impossible because we only observe, on average, 1/12 or 1/24 of the individuals within each firm. We are unable to construct reliable statistics from the within-firm wage distribution, or construct poaching indices similar to Bagger and Lentz (2014).²² Therefore, we turn to POST to construct firm-ranking statistic from the within-firm wage distribution.

²²The poaching index proposed by Bagger and Lentz (2014) is a fraction of hires that were poached from another firm. As they discuss in their paper, a reliable poaching index requires a substantial number of hires and hires from another firm.

Table 4.2: Firm statistics for ranked and unranked firms. Statistics are computed based on POST, and restricted to jobs that are non-executive, full-time, in the private sector, and are filled by men of age 30-55. The “Highest firm wage” of a firm is the 99th monthly wage percentile ever reported by the firm; the “Mean firm wage” of a firm is the average monthly wage ever reported by the firm; and “Firm size” is the total number of employee-days divided by the total number of days a firm is observed in POST. All wages are monthly gross wage measured in 2010 Euros.

Firm statistic:	(1) Highest firm wage	(2) Mean firm wage	(3) Firm size
Ranked firms (firm size ≥ 10)	5277.8	2306.0	54.8
Unranked firms (firm size < 10)	3110.7	2106.7	1.50
All firms	3236.8	2116.4	4.10

Our model predicts that the highest worker type a firm can attract increases with firm productivity. In addition, the “best match wage” also monotonically increases in both worker and firm types ($\partial \bar{\phi}(x, y) / \partial x \geq 0$ and $\partial \bar{\phi}(x, y) / \partial y \geq 0$). Thus, in probability, the highest wage observed in a firm increases with the firm type. In practice, we choose to use the 99th within-firm wage percentile to rank firms with an average firm size of at least 10 workers, where firm size is defined as the number of male workers age 30-55 in non-executive, full-time, private sector positions. In this way, about 30% of firms in POST can be ranked, accounting for over 80% of employment.²³ Firms satisfying our ranking criteria are assigned to $N_{ybin} = 4$ ranked bins such that a firm with a lower 99th wage percentile measure is assigned to a lower bin.

Table 4.2 compares firm wages and firm size between ranked (larger) and unranked (smaller) firms; it is clear that wages are lower in the unranked firms. According to our model, firm size monotonically increases in firm productivity. The set of ranked firms is thus not randomly selected, but rather represents more productive firms. We replicate this selection in our simulation by using the same firm size criteria to determine the set of ranked firms and matching the share of employment accounted for by ranked firms.

4.3 Parametrization and Identification

In this Subsection, we discuss the sources of identification for our model parameters. To facilitate the exposition, we first introduce some notations. Let $\chi_{i,t}$ be the observed “status” of worker i at period t , where $\chi_{i,t} = 0$ if i is non-employed, and $\chi_{i,t} = j$ if the worker is employed in firm of index j . Let $i \in \{1, 2, \dots, I\}$ denote the worker index and $j \in \{1, 2, \dots, J\}$ denote the firm index. Moreover, let $b_x(i) \in \{1, 2, \dots, N_{xbin}\}$ and $b_y(j) \in \{1, 2, \dots, N_{ybin}\}$ denote the ranked bin of workers and firms, respectively.

²³See Appendix E.3 for details on firm size distribution.

4.3.1 Production

Worker productivity follows log-Normal distribution. More precisely, the mapping $\mathfrak{h}(x) = \exp[\Phi_x^{-1}(x)]$ has support $[0, 1]$, and Φ is the cumulative distribution function of the Normal distribution $N(\tilde{\mu}_x, \tilde{\sigma}_x)$. The mean standard deviation of the worker productivity are thus $\mu_x = \exp(\tilde{\mu}_x + \tilde{\sigma}_x/2)$ and $\sigma_x = \sqrt{[\exp(\tilde{\sigma}_x) - 1] \exp(2\tilde{\mu}_x + \tilde{\sigma}_x^2)}$.

Firm productivity follows a right-truncated log-Normal distribution. More precisely, the mapping $\mathfrak{p}(y) = \exp[\Phi^{-1}(y)]$ has support $[0, y_h]$ such that $y_h = \Phi_y(\ln(p_h))$ for some exogenously given p_h , which is the highest firm productivity. Φ_y is the cumulative distribution function of the Normal distribution $N(\tilde{\mu}_y, \tilde{\sigma}_y)$. Without the truncation, the mean and standard deviation of the firm productivity are $\mu_y = \exp(\tilde{\mu}_y + \tilde{\sigma}_y/2)$ and $\sigma_y = \sqrt{[\exp(\tilde{\sigma}_y) - 1] \exp(2\tilde{\mu}_y + \tilde{\sigma}_y^2)}$.

The production function admits constant elasticity of substitution (CES) between $\mathfrak{h}$ and $\mathfrak{p}$:

$$F(x, y) = \begin{cases} f_0 [\mathfrak{h}(x)^\gamma + \mathfrak{p}(y)^\gamma]^{1/\gamma} & \text{if } \gamma \neq 0 \\ f_0 \mathfrak{h}(x) \mathfrak{p}(y) & \text{if } \gamma = 0 \end{cases}$$

where f_0 is total factor productivity and γ is the coefficient of substitution between workers and firms, with $f_0 > 0$ and $\gamma \leq 1$. If $\gamma = 1$ worker and firm productivities are perfect substitutes. If $\gamma = -\infty$, the productivities are perfect complements. If $\gamma = 0$, the production function is Cobb-Douglas.

Since we do not use data on firm profit or value-added, we cannot jointly identify the relative levels of worker and firm productivities. Therefore, we normalize $\mu_x = 1$, $\mu_y = 1$, and $p_h = 4$. Given μ_x , μ_y , and y_h , higher f_0 would lead to higher wages in the economy, so wage levels can identify f_0 . The parameters σ_x and σ_y influence the wage dispersions between different worker types and firm types respectively. To recover σ_x and σ_y from the data, we use the median wage by worker bins $\{\text{median}(w_{i,t} | b_x(i) = b)\}_{b=1, \dots, N_{xbin}}$ and by firm bins, $\{\text{median}(w_{i,t} | b_y(\chi_{i,t}) = b)\}_{b=1, \dots, N_{ybin}}$ as moments in the estimation.²⁴

The job finding rate for an unemployed worker of rank x is $\kappa \int_{\underline{y}(x)}^1 v(y') dy'$. The parameter γ influences the shape of the function $\underline{y}(\cdot)$, which in turn influences how the job finding rate varies workers of different ranks. In addition to the job finding rates, γ also affects the skewness of the wage distribution as greater complementarity leads to more right-skewed wage distribution.

²⁴While σ_y is related the wage dispersion across firms, the relationship is not necessarily monotone because not all firms are always active. On one hand, a very low σ_y implies little firm productivity dispersion. On the other hand, a high σ_y may cause individuals to become more selective in accepting matches, and this increases the productivity of the least productivity firm p_l . This compresses the interval over which firms are active.

In practice, we use the following moments to identify γ : job finding rates by worker bins relative to the highest ranked bin, $\left\{ \frac{Pr(\chi_{i,t} > 0 | \chi_{i,t-1} = 0 \text{ and } b_x(i) = b)}{Pr(\chi_{i,t} > 0 | \chi_{i,t-1} = 0 \text{ and } b_x(i) = N_{xbin})} \right\}_{b=1, \dots, N_{xbin}-1}$, the observed wage percentiles, $w(p10)$, $w(p20)$, ..., $w(p90)$, and the observed wage distribution relative to w_{min} , $Pr(w \leq 1.05w_{min})$, $Pr(1.05w_{min} < w \leq 1.3w_{min})$, $Pr(1.3w_{min} < w \leq 1.6w_{min})$ and $Pr(1.6w_{min} < w \leq 2.5w_{min})$. The job finding rate is computed based on monthly data of sample workers. It is equal to the fraction of workers who are unemployed in a given month that become employed in any type of job in the following month.

4.3.2 Wage Bargaining

In a wage negotiation, an unemployed worker's wage is determined by her receiving α share of the match surplus, unless the minimum wage is binding.. As a worker receives one-the-job offers, the worker receives an increasing share of the match surplus through a wage closer to the "best match wage". The higher the worker's bargaining power α is, the smaller the difference is between the out-of-unemployment wage and her later wages, and also the smaller the overall wage dispersion is. The median out-of-unemployment wage $\text{median}(w_{i,t} | \chi_{i,t-1} = 0)$, and the wage percentiles $w(p10)$, $w(p20)$, ..., $w(p90)$ both help identify α .

4.3.3 Non-Employment Benefit

We assume that the non-employment benefit is a linear function in worker's productivity such that

$$B(h) = b_0 + b_1 h$$

with $b_0 \geq 0$ and $b_1 \geq 0$.²⁵ We view $B(h)$ as the transfers that non-employed workers receive and therefore we identify b_0 and b_1 by matching the median benefit level by worker bin, $\{\text{median}(B_{i,t} | b_x(i) = b)\}_{b=1, \dots, N_{xbin}}$.

Note that our data sample does not include individuals who have never been in the labor force, thus our computation of the simulated moments of the benefit levels are also based solely on those in the labor force. Predicting the benefit levels of labor force non-participants relies on the functional form assumption.

4.3.4 Search Technology and Search Cost

We assume that the search cost for unemployment search q is a constant; a higher search cost deters the non-employed from participating in the labor force. We thus use the labor force participation

²⁵Simulated benefit levels under the linear specification provides a close match to the data, so we do not include terms of higher orders in $B(\cdot)$.

(*LFPR*) to identify q .

The parameter s_1 determines the efficiency of on-the-job search relative to unemployment search; it influences the ratio of the job-to-job transition rate to the unemployment-to-job transition rate (JJ/UE). Moreover, a higher s_1 implies workers move faster to more productive firms, resulting in a more skewed firm size distribution. Thus, we also use the employment share by firm bin to identify s_1 , which is denoted by $\{Emp(b_y = b)/Emp\}_{b=1,\dots,N_{b_y}}$, where $Emp(b_y)$ is the number of employed workers in firm bin b_y , and Emp is the total number of employed workers.

We assume that the meeting technology $M(\xi, V)$ is constant return to scale and symmetric in search units ξ and vacancies V :²⁶

$$M = m_0 \sqrt{\xi V}$$

The parameter m_0 determines the efficiency of the matching technology: a higher m_0 leads to more meetings, which in turn leads to more matches and less unemployment. We use the unemployment rate (UR) to identify m_0 .

We assume that the cost for firms to post vacancies is a power function in the measure of vacancies v that a firm posts, that is:

$$c(v) = (c_0 v)^{1+1/c_1}$$

c_0 influences the number of vacancies each firm posts. To identify c_0 , we use the vacancy rate (VR), which is defined as $VR \equiv \frac{V}{V+E}$. Since we do not have micro-data on vacancy, we fix c_1 at 0.01 as it allows for a plausible firm size distribution.²⁷

4.3.5 Employment Separation

We assume that the exogenous separation rate δ is a constant. In the model, all job separations in the steady state are exogenous. By directly calculating the monthly employment separation rate in the data, we get $\hat{\delta} = 0.00855$, or an annual separation rate of 0.098.²⁸

²⁶We do not exploit policy changes in our estimation strategy, so that we cannot identify the elasticity of M in ξ and V .

²⁷Bagger and Lentz (2014), who estimate a search-and-matching model based on Danish data, estimate a c_1 on the same order of magnitude.

²⁸The separation rate is computed based on monthly data of ranked workers. It is equal to the fraction of workers who are employed in any type of job in the current month that become unemployment in the following month.

4.4 Estimation results

Table 4.3 shows parameter estimates; we discuss their interpretation in turn. The estimate of the parameter γ indicates that workers and firms are complementary in production at a degree slightly greater than a Cobb-Douglas specification. Given the estimated values of γ , f_0 , σ_x , and σ_y , we plot the production function in Figure 4.1. It shows that the output of a median worker in terms of her productivity at a median active firm in terms of its productivity is 2633 euros per month. While the upper bound of the firm productivity distribution is fixed at $p_h = 4$, the endogenous lower bound is $p_l = 2.85$. Given the estimated σ_y , the standard deviation of the productivity of active firms is 0.33, which is smaller than the estimated standard deviation of worker productivity, $\sigma_x = 0.42$. If matched with the median active firm, the worker with at the 90th percentile of the productivity distribution produces 1.49 times the output of the median worker, while the median worker produces 1.51 times the output of the worker at the 10th percentile of the productivity distribution. Given the median worker, the firm at the 90th percentile of productivity distribution of active firms produces 1.07 times the output of the median firm, while the median firm produces 1.06 times the output as the firm at the 10th percentile of the same distribution.

