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Thomas Breda
Paris School of Economics, CNRS and IZA

Luke Haywood
MCC Berlin and DIW Berlin

Haomin Wang
University of Konstanz

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Equilibrium Effects of Payroll Tax Reductions and Optimal Policy Design*

Recent empirical literature documents that targeted tax reductions or minimum wages can have unintended reallocation and spillover effects on workers not directly targeted by these policies. We quantify these effects using an equilibrium search-and-matching model estimated on French data before a low-wage payroll tax reduction in 1995; the model features heterogeneous workers and firms, labor taxation, and a minimum wage. Based on our model, the tax reduction led to changes in the vacancy distribution such that it becomes harder for workers to move up the job ladder in terms of firm productivity. We refer to this as the negative reallocation effect. The tax reduction also increased labor force participation of low-productivity workers, leading to a negative spillover effect because these workers create congestion in the labor market, lowering the job-finding rate for all workers. Given these unintended effects, low-wage tax reduction should cover jobs in a broad wage range. Finally, we find that the efficiency-maximizing policy mix involves moderately regressive payroll taxation and a low but binding minimum wage.

JEL Classification: J64, E24, H24, J38

Keywords: payroll tax, minimum wage, equilibrium job search, worker and firm heterogeneity

Corresponding author:
Thomas Breda
Paris School of Economics
48 Bd Jourdan
75014 Paris
France

E-mail: thomas.breda@ens.fr

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1 Introduction

Labor market policies often seek to increase the employment or income of workers who do not achieve high earnings in the labor market. However, recent empirical literature shows that the impacts of policies such as targeted tax cuts and minimum wages do not limit to directly targeted workers. First, such policies can change the composition of firms active in the labor market and lead workers to reallocate to different employers. For example, Dustmann et al. (2022) find that the German minimum wage improves the average firms quality in terms of size and average pay and that workers "upgrade" to better firms. Second, the effects of targeted policies can spill over to other workers. For example, Azmat (2019) shows that a UK tax credit for low-income families affects the wages of workers who are not eligible for the tax credit.[1] However, the quantitative importance of these indirect effects is not well understood. This paper's first set of objectives is to quantify the equilibrium policy effects in the context of a low-wage payroll tax reduction and shed light on the optimal tax-reduction design.

We then study how the two policy instruments, payroll taxation and minimum wages, jointly determine outcomes in labor market equilibrium with heterogeneous workers and firms. While the optimal design of each of these policies has been frequently studied, the joint design of the two is not well understood.[2] The second objective of this paper is to study the optimal design of the policy mix, taking into account both efficiency and social welfare.

To these ends, we develop a Diamond-Mortensen-Pissarides (DMP) style search and matching model with three key features. First, we model labor supply as labor force participation and labor demand as vacancy posting. That is, workers choose whether to participate in the labor market by weighing the cost against the returns of job search; the returns of job search depend on which jobs, or matches, are potentially acceptable. Analogously, firms choose to post vacancies to the extent they see opportunities for making profits, given the cost of vacancy posting. Second, payroll taxation and the minimum wage affect wage determination and the set of viable matches between workers and firms. Third, workers and firms are respectively different in their ability or productivity, make different labor supply and demand decisions in equilibrium, and are affected by labor market policies differently. Importantly, this last feature allows us to study the indirect impacts of labor market policies that lead to reallocation and spillovers.

We first apply our model to study payroll tax reductions for low-wage jobs, a popular tool to boost

[1] See also Saez et al. (2019) for spillover effects of a Swedish tax cut for young workers.