The parameter estimates of b_0 and b_1 indicate that while all non-employed workers receive a basic level of transfer of 590.5 euros per month, the transfer increases with worker productivity. In particular, the marginal increase in the transfer with respect to $\mathfrak{h}$ is 654.9 euros for all workers. For the median worker, the marginal increase in production output with respect to $\mathfrak{h}$ ranges from 1574 to 1873 euros per month.

The job search parameters m_0 and s_1 imply that, on average, an unemployed worker meets a vacancy every 9.0 months, an employed worker meets a vacancy every 14.7 months, and a vacancy meets a worker every month.²⁹ The search cost q is small. Estimated as 13.2 euros per month, it is only 1.4% of the minimum wage. The vacancy cost parameter c_1 implies that the cost of posting one additional vacancy for the least productive firm is 3.15 euros per month, while the cost for the most productive firm is 1472 euros per month.

Finally, our estimated workers' bargaining power α is 0.729, which is higher than the common findings in the related literature due to differences in the model environment and identification strategy.³⁰ Our estimate of α is driven by a relatively low dispersion in the net wage and a high out-of-unemployment wage. If we assume that individuals care about the labor cost instead of the net wage in wage bargaining, we would end up with a lower estimate of α because there would be a greater level of dispersion in the labor cost.

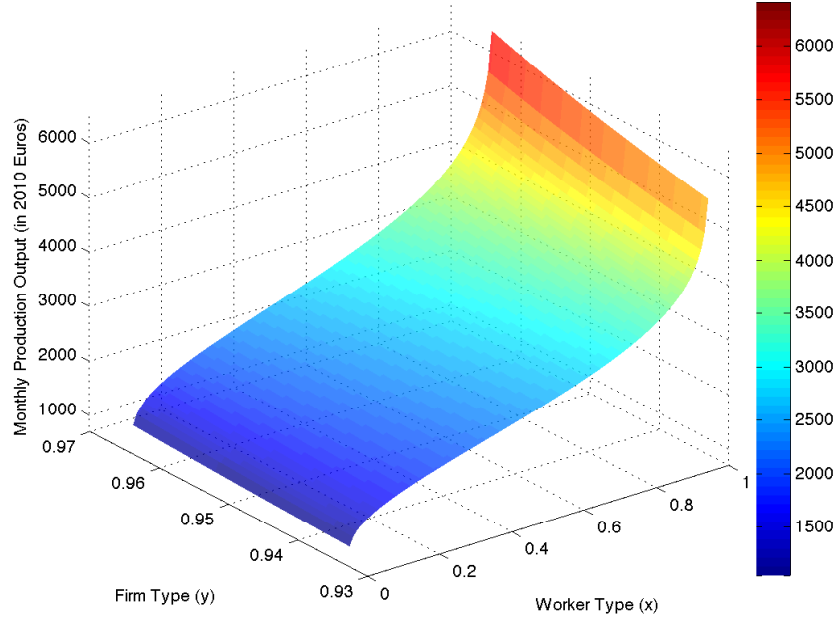
²⁹Note that these are meeting rates. The job finding rate also depends on the probability of forming a viable match.

³⁰For example, using the relationship between job productivity and labor cost, Cahuc et al. (2006) estimate the bargaining power to be close to zero for workers in the two least skilled categories.

Table 4.3: Parameter Estimates.

Parameter	Value
<i>Production function: $F(x, y) = f_0(\mathfrak{h}(x)^\gamma + \mathfrak{p}(y)^\gamma)^{1/\gamma}$</i>	
γ	-0.12
f_0	524537.6
<i>Dispersion parameter of the worker productivity distribution</i>	
σ_x	0.424
<i>Dispersion parameter of the firm productivity distribution</i>	
σ_y	2.49
<i>Non-employment benefit: $B(\mathfrak{h}) = b_0 + b_1\mathfrak{h}$</i>	
b_0	590.5
b_1	654.9
<i>Efficiency of on-the-job search relative to unemployment search:</i>	
s_1	0.593
<i>Meeting technology: $M(\xi, V) = m_0\sqrt{\xi V}$</i>	
m_0	0.914
<i>Cost of unemployment search:</i>	
q	13.2
<i>Vacancy price: $c(v) = (c_0v)^{100}$</i>	
c_0	1980.7
<i>Worker's share of surplus:</i>	
α	0.729

Figure 4.1: Estimated production function. Parameter values are shown in Table 4.3.



4.5 Model Fit

Before showing the fit of the moments, we note that our firm ranking scheme leaves us with a similar fraction of ranked firms in the simulated data as in the actual data. Of the 2000 simulated firms, 31.25% are ranked. These firms account for 81.9% of total employment. In comparison, 29% of firms in POST are ranked, accounting for 88% of total employment.

Table 4.4 shows the fit of the targeted moments. Overall our model is able to fit the moments well. We replicate the hump-shape pattern in the job finding rate: it is lower among the lowest and the highest ranked workers and higher for those in the middle.

Our model also closely matches the unconditional wage distributions and wage dispersion across worker bins. We under-predict the wage dispersion across firms ranks (moments 29-32). It should be noted, however, that our simulation reveals that the firm ranking is substantially less accurate than worker ranking. The correlation between our simulated workers' rank b_x and true type x is

0.983. 77% of the simulated workers are correctly ranked, 23% are ranked higher or lower by one bin. Of the ranked firms, the correlation between firms' rank b_y and type y is 0.390. 33.6% are correctly ranked, 44.6% are ranked higher or lower by one bin.

The rest of the moments, including the median out-of-unemployment wage, non-employment transfers, and measures of labor force stocks and flows, all closely match their data counterparts.

5 Equilibrium effects of payroll tax reductions

According to our model, payroll tax reductions for low-wage jobs make unproductive jobs viable, expanding employment opportunities for low-productivity individuals. However, the creation of low-productivity jobs may exert negative externalities on highly productive workers because the newly created jobs dilute the pool of high-productivity jobs. In this section, we quantify the equilibrium effects of tax reductions, and decompose the equilibrium effects into a direct supply-driven effect and an indirect demand-driven effect. This exercise helps us understand the implications of labor demand adjustments on individuals who are not directly affected by the tax reductions.

For this exercise, we focus on changes to payroll taxes (total social security contributions in France) between 1995 and 1997. Over this period, the then prime minister Alain Juppé enforced tax reductions that targeted jobs with a wage of less than 1.3 times the minimum wage.³¹ Figure 5.1 shows the social security contributions in the baseline period and in 1997. We simulate the equilibrium effects of the tax changes, we impose the 1997 tax schedule on the estimated baseline environment

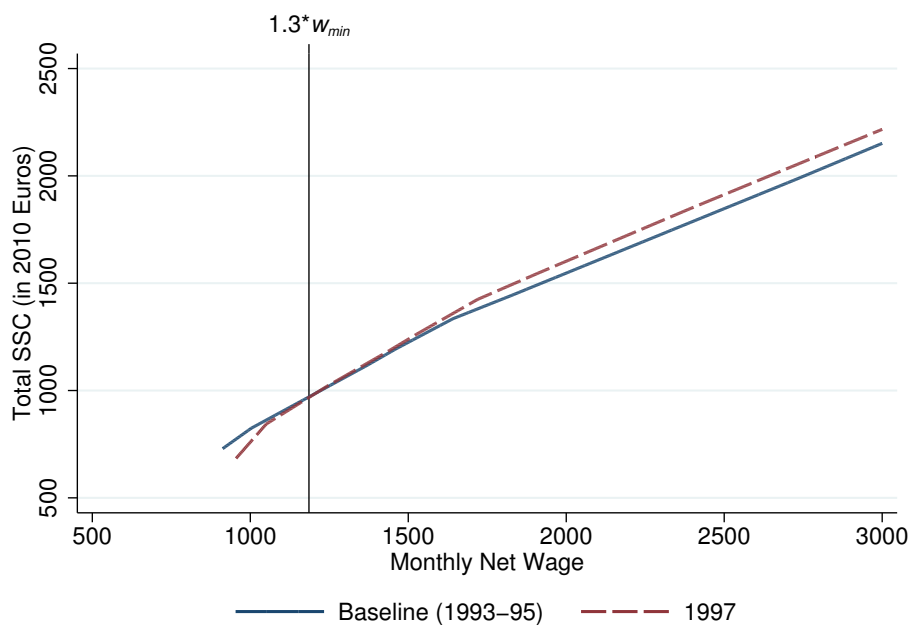
In Table 5.1, Panel (a) shows the equilibrium effects. Overall, our simulation suggests that changes in taxes between 1995 and 1997 lead to a 4.8% increase in the total number of vacancies. There is a 2.5% increase in employment as a result that previously unviable matches are now viable. Over 2/3 of the increase in employment come from the participation margin - workers who were not searching for work are searching and finding work - while the rest is due to the expansion of job opportunities for those who are already actively participating in the labor force. As the new

³¹ Although there are other changes to the payroll tax schedule over the same period, the employment effects mainly come from low-wage tax reductions based on our simulation.

Table 4.4: Moments.

Moment		Data	Simulation	Moment		Data	Simulation
<i>Job finding rate of workers in bin b_x</i> <i>relative to that of workers in the top bin:</i> $\frac{Pr(\chi_{i,t}>0 \chi_{i,t-1}=0 \text{ and } b_x(i)=b_x)}{Pr(\chi_{i,t}>0 \chi_{i,t-1}=0 \text{ and } b_x(i)=8)}$				<i>Median wage by firm bin:</i> $\text{median}(w_{i,t} b_y(\chi_{i,t}) = b_y)$			
1	$b_x = 1$	0.472	0.518	29	$b_y = 1$	1358	1497
2	$b_x = 2$	0.870	1.004	30	$b_y = 2$	1527	1557
3	$b_x = 3$	1.048	1.089	31	$b_y = 3$	1717	1589
4	$b_x = 4$	1.200	1.127	32	$b_y = 4$	1861	1621
5	$b_x = 5$	1.201	1.143	<i>Median out-of-unemployment wage</i>			
6	$b_x = 6$	1.209	1.142	33	$\text{median}(w_{i,t} \chi_{i,t-1} = 0)$	1492	1491
				<i>Median non-employment benefit by worker bin: $\text{median}(B_{i,t} b_x(i) = b_x)$</i>			
7	$b_x = 7$	1.196	1.129				
<i>Wage percentiles:</i>				34	$b_x = 1$	811	833
8	$w(p10)$	1131	1090	35	$b_x = 2$	941	961
9	$w(p20)$	1280	1226	36	$b_x = 3$	1017	1044
10	$w(p30)$	1401	1340	37	$b_x = 4$	1090	1143
11	$w(p40)$	1518	1460	38	$b_x = 5$	1196	1243
12	$w(p50)$	1638	1575	39	$b_x = 6$	1338	1388
13	$w(p60)$	1769	1716	40	$b_x = 7$	1540	1594
14	$w(p70)$	1929	1885	41	$b_x = 8$	2181	2095
15	$w(p80)$	2155	2107	<i>Labor force participation rate</i>			
16	$w(p90)$	2502	2438	42	$LFPR$	0.947	0.95
<i>Wage distribution relative to w_{min}</i>				<i>Unemployment rate</i>			
17	$Pr(w \leq 1.05w_{min})$	0.040	0.033	43	UR	0.077	0.085
18	$Pr(1.05w_{min} < w \leq 1.3w_{min})$	0.093	0.148	<i>Job-to-job transition rate relative to unemployment-to-job transition rate</i>			
19	$Pr(1.3w_{min} < w \leq 1.6w_{min})$	0.217	0.166	44	JJ/UE	0.091	0.105
20	$Pr(1.6w_{min} < w \leq 2.5w_{min})$	0.494	0.499	<i>Vacancy rate (vacancies over vacant and filled jobs)</i>			
<i>Median wage by worker bin:</i> $\text{median}(w_{i,t} b_x(i) = b_x)$				45	VR	0.011	0.011
				<i>Employment share by firm bin: $Emp(b_y)/Emp$</i>			
21	$b_x = 1$	998	1014				
22	$b_x = 2$	1176	1191	46	$b_y = 1$	0.140	0.127
23	$b_x = 3$	1293	1335	47	$b_y = 2$	0.256	0.240
24	$b_x = 4$	1418	1477	48	$b_y = 3$	0.331	0.325
25	$b_x = 5$	1562	1638	49	$b_y = 4$	0.272	0.308
26	$b_x = 6$	1731	1837				
27	$b_x = 7$	1978	2107				
28	$b_x = 8$	2496	2620				

Figure 5.1: Payroll tax schedule in the baseline period (January 1995 to August 1997) and in 1997. The relationship between taxes (SSC) and net wage is estimated based on data from the DADS by regressing SSC on net wages using a linear spline model. SSC for each job spell is computed by TAXIPP. We restrict our sample to non-executive, full-time, and private sector jobs.



additions to employment come from low-productivity jobs, the average production per employed worker is lowered by 1.4%. Positively affected by the rise in employment and negatively affected by the drop in average production, the aggregate production increases by 1.2%. The magnitudes of our simulated equilibrium effects on employment and production are in line with Crépon and Desplatz (2003) and Chéron et al. (2008).

To decompose the equilibrium effects into the direct and indirect effects, we first restrict the vacancy distributions to be the same as the baseline environment to obtain the direct effects, and compute the difference between equilibrium and direct effects to obtain the indirect effects. Panels (b) and (c) of Table 5.1 show the magnitudes of direct and indirect effects respectively. Without vacancy adjustments, the employment effect is stronger and leads to an increase of employment by 2.8%, suggesting that vacancy adjustments lowers employment growth by about 9%. While vacancy adjustments do not affect the participation margin, the chance of being unemployment rises for workers who were previously in the labour force. This is because the additional job vacancies are posted by low-productivity firms, some of which are previously inactive (Figure 5.1). These jobs are not acceptable to high productivity workers because the matches would not be productive enough to compensate for the workers' high option value of search and high non-employment transfers. As search is random, the low-productivity jobs congest the labor market for high productivity workers, lowering their job finding rate.

Vacancy adjustments also lead to a small but negative effect on average production per employed worker; this results from the shift in the composition of employed workers as low-productivity workers have more job opportunities and more productive workers find worker less frequently. This is further exacerbated by the production complementarity between workers and firms, as highly productive workers contribute disproportionately to production outputs. Overall, vacancy adjustments lower aggregate production by 0.25%, which is about 18% of the direct effect.

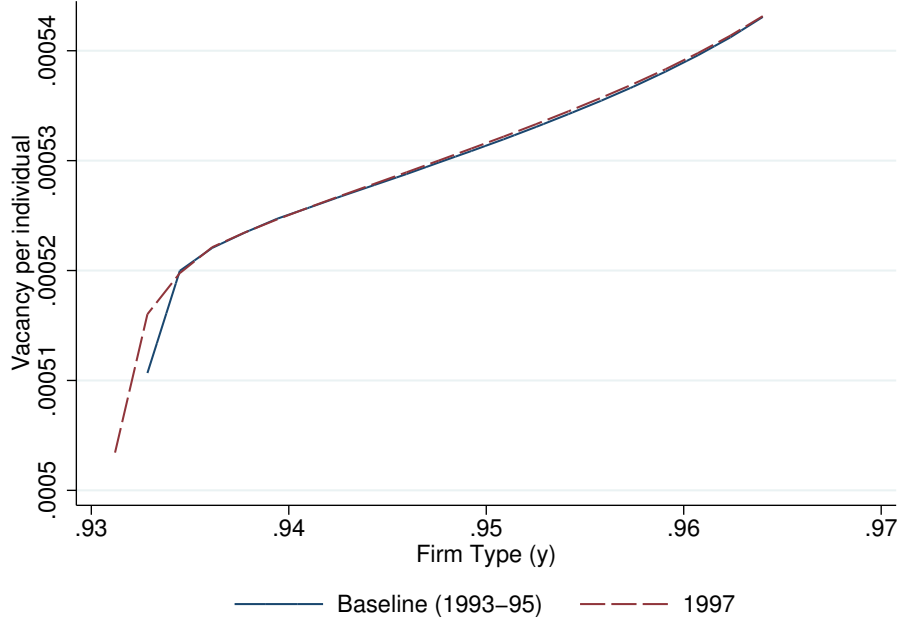
6 Nominal Incidence of Payroll Tax Reductions

The nominal incidence of tax reductions, or whether the reductions are applied to employees or employers, often do not affect equilibrium outcomes. However, this is not the case if there were a legal wage floor on the gross wage. As in many countries, the French payroll tax is shared between

Table 5.1: Simulated effects of tax changes between the baseline period and 1997. Tax changes are applied to the employer payroll tax. The baseline period is between January 1993 to August 1995.

	Change in...	(a) Equilibrium Effects		(b) Direct effects		(c) Indirect Effects	
		Level	Percent	Level	Percent	Level	Percent
1	vacancies per individual	0.001	4.8%	-	-	0.001	4.8%
2	employment	0.022	2.5%	0.024	2.8%	-0.002	-0.2%
	<i>due to changes in emp. of existing LF participants.</i>	<i>0.015</i>		<i>0.015</i>		<i>0</i>	
3	average job productivity	<i>0.007</i>		<i>0.009</i>		<i>-0.002</i>	
	<i>due to changes in emp. of existing LF participants.</i>	-40.7	-1.4%	-39.8	-1.3%	-1.0	-0.03%
4	aggregate production (measured by productivity per individual-month)	30.5	1.2%	37.1	1.4%	-6.6	-0.25%

Figure 5.2: Simulated effects of changes in payroll taxes between the baseline period and 1997 on the vacancy distribution. The baseline period is between January 1993 to August 1995.



employers and employees, and the gross wage constitutes the net wage and the employee-share of the payroll tax.

Given payroll taxes, the legal minimum gross wage effectively imposes a minimum requirement for the net income from employment. We denote the minimum net income from employment by Inc_{min} . Without any payroll tax subsidy, $Inc_{min} = w_{min}$, where w_{min} is computed by subtracting the employee payroll tax from the minimum gross wage. If the payroll tax reductions were given to employers (employer tax reductions), the relationship that $Inc_{min} = w_{min}$ still holds. This is the assumption under which we conducted our simulations in Subsection 5. Since the two minimum concepts are equivalent, the employer tax reduction is simply a change in our tax function $T(\cdot)$.

If the subsidy were instead applied to the employee payroll tax (employee tax reduction), it effectively increases Inc_{min} , causing it to diverge from w_{min} . This is because the gross wage of the worker cannot fall below the legal minimum gross wage, which we denote by w_{min}^{gross} . To see this, note that the minimum net income from employment becomes $Inc'_{min} = w_{min}^{gross} - T_{employee}(w_{min}) + \text{Subsidy}(w_{min})$ where $\text{Subsidy}(w_{min})$ is the amount of subsidy given to a minimum wage job. Since w_{min} was derived from subtracting the employee payroll tax from the w_{min}^{gross} , the gross minimum wage can be written as $w_{min}^{gross} = w_{min} + T_{employee}(w_{min})$. Therefore, we have $Inc'_{min} = w_{min} + \text{Subsidy}(w_{min})$. From a job that pays a net wage w , the worker receives a net income of $w + \text{Subsidy}(w)$, and the amount of $T(w) - \text{Subsidy}(w)$ is collected as tax revenue. This requires some modification of the

wage determination process in our model: in a bilateral meeting between a worker and a firm, the pair splits the match surplus by determining the net income of the worker, and the net income is constrained by the Inc'_{min} in the same way wages in the baseline model were constrained by the minimum net wage.

While the employee subsidy guarantees higher income for minimum-wage workers, earning its fame as a “make-work-pay” policy, it may further endanger employment opportunities for the low-productivity workers as it raises the minimum net income from employment. However, the negative effects on employment can be countered by a lower legal gross minimum wage. In fact, a low minimum wage combined with employee tax reductions are distinctive institutional features of the U.S. and the U.K. labor markets with their tax credit programs; this combination is seen as a policy alternative for France.

In the following, we compare the policy of maintaining the minimum wage and giving employer tax reductions to the policy of lowering the minimum wage and giving employee tax reductions. The former has been the strategy chosen by French policy makers, while the latter is in the same spirit as the EITC of the U.S. or the WFTC of the U.K.. In particular, we ask the following questions: First, how much does the gross minimum wage have to decrease so that the employee tax reduction would have the same effects on employment as the employer tax reduction? Second, would an equivalent employee tax reduction in terms of employment levels lead to different equilibrium outcomes in job-productivity, and aggregate output, and labor demand responses?

We revisit the tax reforms between 1995 and 1997 (Figure 5.1), but this time we assume that all changes in the payroll taxes are applied to employees rather than employers. Based on our simulations, we find that the net minimum wage w_{min} has to be lowered by 12.7%, or 115.8 euros, so that the employer tax reduction gives the same equilibrium employment effect the employer tax reduction.³² If the total payroll tax is shared equally between employers and employees (i.e. $T_{employee}(w) = 0.5T(w)$ for all w), this decrease in the net minimum is equivalent to a 13.8% or 176.7 euros decrease in the gross minimum wage. Interestingly, such a decrease in the minimum wage results in a new minimum net income from employment, Inc'_{min} , of 913 euros, which is almost identical to the original value of w_{min} (or, Inc_{min}).

With the decrease in the minimum wage, the employee tax reduction also gives similar equilibrium outcomes the employer tax reduction. Table 6.1 summarizes the equilibrium effects on vacancy, employment, and productivity, and the decomposition into direct and indirect effects, all of which are strikingly similar to Table 5.1. We therefore conclude that, given the tax changes between 1995 and 1997, the policy that entails maintaining the minimum wage and allocating tax reductions toward employers produces the highly similar equilibrium outcomes as the policy alternative that

³²Recall that our wage measures are monthly in 2010 euros and are based on full-time employment.

entails lowering the minimum wage and allocating tax reductions toward employees. Choosing between the two policies is therefore not an economic decision. If the minimum wage is unable to change, to whom a tax reduction should be allocated would depend on the level of the minimum wage. Employer tax reductions may be more preferable when the minimum wage is high.

7 Optimal coverage of payroll subsidies

The high minimum labor cost, arising from the high minimum wage and the high payroll taxes at the minimum wage, is often blamed for low-employment in France. Given that lowering the minimum wage is difficult due to political pressures, French policy makers have opted to provide payroll tax reductions in order to lower the minimum labor cost and boost job creation.³³ This is in contrast to the U.S. or U.K. economies where low-employment is due to poor wages and the unwillingness to work. In France, policy measures that aim for job creation for the less productive workers have often met with concerns of declining job productivities.

Since the Juppé reform in the 1990s, France has continued to implement payroll subsidies that cover an increasingly broader range of jobs. Most notably are the Fillon reform in 2003-2005 that provided social security subsidies for jobs with a wage of up to 1.6 times the minimum wage, and the “tax credit for competitiveness and employment (CICE)” announced in 2012 that provided payroll subsidies for jobs earning up to 2.5 times the minimum wage.³⁴ Subsidies of different coverages will likely have different implications on the aggregate productivity. On one hand, a narrower subsidy, one that only offers payroll subsidies to a smaller set of jobs with wages close to the minimum wage, may only benefit matches between low-productivity workers and firms, resulting in the creation of only low-productivity jobs and negatively affect aggregate production. On the other hand, a narrower subsidy may be more effective in distribution toward low-productivity workers. We refer to the trade-off between aggregate production and equality as the “efficiency-equity” trade-off.

In Subsection 7.1, we develop a framework to examine the “efficiency-equity” trade-off. We present results of optimal subsidy coverages in Subsection 7.2.

7.1 Framework to study optimal subsidy coverage.

In this subsection, we propose a framework that encompasses the two large payroll subsidy programs implemented in France: the Fillon reform and the CICE reform. We show how the labor market

³³Consistent with what we would recommend based on results in Section 6, the payroll tax reductions are applied to employers rather than employees to avoid further increase in the minimum labor cost

³⁴For institutional details, see Bunel and L’Horty (2012) and André et al. (2015).

Table 6.1: Simulated effects of tax changes between the baseline period and 1997. Tax changes are applied to the employee payroll tax. The baseline period is between January 1993 to August 1995.

Change in...	(a) Equilibrium Effects		(b) Direct effects		(c) Indirect Effects	
	Level	Percent	Level	Percent	Level	Percent
1 vacancies per individual	0.001	4.8%	-	-	0.001	4.8%
2 employment	0.022	2.5%	0.024	2.8%	-0.002	-0.2%
			<i>0.015</i>		<i>0</i>	
			<i>0.010</i>		<i>-0.002</i>	
3 average job productivity	-40.4	-1.3%	-39.5	-1.3%	-0.9	-0.03%
4 aggregate production (measured by productivity per individual-month)	30.4	1.2%	36.8	1.4%	-6.4	-0.20%

outcomes differ as a result of the differing coverage of the payroll subsidies, and test for the optimal coverage. Since the main goal of reforms like the Fillon and CICE was to increase employment, we focus on the question of how to optimally raise employment to a certain level by choosing the coverage and generosity of the payroll subsidy program. A payroll subsidy program is in addition to the tax schedule in our baseline environment.