[2] Recent papers that study the optimal income tax policies or minimum wages in equilibrium environments with household and/or firm heterogeneity include Shephard (2017), Wilemme (2021) and Ahlfeldt et al. (2022). Few studies consider the joint design of the two policies. Exceptions include Chéron et al. (2008), who study the optimal design of payroll tax reduction in the presence of a minimum wage, and Hurst et al. (2022), who study the joint design of the income tax credits and the minimum wage in the short- and the long-run.

job creation and expand employment opportunities for low-skilled individuals. Specifically, we study the French payroll tax reduction implemented at the end of 1995 in response to a particularly acute employment problem in the country.[3] Tax reductions for low-income workers have been widely studied in the empirical policy-evaluation literature (see surveys by Hotz and Scholz, 2003; Nichols and Rothstein, 2015), but not their equilibrium effects on heterogeneous workers and firms. We conduct policy evaluation in a search and matching model that includes sorting between workers and firms (Lise et al., 2016; Bagger and Lentz, 2019) to analyze the equilibrium effects of such policies quantitatively.

To conduct our quantitative analysis, we estimate our model based on French social security records data prior to the payroll tax reduction. We exclude public sector workers and workers in professional and executive occupations and focus on the broadly-defined low-skilled workers. Central to our empirical analysis are the parameters governing the productivity distributions of workers and firms and the production technology. Identifying these parameters requires the knowledge of the ranks of workers and firms in the respective productivity distributions, which our employer-employee linked data allows us to estimate. Given this ranking, we use the simulated method of moments to estimate model parameters. Our model not only replicates aggregate labor market statistics such as the unemployment and vacancy rates but also differences in wage, employment, and job-finding rate across different worker and firm ranks. In addition, the aggregate employment effect of the 1995 payroll tax reduction as estimated by the model is in line with reduced form evidence (Crépon and Desplatz, 2003), and the distributional effects are consistent with our observations based on post-reform data.

Based on our estimated model, the low-wage tax reduction expands the set of viable matches for workers and firms by reducing labor costs of low-wage jobs, and leads to uneven labor supply and demand adjustments. Low-productivity workers increase their labor force participation and low-productivity firms post more vacancies, giving rise to negative spillover reallocation effects.

Specifically, negative spillover refers to the phenomenon that an increased labor force participation of low-productivity workers leads to a lower rate of all workers contacting vacancies, resulting in lower employment and output of workers with high productivity. Nevertheless, the magnitude of the negative spillover effect is modest in comparison to the positive effects due to higher participation: workers in the bottom quartile of the productivity distribution contribute to an aggregate output increase of 1.26%, while the spillover effect on the top three quartiles of workers contributes to a 0.11% decrease in aggregate output.

The negative reallocation effect refers to the fact that, due to the shift in the vacancy distribution toward low-productivity firms, workers are more likely to find jobs in these firms and face fewer

[3] During this period, France has a high minimum wage and high payroll tax rates, which, in combination, make it costly for firms to hire low-skilled workers.

opportunities to climb up the job ladder in terms of firm productivity. This effect leads to a decrease in the average output per job of 0.17%; workers in all productivity quartiles contribute to the decrease.

Comparing a generous payroll tax reduction that narrowly targets minimally paid jobs to a modest tax reduction that covers a broader range of low-wage jobs, the former may be better at fostering employment and redistributing toward the poor, but is more likely to lead to worse spillover and reallocation effects. Based on our model, to raise employment by 2%, an inequality-averse policy-maker would reduce payroll taxes for jobs that pay up to twice the minimum wage, a much broader range than the payroll tax reduction that we study (which vanishes at 1.3 times the minimum wage).[4]

Our analysis of payroll tax reductions takes the minimum wage as given. This choice can be justified in a political environment in which lowering the minimum wage is widely unpopular. However, the two policy instruments have complementarities and can be optimized jointly. Indeed, payroll tax reductions can compensate for the extra labor cost induced by a higher minimum wage and mitigate its potentially detrimental effect on employment. A more general economic question is how to jointly design the minimum wage and payroll taxes.

We show that the decentralized economy with no minimum wages and no payroll taxes is inefficient by demonstrating that workers' bargaining powers in low-productivity firms are too low. This suggests that, in our empirical setting, the congestion externality outweighs the thick-market externality among low-productivity firms (Hosios, 1990), resulting in these firms posting too many vacancies. Imposing a minimum wage or payroll taxes on low-wage jobs may disincentivize vacancy posting by low-productivity firms. Thus, in addition to reducing inequality, these policy tools can potentially limit inefficiency in the frictional labor market. Jointly optimizing payroll taxation and minimum wage to maximize economic efficiency, we find the efficiency-maximizing policy mix to be moderately regressive payroll taxation and a low but binding minimum wage. If the policy-maker is inequality-averse, the optimal policy mix involves a less regressive payroll taxation and a non-binding minimum wage.