To simplify our analysis, we restrict our attention to subsidy programs that offer the maximum payroll subsidy for minimum wage jobs, and phase out at the upper bound of the subsidy coverage threshold. We parametrize the subsidy level as follows:

$$\text{Subsidy}(w) = \begin{cases} (subb \times w_{min} - w)suba & \text{if } w \leq subb \times w_{min} \\ 0 & \text{otherwise} \end{cases} \quad (15)$$

where *suba* is the generosity of the subsidy and *subb* is the tax coverage threshold with respect to the statutory minimum wage. A larger *subb* means a broader coverage. The effective tax rate under a subsidy program is

$$T(w; suba, subb) = \max \{0, T(w) - \text{Subsidy}(w)\} \quad (16)$$

where $T(w)$ is the baseline tax schedule (Fig. 3.1).

As criteria for evaluating alternative policy programs, we assume a social welfare function that allows policy makers to care more about the consumption of the less well-off than others. We vary the parameter from a complete utilitarian welfare function to strong inequality aversion. Based on a sample of N_i individuals over T periods, the social welfare level $\mathcal{W}$ is computed as follows:

$$\mathcal{W} = \frac{1}{TN_i} \sum_{t=1}^T \sum_{i=1}^{N_i} welfare(c_{i,t}) \quad (17)$$

where $welfare(c_{i,t})$ is the individual welfare weight placed on worker i in period t if her consumption is $c_{i,t}$. We assume a constant-relative-risk-aversion formulation for $welfare(\cdot)$, so that the parameter ρ captures the policy maker's taste over efficiency and equity:

$$welfare(c_{i,t}) = \begin{cases} \frac{c_{i,t}^{1-\rho}}{1-\rho} & \text{if } \rho \neq 1 \text{ and } \rho > 0 \\ \log c_{i,t} & \text{if } \rho = 1 \end{cases} \quad (18)$$

If $\rho = 0$, the policy maker is utilitarian; in equilibrium, the social welfare equals the total value-added since firms make zero profit. For all $\rho > 0$, the policy maker is concerned with the distribution of consumption as well as total value-added.

In the calculation of consumption, we assume that all tax revenues are redistributed. More specifically, we assume that tax revenues are first used to finance non-employment benefit payments, and the remaining revenue is redistributed to the entire population as a lump-sum transfer. Define D_t as the per-person redistribution of the remaining tax revenue in period t :

$$D_t = \frac{1}{N_i} \left[\sum_{i:\chi_{i,t}>0} T(w_{i,t}; suba, subb) - \sum_{i:\chi_{i,t}=0} B(\mathfrak{h}(x_{i,t})) \right] \quad (19)$$

where $\sum_{i:\chi_{i,t}>0} T(w_{i,t}; suba, subb)$ is the total tax revenue and $\sum_{i:\chi_{i,t}=0} B(\mathfrak{h}(x_{i,t}))$ is the total non-employment benefit payment in period t .

Since individuals in our model are risk-neutral and do not save, their consumption is equal to the sum of labor income and transfers:

$$c_{i,t} = \mathbf{1}_{\{\chi_{i,t}=0\}} B(\mathfrak{h}(x_{i,t})) + \mathbf{1}_{\{\chi_{i,t}>0\}} w_{i,t} + D_t$$

7.2 Optimal subsidy coverage under different employment goals

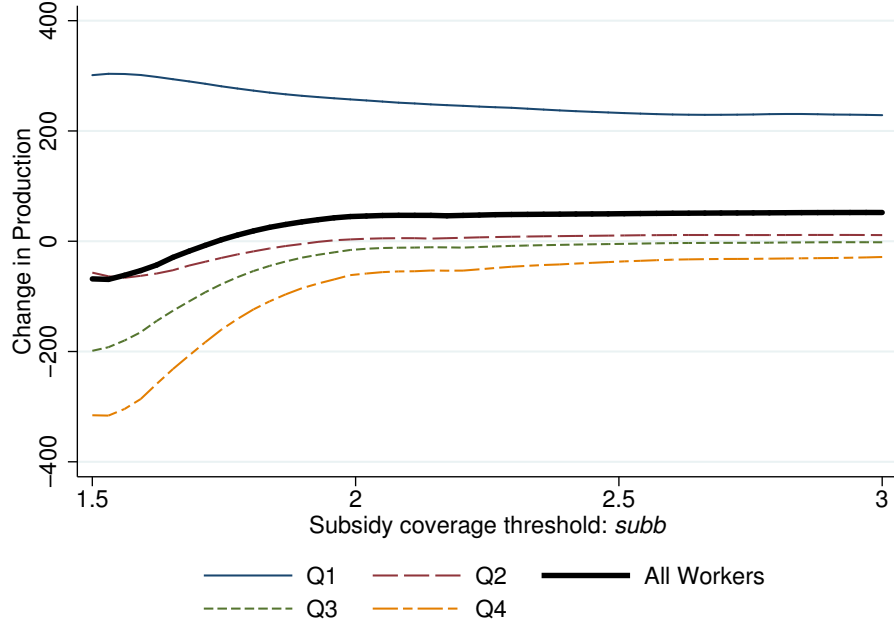
Given the framework outlined above, we begin by considering subsidy programs that raise the baseline employment-to-population rate by 5%. The broadness of a subsidy coverage has implications on the overall production output.

Figure 7.1 shows the total production output by quartiles of worker productivity. Compared to a broader subsidy, the least productive workers contribute more to the aggregate production under a narrower subsidy. The opposite is true for more productive workers: a subsidy that is too narrow may even result in lower production output from these workers. Overall, we see that a broader subsidy results in a greater production output than a narrower one.

The effects on production output can be decomposed into effects on employment (Figure 7.2) and the effects on average job output (Figure 7.3). We have seen in Section 5 that a subsidy encourages vacancies from the least productive firms, which makes it harder for highly productive workers to find viable matches. This is particularly true for narrow subsidies: with a narrower subsidy, the employment rate increases among the least productive workers, but decreases among the most productive ones. Moreover, the creation of low-productivity jobs under narrower subsidy programs reduces the average job productivity, which also explains the relationship between production output and the subsidy coverage.

The subsidy coverage also has distributional impacts: a broader subsidy spreads its benefits to more jobs and thus more worker types, resulting in less redistribution toward the least productive

Figure 7.1: Effects of expanding subsidy coverage on production by quartiles of worker productivity. All subsidy programs raise baseline employment by 5%. The lines “Q1-Q4” represent quartiles of worker productivity. “Change in production” is the difference in the monthly total production output divided by the number of individuals between the counterfactual and the baseline environments. The subsidy coverage threshold parameter $subb$ is a multiple of the minimum wage (see Eq. 15). The graph has been smoothed using a third degree polynomial.



workers. From Figure 7.2, we have already seen that a narrower subsidy is better at narrowing the employment gap between the least and the most productive workers. Figure 7.4 shows that a narrower subsidy also narrows the consumption gap: while the least productive workers are better-off under a narrower subsidy, the more productive workers are worse-off.

As there are both advantages and disadvantages associated with any subsidy coverage, a certain level of subsidy coverage may be optimal in terms of social welfare criteria that consider both

Figure 7.2: Effects of expanding subsidy coverage on employment by quartiles of worker productivity. All subsidy programs raise baseline employment by 5%. The lines “Q1-Q4” represent quartiles of worker productivity. “Change in employment rate” is the difference in the employment to population rate between the counterfactual and the baseline environments. The subsidy coverage threshold parameter $subb$ is a multiple of the minimum wage (see Eq. 15). The graph has been smoothed using a third degree polynomial.

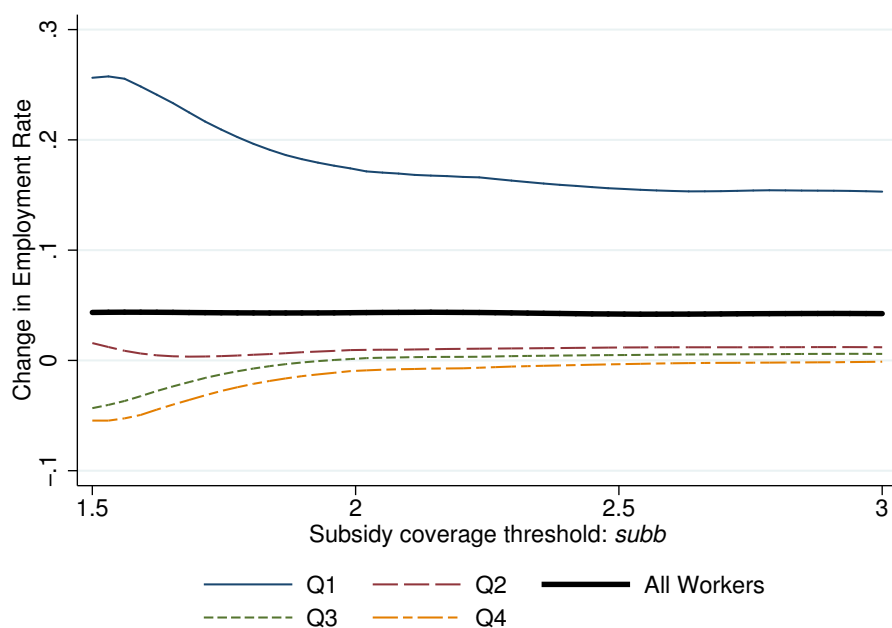


Figure 7.3: Effects of expanding subsidy coverage on job productivity by quartiles of worker productivity. All subsidy programs raise baseline employment by 5%. The lines “Q1-Q4” represent quartiles of worker productivity. “Change in production of employment workers” is the difference in the average output per job between the counterfactual and the baseline environments. The subsidy coverage threshold parameter $subb$ is a multiple of the minimum wage (see Eq. 15). The graph has been smoothed using a third degree polynomial.

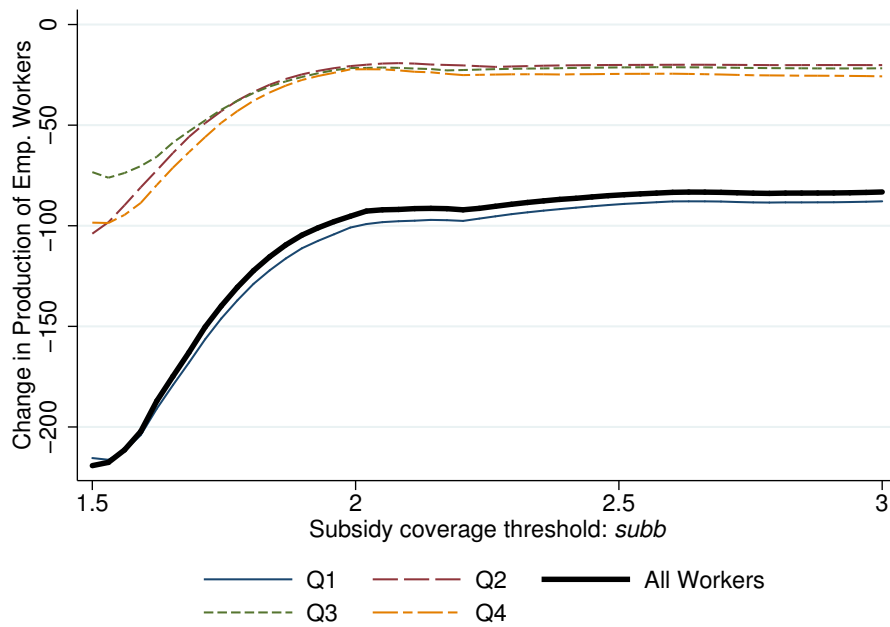
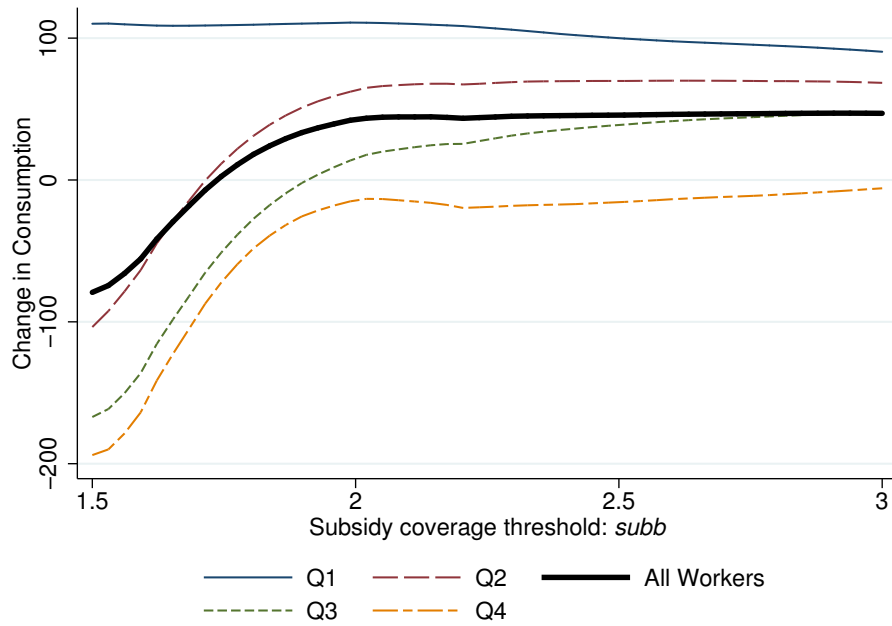


Figure 7.4: Effects of expanding subsidy coverage on consumption by quartiles of worker productivity. All subsidy programs raise baseline employment by 5%. The lines “Q1-Q4” represent quartiles of worker productivity. “Change in consumption” is the difference in the average consumption $c_{i,t}$ between the counterfactual and the baseline environments. The subsidy coverage threshold parameter $subb$ is a multiple of the minimum wage (see Eq. 15). The graph has been smoothed using a third degree polynomial.



efficiency and equity. Figure 7.5 shows the social welfare gains under subsidy programs that raises the baseline employment by 2, 3, and 5%.³⁵ The figure shows that a more ambitious employment goal calls for a broader subsidy coverage. With the 2% goal, the social welfare reaches the maximum with a coverage threshold of around 1.3 times the minimum wage. With the 3% goal the optimal threshold is around 1.7 times the minimum wage. With the 5% goal, the optimal threshold becomes 2.1 times the minimum wage. Comparing across subsidy programs that reach the three employment goals, it is evident that, in equilibrium, the optimal subsidy program that increases employment by 5% is most favorable compared to programs with a less ambitious employment goal.

Chéron et al. (2008) conduct a similar exercise regarding the subsidy coverage. However, instead of considering fixed employment goals, they are concerned with maximizing welfare and total production while restricting to the same ex-ante fiscal cost of the measure (i.e. the same upfront sum of subsidies before equilibrium labour market reactions are taken into account). They conclude that the optimal coverage threshold is 1.36 times the minimum wage, which results in an employment rise of around 2%. Their result is not inconsistent with our findings. We also find the optimal coverage to be around 1.3 times the minimum wage when we fixed the employment goal at 2%. Moreover, fixing the ex-ante budget cost does not imply that the equilibrium budget cost is unchanged. Based on our simulations, ex-post, or equilibrium, fiscal budget can be drastically different from the ex-ante budget and their relationship can be non-monotone. For example, given a fixed coverage (*subb*), the ex-ante budget shrinks with greater subsidy generosity (*suba*). However, the subsidy may increase employment which lead to higher tax revenue and lower benefit payment, resulting in a larger budget ex post. Figure 7.6 shows the equilibrium fiscal costs of different subsidy programs, measured as decreases in D from the baseline. We can see that, although raising employment by 5% is costly, at the optimal coverage threshold of around 2.1 times the minimum wage, the equilibrium fiscal cost is close to zero; such a subsidy would be highly costly based on ex-ante calculations. In fact, any subsidy program that with an ambitious employment goal is too costly ex-ante, and are thus excluded from the exercise conducted in Chéron et al. (2008).

To close this section, we would like to point out that the analyses so far have focused exclusively on the steady state equilibrium and places no weight on periods when the economy transitions between steady states. The speed at which the employment rate responds to the subsidy and the potential

³⁵We show the social welfare specification with $\rho = 4$. Alternative specifications of $\rho = 1$ and 2 give similar results for the optimal coverage.

Figure 7.5: Equilibrium social welfare gain ($\mathcal{W} - \mathcal{W}_{baseline}$) of alternative subsidy programs. We consider an inequality-averse welfare specification with $\rho = 4$. Subsidy generosity $suba$ varies such that the subsidy program raises baseline employment by the corresponding percentage.

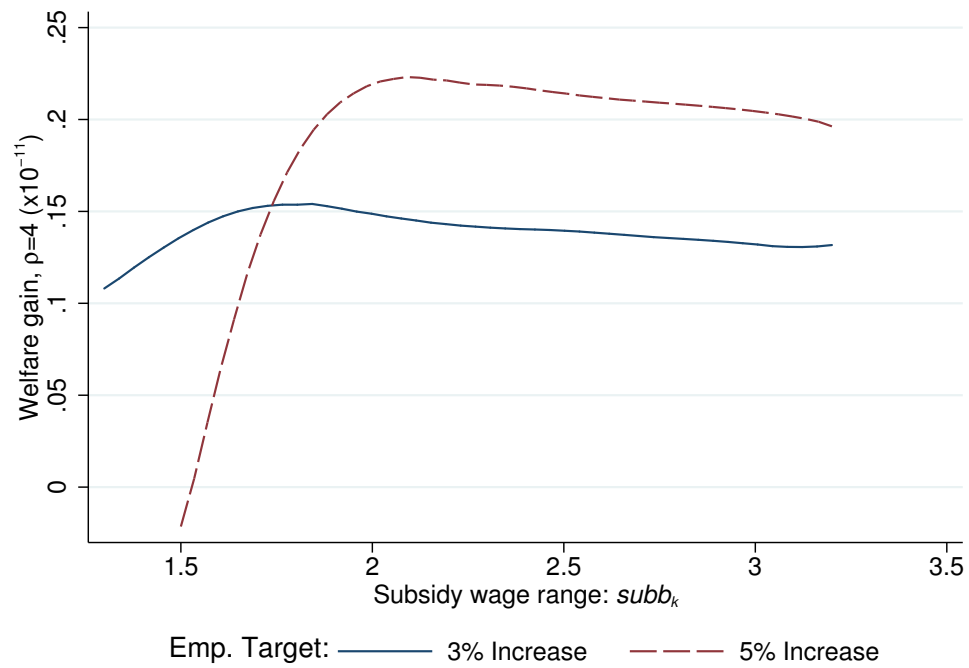
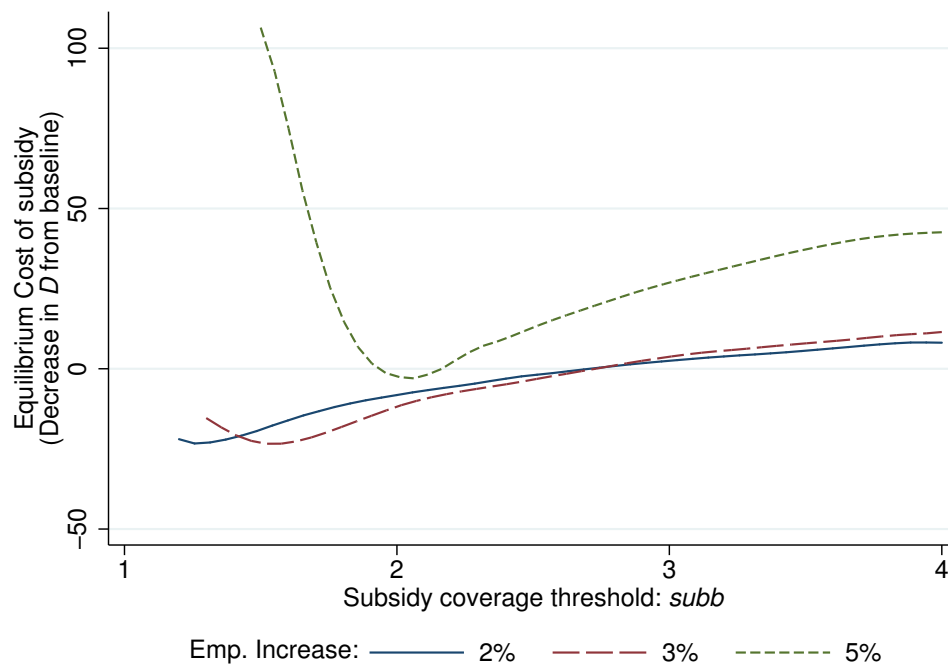


Figure 7.6: Equilibrium costs of subsidy programs measured as the decrease in tax revenue redistribution ($D_{baseline} - D$). We consider an inequality-averse welfare specification with $\rho = 4$. Subsidy generosity $suba$ varies such that the subsidy program raises baseline employment by the corresponding percentage.



short-run welfare costs to individuals may be highly relevant for policy makers, particularly if they have a short horizon due to term limits of their office or if there are frequent policy changes. A policy evaluation conducted using the short-run data may not fully capture the employment effects. In addition, a subsidy program that maximized the equilibrium welfare may be less desirable in the short run. However, simulating the short-run dynamics is difficult because our model is intractable off the steady state equilibrium.³⁶ In Appendix F, we develop approximation methods to simulate the short-run behaviors of workers and firms. Based on our approximated transitional paths, we find that subsidy programs only achieve 50-65% of the equilibrium employment growth in the first year after implementation. Moreover, with subsidies applied to employers, workers may be strictly worse-off in the short run.

8 Conclusion

In this paper, we examine the effects of payroll tax reduction policies using an equilibrium search-and-matching model that incorporates two important labor market institutions, a statutory minimum wage and a nonlinear payroll tax schedule. The model is particularly suited for studying tax reduction policies in France, a country in which the high minimum labor cost is blamed for the lack of employment opportunities. French tax reductions aim to lower the minimum labor cost and open up employment possibilities for the low skilled, but they also raise concerns about the potential negative impacts on workers who are not directly targeted.

In our model, employment opportunities are captured by the set of viable jobs, which may vary across workers due to the differences in their productivity levels or outside options. Effects of low-wage tax subsidies can reach beyond those not directly targeted because all workers search in the same market. When jobs of poor qualities are created, high-productivity workers can be negatively affected if these jobs are not viable for them and if jobs of better qualities become harder to find. To quantify the indirect effects, we estimate our model using French administrative data and simulate equilibrium effects of low-wage payroll subsidies.

We decompose the equilibrium effects of the Juppé tax reductions between 1995 and 1997 into a labor supply driven “direct effect” and a labor demand driven “indirect effect”. We find that labor demand response is an increase in job vacancies concentrated in low-productivity firms. The labor demand response shrinks the employment increase by 9%, and the aggregate productivity increase by 18%.

³⁶Robin (2011) and Lise and Robin (2017) develop dynamic equilibrium search-and-matching models to study aggregate shocks. A key assumption that allow them to maintain model tractability is that firms have full bargaining power, so that decisions of search and match can be determined independent of wages. Since wage is important to studying payroll taxes, we cannot make the same assumption.

We compare subsidies of different levels of wage coverage and generosity with the restriction that they raise the baseline employment to certain levels. We find that a subsidy that is narrowly focused on minimum wage jobs is more likely to distort the vacancy distribution and lead to more severe negative effects on employment and aggregate productivity. However, a narrower subsidy is more effective in redistributing toward the less productive workers. We assume that taxes are redistributed and adopt a social welfare function that account for both the levels and the distribution of consumption. Our simulation results show that a higher employment goal calls for a broader subsidy. The optimal subsidy program to increase the baseline employment by 5% covers jobs earning up to 2.1 times the minimum wage. This is preferred to programs that result in more moderate employment growths. Nevertheless, we note that the short-run implications may be different from the long-run. In particular, subsidy programs only achieve 50-65% of the equilibrium employment growth in the first year after implementation.

Furthermore, we also note that the French tax reductions are applied to employers. As an alternative policy measure, an employee tax reduction combined with a reduction in the minimum wage can also achieve the goal of reducing the minimum labor cost. Employee tax reductions has been the policy adopted by countries like the U.S. or the U.K.. We find that, with an appropriate reduction in the minimum wage, employee tax reduction results in almost identical equilibrium outcomes as the employer tax reduction. Therefore, the choice between the two policy measures is not an economic decision, but rather a matter of practicality. Given the existing high minimum wage in French, opting for employer tax reductions is a sensible policy decision.

Finally, our findings shed doubts on the ability of reduced form studies to correctly capture the effects of tax reforms. First, when the equilibrium effects go beyond those directly affected, it is not possible to identify a control group. Moreover, if a tax reform takes time to become fully effective, policy evaluations based on short-run data may poorly reflect the long-run effects.

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A Nash Bargaining

Consider the wage bargaining between an unemployed worker and a firm. The Nash bargaining wage maximizes the Nash product:

$$\phi_u^{Nash}(x, y) = \arg \max_w [W_e(w, x, y) - W_u(x)]^{\alpha_{Nash}} [J_f(w, x, y) - J_u(y)]^{(1-\alpha_{Nash})} \quad (20)$$

The Nash wage is characterized by the first order condition

$$W_e(w, x, y) - W_u(x) = \frac{\alpha_{Nash}}{1 - \alpha_{Nash}} [J_f(w, x, y) - J_u(y)] \frac{\partial W_e / \partial w}{-\partial J_f / \partial w} \quad (21)$$

Without taxes, $\frac{\partial W_e / \partial w}{-\partial J_f / \partial w} = 1$, utility is perfectly transferrable between workers and firms, and thus the wage under Nash and that under our proportional bargaining scheme coincide ($\phi_u^{Nash}(x, y) = \phi_u(x, y)$ whenever $\alpha_{Nash} = \alpha$).³⁷ With taxes, the marginal tax rate matters.

Given values functions 6 and 7 and sets 13 and 14, derivatives can be written as

$$\begin{aligned} [r + \delta + s_1 \kappa V] \frac{\partial W_e(w, x, y)}{\partial w} &= 1 \\ + s_1 \kappa \frac{\partial \left[\int_{y_0(w, x, y)}^y W_e(\phi_e(x, y, y'), x, y) v(y') dy' \right]}{\partial w} \\ + s_1 \kappa \frac{\partial \left[\int_{y_l}^{y_0(w, x, y)} W_e(w, x, y) v(y') dy' \right]}{\partial w} \end{aligned} \quad (22)$$

$$\begin{aligned} (r + \delta + s_1 \kappa V) \frac{\partial J_f(w, x, y)}{\partial w} &= -1 - \frac{dT(w)}{d} \\ + s_1 \kappa \frac{\partial \left[\int_{y_0(w, x, y)}^y J_f(\phi_e(x, y, y'), x, y) v(y') dy' \right]}{\partial w} \end{aligned} \quad (23)$$

$$+ s_1 \kappa \frac{\partial \left[\int_{y_l}^{y_0(w, x, y)} J_f(w, x, y) v(y') dy' \right]}{\partial w} \quad (24)$$

Applying the Leibniz integral rule, and noting that $\phi_e(x, y, y_0(w, x, y)) = w$, we get

³⁷Consistent with l'Haridon et al. (2013) and Jacquet et al. (2014).

$$\frac{\partial W_e(w, x, y)}{\partial w} = \frac{1}{r + \delta + s_1 \kappa \int_{y_0(w, x, y)}^{y_h} v(y') dy'} \quad (25)$$

and

$$-\frac{\partial J_f}{\partial w} = \frac{1 + \frac{dT(w)}{dw}}{r + \delta + s_1 \kappa \int_{y_0(w, x, y)}^{y_h} v(y') dy'} \quad (26)$$

The Nash equation can be rewritten as

$$\frac{W_e(w, x, y) - W_u(x)}{J_f(w, x, y) - J_u(y)} = \frac{\alpha}{[1 - \alpha]} \frac{1}{\left[1 + \frac{dT(w)}{dw}\right]} \quad (27)$$

which states that the ratio of the worker and firm surpluses is equal to the product of the ratio of their respective bargaining parameters and $\frac{1}{\left[1 + \frac{dT(w)}{dw}\right]}$. Whether Equation 27 has a unique solution depends on how the marginal tax rate $\frac{dT(w)}{dw}$ varies with w . If the marginal tax rate is continuously increasing in w , a unique solution (interior or corner) exists. However, the French tax (SSC) schedule that we consider for our empirical section exhibits decreasing $\frac{dT(w)}{dw}$, and thus a unique Nash bargaining solution is not guaranteed. This poses theoretical and numerical challenges to solving the model and therefore we opt for the simpler proportional bargaining scheme that we describe in the main text.

By assumption, $dT(w)/dw \geq 0$, thus $\frac{1}{\left[1 + \frac{dT(w)}{dw}\right]} \leq 1$. Given x and y , the Nash wage ϕ_u^{Nash} must be smaller than the proportionally bargained wage ϕ_u , implying that the α parameter we estimate must be smaller than the α_{Nash} if Nash bargaining were in place. The intuition is that, with Nash, the worker needs to compensate the firm knowing that increasing wage leads to increasing tax burden. In proportional bargaining, the two parties remain ignorant about how the tax burden comes about.

B Numerical Solution of Steady State Equilibrium

In this Section, we describe the procedure of the numerical solution. As we have explained, the surplus of every match in our model depends on current and future wages due to the fact that firms do not have full bargaining power. In addition, due to the presence of taxes and the minimum wage, we are unable to derive an analytical wage equation, and thus solving the model relies on iterating the value functions.

Before solving the model, we fix the exogenous components of the model and choose a tolerance level and a criterion function. We discretize the state space containing worker type, firm type, and wage into respective grids. We allow the grids for firm type and wage are to depend on model parameters for numerical efficiency.

We make initial guesses for the value functions W_e , W_n , and J_f such that W_e and J_f are increasing in wage. The initial guess for the match and unemployment distributions $h(\cdot, \cdot)$ and $u(\cdot)$ are such that the sum of them across all worker and firm times is equal to 1. We also make initial guess for the vacancy distribution $v(\cdot)$ such that the sum of vacancies is greater than 0. Given the initial guesses, we enter the loop for the fixed point solution. In each iteration, we take the $\tilde{W}_e, \tilde{W}_n, \tilde{J}_f, \tilde{h}, \tilde{u}$, and $\tilde{v}$ as given and solve for the optimal decisions. The tilde-notation refers to the initial guesses if we are in the first iteration, otherwise, it refers to the resulting objects from the previous iteration.

More specifically, each iteration can be broken down into several steps:

1. Given $\tilde{W}_e, \tilde{W}_n, \tilde{J}_f$, we solve for the set of viable matches, $\tilde{\Omega}$, such that

$$\tilde{\Omega} = \{(x, y) : \exists w \text{ s.t. } w \geq w_{min} \text{ and } \tilde{W}_e(w, x, y) - \tilde{W}_n(x) \geq 0 \text{ and } \tilde{J}_f(w, x, y) \geq 0\}$$

2. Solve for $\tilde{\phi}_u(x, y)$ for all $(x, y) \in \tilde{\Omega}$.
3. Define $\tilde{\phi}(x, y)$ as the highest wage such that $\tilde{J}_f(w, x, y) = 0$. Solve for $\tilde{\phi}_e(x, y', y)$ for all (x, y', y) such that $(x, y) \in \tilde{\Omega}$ and $(x, y') \in \tilde{\Omega}$ from the following equation.

$$\tilde{W}_e(\tilde{\phi}_e(x, y', y), x, y') - \tilde{W}_e(\tilde{\phi}(x, y), x, y) = \frac{\alpha}{1 - \alpha} \tilde{J}_f(\tilde{\phi}_e(x, y', y), x, y')$$

4. Define $mobility(x, y', y) = 1$ if either of the following criteria is satisfied.

- (a) $(x, y) \in \tilde{\Omega}$, $(x, y') \in \tilde{\Omega}$, $\tilde{\phi}_e(x, y', y) \leq \tilde{\phi}(x, y')$, and $\tilde{W}_e(\tilde{\phi}(x, y'), x, y') - \tilde{W}_e(\tilde{\phi}(x, y), x, y) \geq 0$.
- (b) $(x, y) \notin \tilde{\Omega}$ but $(x, y') \in \tilde{\Omega}$.

5. Solve for $\tilde{s}(x)$ for all x , such that

$$\tilde{s}(x) = \arg \max_{s=\{0,1\}} \left\{ B(x) - sq + s\tilde{\kappa} \int_{y' \in \tilde{\mathcal{A}}_u(x)} [\tilde{W}_e(\max\{w_{min}, \tilde{\phi}_u(x, y')\}, x, y') - \tilde{W}_n(x)] \tilde{v}(y') dy' \right\}$$

$$\text{where } \tilde{\kappa} = \frac{M(\tilde{\xi}, \tilde{V})}{\tilde{\xi} \tilde{V}}, \text{ and } \tilde{\mathcal{A}}_u(x) = \{y : (x, y) \in \tilde{\Omega}\}.$$

6. Update the efficiency search units: $\tilde{\xi} = \int \left[\tilde{s}(x)\tilde{u}(x) + \int \tilde{h}(x, y)dy \right] dx$.
7. Solve for $\tilde{v}(\cdot)$ using Eq. 8, with $I_u(y)$ and $I_e(y)$ being replaced by their tilde-counterparts:

$$\begin{aligned}\tilde{I}_u(y) &= \int_{x \in \tilde{\mathcal{B}}_u(y)} \tilde{s}(x) \tilde{J}_f(\tilde{\phi}_u(x, y), x, y) \tilde{u}(x) dx \\ \tilde{I}_e(y) &= \iint_{(x, y') \in \tilde{\mathcal{B}}_e(y)} s_1 \tilde{J}_f(\tilde{\phi}_e(x, y, y'), x, y) \tilde{h}(x, y') dy' dx\end{aligned}$$

where $\tilde{\mathcal{B}}_u(y) = \{x : (x, y) \in \tilde{\Omega}\}$ and $\tilde{\mathcal{B}}_e(y) = \{(x, y') : mobility(x, y, y') = 1\}$.

8. Update $\tilde{\kappa} = \frac{M(\tilde{\xi}, \tilde{V})}{\tilde{\xi}\tilde{V}}$, and value functions the value functions $\tilde{W}_e, \tilde{W}_u, \tilde{J}_f$ using Eq. 6, 5, and 7 and the appropriate tilde-objects.
9. Update the unemployment distribution $\tilde{u}(\cdot)$ using Eq. 10, and the match distribution $\tilde{h}(\cdot, \cdot)$ by using Eq. 9.
10. Evaluate the criterion function and compare the value with the pre-set tolerance level. If the distance is within tolerance, terminate the loop.

C Imputing the status of individuals in gap spells

We use the *Enquête Emploi* (Hereafter, EE), French labor force survey, to impute the status of an individual in a gap spell in the DADS. Within EE, we label all spells that are not covered by the DADS panel as “not employed”, with the indicator *nw*. This include in particular unemployment, but also self-employment and non-participants. The aim is to identify the probability of unemployment conditional on non-employment using individual and job characteristics that are available in both EE and DADS.

The first step is to select an EE sample to resemble the sample in DADS. This entails restricting to men of age 30-55 and dropping individuals who have never been employed prior to or following an *nw* spell. The latter restriction is related to the data structure in the DADS panel, in which a gap spell can only be observed if it is sandwiched between two employment spells. We also drop *nw* spells that last for more than 3 years.

We then estimate the likelihood of unemployment in EE. We use information on the individual’s age, the duration of the *nw* spell, the social-professional status, industry, and sector (private or public) of the employment spell following the *nw* spell. We denote these information by Ω_s . Using a Probit model, we estimate $P(u_s | nw_s, \Omega_s)$, where $u_s = 1$ indicates unemployment.

Table D.1: Values of the policy parameters $\tilde{f}$ and $\tilde{m}$ for simulating non-employment benefits. Values are nominal. Values prior to 2001 have been converted from French francs (FF) to Euros (€) using the conversion rule of 1€=6.55957FF.

Date effective	$\tilde{f}$	$\tilde{m}$	Date effective	$\tilde{f}$	$\tilde{m}$
7/1/10	11.17 €	27.25 €	7/1/00	9.56 €	23.32 €
7/1/09	11.04 €	26.93 €	7/1/99	9.38 €	22.86 €
7/1/08	10.93 €	26.66 €	7/1/98	9.26 €	22.58 €
7/1/07	10.66 €	26.01 €	7/1/97	9.09 €	22.16 €
7/1/06	10.46 €	25.51 €	7/1/96	8.90 €	21.68 €
7/1/05	10.25 €	25.01 €	7/1/95	8.68 €	21.17 €
7/1/04	10.25 €	25.01 €	7/1/94	8.43 €	20.39 €
7/1/03	10.15 €	24.76 €	7/1/92	8.26 €	19.97 €
7/1/02	9.94 €	24.24 €	7/1/91	8.04 €	19.45 €
7/1/01	9.79 €	23.88 €	10/1/90	7.87 €	19.02 €

The final step is to impute the unemployment status for gap, or nw , spells in DADS. We similarly construct Ω_s^{DADS} for each spell s , and compute the predicted likelihood that s is an unemployment spell using the estimated predictor from EE, $\hat{P}(u_s|nw_s, \Omega_s^{DADS})$. We draw the unemployment status of each nw spell from the distribution given by the predicted likelihood.

D Simulating non-employment benefits.

We simulate the benefit level, denote by $\tilde{B}$, as a function of the average daily gross wage $\tilde{w}$ in the year preceding the unemployment spell. Specifically, $\tilde{w}$ is equal to the total gross earnings during the preceding year divided by the number of days worked in that year. The procedure to compute $\tilde{B}$ is as follows:

1. compute $\tilde{B}_0(\tilde{w}) = \max \left\{ \tilde{f} + \tilde{s}_0\tilde{w}, \tilde{s}_1\tilde{w} \right\};$
2. compute $\tilde{B}_1(\tilde{w}) = \max \left\{ \tilde{B}_0(\tilde{w}), \tilde{m} \right\};$
3. if $\tilde{B}_1(\tilde{w}) = \tilde{m}$, the simulated benefit $\tilde{B} = \tilde{m}$. Otherwise, $\tilde{B} = \min \left\{ \tilde{B}_0(\tilde{w}), \tilde{s}_2\tilde{w} \right\}.$

The parameters $\tilde{f}$, $\tilde{m}$, $\tilde{s}_0$, $\tilde{s}_1$, and $\tilde{s}_2$ are policy parameters. $\tilde{f}$ and $\tilde{m}$ are time-varying, whose values are shown in Table D.1. The values of $\tilde{s}_0$, $\tilde{s}_1$, and $\tilde{s}_2$ are fixed in the entire sample period from 1991 to 2008, with $\tilde{s}_0 = 40.4\%$, $\tilde{s}_1 = 57.4\%$, and $\tilde{s}_2 = 75\%$.

E Panel data from the DADS

This section provides details on data cleaning procedures in dealing with the combined dataset from the two panels from the DADS, *panel DADS* and *panel tous salariés*. In Section E.1, we describe the procedures of converting the spell-based data in the original panel to monthly-based sample. In Section E.2, we explain sample restrictions and the calculation of individual ranking statistics.

E.1 Procedures to convert data into monthly data

The raw data is spell-based; there is one observation per individual-job-year. We took the following steps to convert the raw data into a monthly dataset.

E.1.1 Correcting missing spell dates.

Around 0.5% of employment spells contains missing start and end dates; the spell duration is available for over 99.998% of the spells. We infer the spell start and end dates using spell duration and the employment spells in the surrounding years. Let $spell(i, Y, j)$ denote an employment spell of worker i in year Y and firm j . Suppose we observe $spell(i, Y, j)$ with missing dates, and we also observe $spell(i, Y + 1, j)$ that starts on the first day of year $Y + 1$, and we do not observe $spell(i, Y - 1, j)$. In this case, the end date of $spell(i, Y, j)$ is the last day of year Y , and the start date is derived from the spell duration. In all other cases, we assume that the spell start date is day 1 of the spell year, and the end date is derived from spell duration. In the extremely rare cases that the spell duration is missing, we assume that the spell lasts for the entire year.

E.1.2 Correcting overlapping spells.

Multiple spells of the same worker at the same or different firms may have overlaps in time. About 40% of the individuals have held overlapping jobs. In these cases, we need to identify a main job and define the wage for the job. During the time window that two jobs overlap, the main job is the one that is full-time, private sector, and non-executive. If both or neither jobs satisfy these criteria, the main job is identified by a higher wage. Wages from overlapping jobs are only summed if they are in the same firm. Lastly, continuous employment spells within the same firm in a given year are concatenated and the wage is defined as the average wage over the concatenated spell.

E.1.3 Correcting whole-year gaps.

We notice that in years 1994, 2003, and 2005, there are high occurrences that individuals are missing for the entire year but are observable in the preceding or the following years; we refer to this as a whole-year gap. Over the period between 1991 and 2008, whole-year gaps occurs in 1.4% of the sample individuals. In 1994, 2003 and 2005, the occurrences are 10.3%, 3.0% and 1.4% respectively. A potential reason for the whole-year gaps may be missing data for these individuals in the three years. To correct for this problem, we replace the whole year gaps with employment spells if the worker is employed on the day before and after the gap year in the same firm. We take the average wages in the surrounding years as the wage for the new employment spells. Overall, 86.6% of the whole-year gaps in the three years are corrected.

E.1.4 Transforming spell data to monthly data

In the monthly data, there is one observation per individual-month. If more than one spells occupy the same month, we take the one that occupies the largest fraction of the month.

E.2 Ranking workers

In constructing individual statistics for ranking, we set two additional sample selection criteria. First, we exclude individuals whose sample duration is less than 5 years, where the sample duration is calculated as the difference between the start date of the first employment spell and the end date of the last employment spell. Second, we exclude individuals such that less than 50% of the sample duration is occupied by sample jobs or unemployment, where sample jobs are defined as full-time non-executive jobs in the private sector. Our final sample contains 416,221 men of age 30-55 between 1991-2008 who satisfy the sample selection criteria. Table E.1 compares the raw data from DADS and our final sample. As expected, individuals in the final sample have longer sample duration, and are more likely found in sample jobs. Since we exclude individuals who mainly work as executives, the average sample job wage is lower in our sample.

In computing the ranking statistics of an individual, we include all labor incomes including those from overlapping jobs and non-sample jobs. All income measures are net of taxes. The lifetime minimum and maximum wage are annualized wages in any job divided by 12. Since part-time

Table E.1: Descriptive Statistics. “DADS” refers to the merged DADS panels restricted to men age 30-55 between 1991-2008. “Sample” refers to our final sample after cleaning and restricting the panel. Sample duration is calculated as the difference between the start date of the first employment spell and the end date of the last employment spell. A sample job is one that is full-time, private-sector, and non-executive. Daily wage is the daily net wage.

	Data	Restricted sample
# Individuals	873,425	416,221
Mean sample duration	2122 days	3754 days
Median sample duration	1229 days	2879 days
% Full time jobs	84.01%	93.45%
% Private Sector jobs	69.32%	96.74%
% Non-executive jobs	74.28%	96.46%
% Sample jobs	44.51%	88.26%
25th daily wage percentile	46.43	45.68
50th daily wage percentile	57.47	55.18
75th daily wage percentile	73.11	68.26

jobs are included in these statistics, the lifetime minimum monthly wage may fall below the legal minimum wage.

Table E.2a shows the distributions of the three ranking statistics, average individual earnings and lifetime maximum and minimum wages. E.2b shows the Spearman rank correlations between the statistics. Lifetime earnings is strongly correlated in rank with the lifetime minimum and maximum wages; the rank correlation between the latter is weaker but nevertheless significantly positive. The weaker correlation may be due to measurement and sampling errors, which pose a greater problem for the extrema measures.

E.3 Firms

We compute firm size from POST by counting the total number of employee-days divided by the total number of days a firm is in the sample. In the computation, we only consider jobs that are non-executive, full-time, in the private sector, and are filled by individuals who are male, age 30-55. Table E.3 shows the firm size distribution and the average sample duration for firms of different sizes. On average, larger firms have longer sample durations. In our estimation procedure, we only rank firms with a firm size of at least 10. For these firms, the average sample duration is over 10 years. Moreover, although only 29% of firms satisfy our criterion, they account for 88% of total employment.

Table E.2: Ranking statistics of workers. All statistics are monthly. For each individual, the statistics are computed based on the entire period between the first and last observations of the individual in the DADS sample from 1991 to 2008. “Lifetime income” refers to the net-of-tax average income per month, accounting for net wage and imputed non-employment benefits. “Lifetime min. wage” and “Lifetime max. wage” refer to the lowest and the highest net wage from employment that an individual obtains while in sample.

(a) Distributions of worker ranking statistics.

	Lifetime income	Lifetime min. wage	Lifetime max. wage
Mean	1671.3	1140.6	2790.6
P25	1260.9	556.2	1690.2
P50	1549.2	1182.9	2084.4
P75	1950.0	1590.6	2733.0

(b) Spearman rank correlations between worker ranking statistics.

	Lifetime income	Lifetime min. wage	Lifetime max. wage
Lifetime income	1	0.754	0.653
Lifetime min. wage	-	1	0.298

* all correlations are significant at the 1% level.

F The short-run

In this section, we develop methods to approximate short-run labor market distributions by assuming that workers and firms do not perfectly correctly foresee the future. We compute social welfares at the time of policy implementation. When the time horizon for welfare calculations is sufficiently short, the conclusion we draw may be contrary to the one drawn from the steady state equilibrium.

F.1 Approximation methods for the short-run transitions.

The labor market is no longer in an equilibrium when a payroll subsidy is implemented. Because of search frictions, the labor market distributions of unemployment, $u(\cdot)$, and matches, $h(\cdot, \cdot)$, take time to adjust. On the transitional path, the decisions $\Psi = \{s(\cdot), \underline{y}(\cdot), \phi_u(\cdot, \cdot), y_0(\cdot, \cdot, \cdot), \phi_e(\cdot, \cdot, \cdot), v(\cdot)\}$ depend on future distributions.³⁸ For example, in order to decide whether or not to search, a

³⁸If we can write down a surplus function that does not depend on future wages, solving for the decisions would not require knowing the future distributions, and consequently the system would be tractable in the off-equilibrium

Table E.3: Firm size distribution, firm duration in sample and employment share. The statistics are computed from the POST dataset of the DADS. Firm size is computed by counting the total number of employee-days divided by the total number of days a firm is in the sample. We restrict to jobs that are non-executive, full-time, in the private sector, and are filled by individuals who are male, age 30-55.

Firm size	Number of Firms	Fraction of firms	Firm duration in sample	Emp. Share
0 to 1	26,972	71.0%	4.68	12.2%
1 to 2	44,407		8.00	
3 to 5	73,717		9.99	
5 to 10	49,319		10.93	
10 to 50	63,617	29.0%	11.21	87.8%
50-100	8,473		10.93	
>100	7,311		11.16	
Total	273,816	100%	-	100%

non-employed worker needs to know not only the likelihood of finding a job in the current period, but also the likelihoods of receiving outside offers when she becomes employed. Similar examples can be made with firms' decisions. Making such decisions requires the knowledge of the current and future distributions of vacancies, unemployment and employment. However, as a result of the payroll subsidy, these distributions change from period to period. The question thus arises, which distributions our worker uses to determine her search effort. Solving the model at every point in time on the transitional path is not feasible because the distributions are intractable. We believe that a good approximation for the transitional path is to assume that workers and firms misperceive the future with what they can observe around them and what they know about the steady state equilibrium with the new policies.

Let $\Phi = \{u(\cdot), h(\cdot, \cdot)\}$ be the steady state distributions in the “old regime” prior to a policy reform. At $t = 0$, a reform is implemented. We assume the reform is unexpected, so that agents do not react the impending reform prior to $t = 0$. Let $\Phi_t = \{u_t(\cdot), h_t(\cdot, \cdot)\}$ be the actual distributions of unemployment and matches in period $t > 0$, and $\Phi' = \{u'(\cdot), h'(\cdot, \cdot)\}$ be the steady state distribution in the “new regime” under the policy reform. Instead of being correctly informed about Φ and $\{\Phi_t\}_{t>0}$, we assume that workers and firms are misinformed but nevertheless are forward-looking and rational given their information. This allows us to simplify the model solution on the transitional path and allow us to simulate the short-run dynamics of then labor market distributions.

We consider two alternative assumptions: far-sightedness and short-sightedness. Let Φ_t^F and Φ_t^S denote agents' perception about the distributions in period $t > 0$ under the two far-sightedness and short-sightedness assumptions, respectively, and let Ψ_t^F and Ψ_t^S be the decisions in period $t > 0$.

dynamics. This is the case in Lise and Robin (2017), which studies a search and matching model with aggregate shocks. In our model, we cannot achieve tractability if we let $\alpha > 0$, or if there were taxes and minimum wages.

Under the far-sightedness assumption, workers and firms believe that they are already in the new steady state equilibrium such that $\Phi_t^F = \Phi'$ for all $t > 0$. They follow the same decision rules under the new steady state such that $\Psi_t^F = \Psi'$ for all $t > 0$.

Under the short-sightedness assumption, at each period t , agents observe the actual distributions Φ_t . They perceive Φ_t to be the distributions that will last in all future periods, i.e. $\Phi_{t+d}^S = \Phi_t$ for all $d \geq 0$. They make optimal decisions Ψ_t^S consistent with a steady state equilibrium that features these distributions. Along the transitional path, agents' perceptions Φ_t^S are updated every period as Φ_t changes.

While we do not prove the convergence of the approximated transitions analytically, in the simulation exercises we conduct, the approximated transitional paths under the two assumptions always converge to the new regime steady state distributions. The discrepancy between the approximated paths and the actual path depends on the difference between the immediate impact and the new-regime equilibrium.

In addition to the search friction that is inherent to our model, there may be additional frictions in labor market transitions that only apply when policies are altered. In the steady state equilibrium, individuals do not transition in and out of the labor force or transition from jobs to unemployment voluntarily. Therefore, we have not made any assumption about the speed or costs associated with such transitions. However, when the policy environment changes, such transitions are part of the transition process to the new steady state.³⁹

We consider the possibility of a labor force entry (LFE) friction: Individuals have to wait before entering the labour market. We simulate the transitions both with and without the LFE friction. In the case with the LFE friction, we assume that the waiting time distribution is stochastic, and is on average 1 year. LFE friction may arise from the fact that there may be a waiting period for the non-participants to become eligible for jobs or for the worker to regain job search skills. It may also be the case that individuals are not aware of a subsidy program immediately after its implementation.

F.2 Short-Run Simulation Results

In subsection 7.2, we maximize the equilibrium social welfare $\mathcal{W}$ by varying the broadness and generosity of subsidy programs that raise employment to fixed goals. Table F.1 shows the subsidy parameters of the optimal programs that raise the baseline employment rate by 2, 3, and 5%. In

³⁹Note that we do not need to consider friction associated with job destructions and downward wage adjustments because we only consider tax reduction policies. If tax increases were being considered, it may be important to account for frictions in those process, particularly in a country with strong labor protection.

Table F.1: Parameters of three subsidy programs. “Emp. Goal” refers to the equilibrium increase in employment from the pre-reform level. *suba* and *subb* are parameters of the subsidy function in Eq. 15.

Subsidy	Emp. Goal	Generosity (<i>suba</i>)	Coverage (<i>subb</i>)
1	2%	0.34	1.35
2	3%	0.24	1.7
3	5%	0.30	2.1

this Subsection, we simulate the short-run employment and welfare transitions from the baseline to the steady state equilibria under the three subsidy programs.

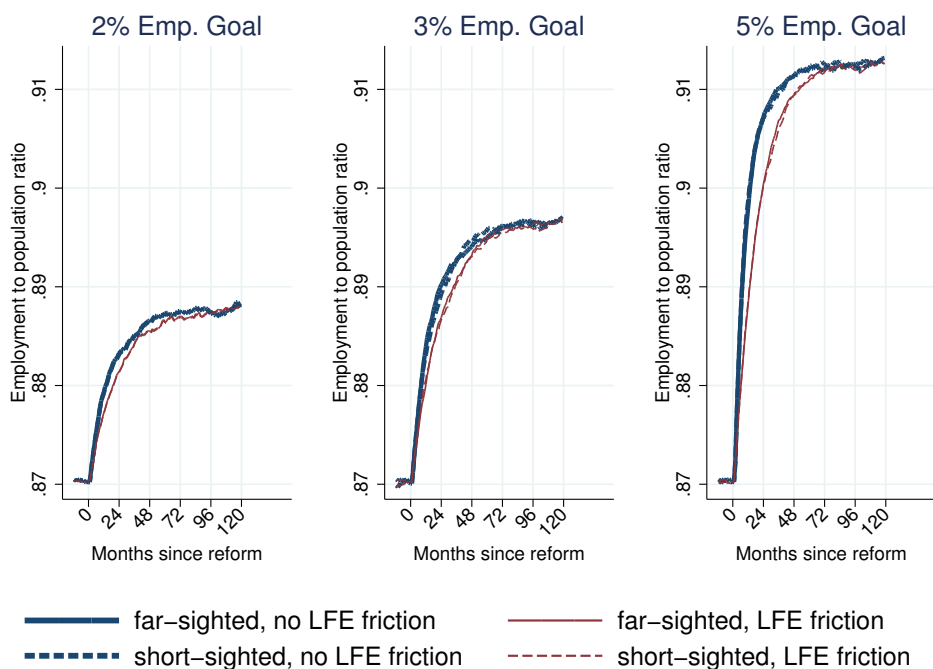
We first simulate short-run transitions of employment based on our two approximation methods. A slow employment response may raise concerns for the efficacy of a subsidy. It may also explain the short-run unresponsiveness found in the empirical literature. Figure F.1a shows the transitional paths. A first observation is that the transitional paths under the far- and short-sightedness approximations closely trace one another. All simulated short-run transitions converge to the correct steady state equilibrium. These provide assurance for our approximation methods and leave little room for the possibility for the multiplicity of transitional paths.

To quantify the speed of convergence, Table F.2 shows the completion of the employment goals in the short-run. The convergence to the new equilibrium employment is slow: without the LFE friction, only 50-65% of the employment goals is completed at the end of the first year after a subsidy is implemented. This one-year completion rate drops to 40% with the LFE friction. The number of new labor force entrants and whether these workers face the LFE friction are important determinants of the speed of employment growth. Of the three subsidy programs we focus on, the most ambitious program with a 5% employment target involves the most labor force entry. Consequently, without the LFE friction, it generates the fastest employment growth, both in terms of the completion rate and in absolute terms. The LFE friction also most strongly slows down the employment growth in this subsidy program.

The results imply that policy evaluations conducted shortly after the implementation of a tax reform would significantly under-estimate the long-term effects on employment. The short-run bias is stronger if non-participants face the LFE friction.

Figure F.1: Simulated short-run transitions of welfare and employment. The simulations correspond to the three subsidy programs shown in Table F.1. “Emp. Goal” refers to the equilibrium increase in employment from the pre-reform level. “Far-sighted” and “short-sighted” refer to the two approximation methods. “LFE friction” is the labor force entry friction. In simulations with LFE friction, non-participants who wish to enter the labor force can do so with probability $1/12$ per month.

(a) Employment to population ratio.



(b) Transition of social welfare of individuals (W_t , $\rho = 4$).

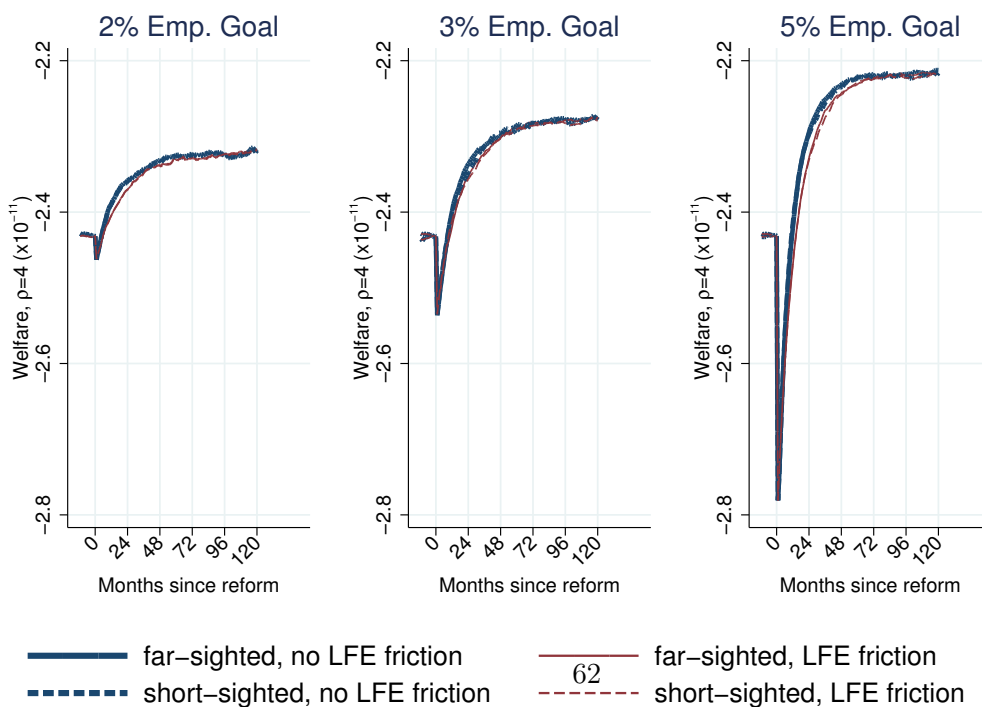


Table F.2: Simulated short-run employment rate based on far-sightedness approximation. Parameters of the subsidy programs are shown in Table F.1. “Emp. Goal” refers to the equilibrium increase in employment from the pre-reform level. “Completion of Emp. Goal” is the percentage of the employment goal that has been completed since the subsidy implementation at the end of each year. “Cum. Emp. Growth” is the cumulative employment growth from the baseline level. “LFE friction” is the labor force entry friction. In simulations with LFE friction, non-participants who wish to enter the labor force can do so with probability 1/12 per month.

(a) Subsidy 1: 2% Emp. Goal

Year	No LFE Friction		With LFE Friction	
	Completion of Emp. Goal	Cum. Emp. Growth	Completion of Emp. Goal	Cum. Emp. Growth
1	53.1%	1.1%	41.2%	0.8%
2	76.2%	1.5%	65.4%	1.3%
3	86.7%	1.7%	81.9%	1.6%
4	95.4%	1.9%	89.3%	1.8%
5	99.5%	2.0%	94.6%	1.9%

(b) Subsidy 2: 3% Emp. Goal

Year	No LFE Friction		With LFE Friction	
	Completion of Emp. Goal	Cum. Emp. Growth	Completion of Emp. Goal	Cum. Emp. Growth
1	53.2%	1.6%	38.5%	1.2%
2	77.4%	2.3%	64.6%	1.9%
3	86.7%	2.6%	79.1%	2.4%
4	92.2%	2.8%	88.9%	2.7%
5	95.5%	2.9%	96.6%	2.9%

(c) Subsidy 3: 5% Emp. Goal

Year	No LFE Friction		With LFE Friction	
	Completion of Emp. Goal	Cum. Emp. Growth	Completion of Emp. Goal	Cum. Emp. Growth
1	64.2%	3.2%	41.8%	2.1%
2	85.5%	4.3%	69.8%	3.5%
3	92.1%	4.6%	84.8%	4.2%
4	95.1%	4.7%	90.7%	4.5%
5	96.9%	4.8%	94.1%	4.7%

Next, we turn to the short-run welfare of individuals. Consistent with the equilibrium simulations, we assume that all tax revenues are redistributed, but firm profits are not redistributed to individuals and the policy maker only concerns with the welfare of individuals.⁴⁰ Furthermore, we assume that payroll subsidies are applied to employers, and they do not adjustment wages of existing jobs unless workers can make a credible threat to separate from the match. This implies that firms may benefit from a payroll subsidy in the short-run, allowing them to make a positive profit. The profits eventually disappear as existing jobs are destroyed either exogenously or as workers receive good outside offers that lead to wage renegotiations or job-to-job transitions. Given our redistribution assumptions, workers may suffer a short-run welfare loss even if they benefit from a welfare gain in the long run.

More specifically, we denote the per-period social welfare by $\mathcal{W}_t$:

$$\mathcal{W}_t = \frac{1}{N_i} \sum_{i=1}^{N_i} welfare(c_{i,t}) \quad (28)$$

where D_t is the amount of tax redistribution (Equation 19) and $welfare(\cdot)$ is the individual welfare function (Equation 18). Figure F.1b shows $\mathcal{W}_t$ in the short run, with inequality-averse specification with $\rho = 4$. In our simulations, the initial drop in welfare is the largest in the most ambitious subsidy program that raises baseline employment by 5%.. This is because the more ambitious the subsidy program is in raising the employment goal, the more strongly and widely existing jobs are affected. As firms make profits from the payroll subsidies, workers suffer from a lower tax redistribution (D). This not only lowers the total consumption, but also has negative distributional impacts.

As a result of finite term limits of political offices and the constant evolution of public policies, policy makers may place a greater weight on the current period than the far future, and they may have a finite horizon when it comes to policy decisions. We have seen that the initial welfare response can be qualitatively different from the long-run effects, the time horizon of the policy maker may alter the her preference over alternative subsidy programs.

We define the continuation welfare $\mathcal{W}^c$ as the sum of discounted future welfare evaluated at $t = 1$, the period that a subsidy program is implemented. More specifically,

$$\mathcal{W}^c = \frac{(1 - \beta^T)}{1 - \beta} \sum_{t=1}^T \beta^{t-1} \mathcal{W}_t$$

⁴⁰These are plausible assumptions because in our model firms do not invest in capital or other productive inputs.

Table F.3: Simulated continuation welfare ($\mathcal{W}^c$ with $\rho = 4$) with different time horizons, inflated by a multiple of 10^{11} . Bolded value indicate the optimal amongst the three employment targets considered. The simulations are based on the far-sightedness approximation. Parameters of the subsidy programs are shown in Table F.1. “Emp. Goal” refers to the equilibrium increase in employment from the pre-reform level.

Subsidy	Emp. Goal	2 Year Horizon	5 Year Horizon	20 Year Horizon
No LFE Friction				
1	2%	-2.396	-2.364	-2.336
2	3%	-2.413	-2.353	-2.304
3	5%	-2.460	-2.338	-2.259
With LFE Friction				
4	2%	-2.408	-2.372	-2.340
5	3%	-2.426	-2.362	-2.307
6	5%	-2.496	-2.363	-2.267

where T is the time horizon of the policy maker. We assume that the discount rate of the policy maker coincides with that of agents in the labor market. Table F.3 shows the simulated continuation social welfare under different time horizons. Of the three subsidy programs we consider, the program that leads to a 5% increase in equilibrium employment results in the highest equilibrium welfare. However, the short-run welfare implications is different. Under the inequality-averse welfare specification with $\rho = 4$, we find that when the policy maker’s horizon is 2 years, the most moderate subsidy program is preferred. With a horizon of 5 years, the most ambitious program is preferred if there were no LFE friction. With the friction, convergence of the welfare to the long-run level is slower.

Note that, if the subsidies were given to employees as in the EITC or the WFTC, the short-run welfare loss would not occur. In this case, the welfare transition would follow a similar path as the employment transition - welfare gradually increases as less-productive workers find jobs.