Related literature

Much of the literature studying the effects of labor market policies rely on reduced-form methods such as difference-in-differences. This literature often focuses on the direct effects of policy reforms on affected workers or firms by comparing those targeted by a reform to similar groups beyond the direct reach of the reform, assuming that the latter does not respond to the reform. However, recent studies show that a targeted policy reform can result in spillovers that affect the distributions

[4] The result is based on an inequality-aversion level common in the literature (see e.g. Saez, 2002).

of workers and firms (see Rothstein (2008), Leigh (2010), and Azmat (2019) regarding tax credit policies, Crépon and Desplatz (2003) and Saez et al. (2019) regarding payroll tax reductions, and Dustmann et al. (2022) for the minimum wage). We complement these papers by quantifying the spillover or reallocation effects in an equilibrium framework and testing for the optimal policy design while considering these unintended effects.

This paper is part of a growing literature that studies labor taxes and minimum wages using equilibrium job-search models. For example, Shephard (2017) studies the tax credit reform in the UK. While his model includes workers that differ in their value of home production, there is no difference in terms of worker productivity, a central component of our analysis.

The paper by Chéron et al. (2008) is closely related to our paper because it also studies payroll tax reductions in France in the presence of a minimum wage. However, it focuses on the effects on firms' investment in specific human capital, assuming that workers and firms are ex-ante identical. Our paper's main difference is considering a model with ex-ante heterogeneous workers and firms. The two-sided heterogeneity is necessary as our research questions concern the reallocation and spillover effects of the policies. It allows us to account for the distributional effects of the policies in our welfare analyses. It also implies that, while in Chéron et al. (2008) labor productivity is determined by firms' human capital investment decisions, in our model, it is driven by workers' participation decisions and the matching between workers and firms.[5]

A small strand of literature studies optimal taxation in equilibrium models with two-sided heterogeneity. Wilemme (2021) studies optimal taxation to correct mismatches. Bagger et al. (2018) study the optimal income taxation in Denmark using a model with heterogeneous workers and firms in terms of productivity. Their paper rules out search externalities by assuming that labor markets are segregated by workers' ability. Our paper is also different in terms of the research question. Bagger et al. (2018) is concerned with the effect of marginal tax rates on job-to-job mobility. We focus on the spillover and reallocation effects of the policies. We also consider a statutory minimum wage, a widely used policy instrument in many advanced economies but not in Denmark, and the joint design of the two policy instruments. Bagger et al. (2021) consider a directed search model with two-sided heterogeneity. Firms in their model differ not only in productivity but also in untaxed amenities. Their paper also does not consider minimum wages or spillover effects of tax policies.

There are also equilibrium analyses of minimum wages using search and matching frameworks (Flinn, 2006; Bloemer et al., 2018; Engbom and Moser, 2021). We are complementary to Engbom and Moser (2021) in that they study the spillover effect of the Brazilian minimum wage in an

[5]Although we do not explicitly model capital investment decisions, firms of different productivity levels make different vacancy-posting decisions that influence the equilibrium labor productivity.

equilibrium wage-posting model, while we study the spillover effect of a low-wage payroll tax reduction. We also contribute to this strand of literature by analyzing these two policy instruments jointly.

The rest of the paper is organized as follows. In Section 2, we discuss the institutional background of low-wage payroll tax reductions in France. We present evidence on labor market mobility showing that labor markets for different types of workers are far from segregated. Hence, policies that directly impact low-wage workers are likely to affect a much broader segment of the labor force indirectly. In Section 3, we present the equilibrium search model and characterize the steady-state equilibrium. We describe the data we use to estimate the model in Section 4 and estimation strategy and results in Section 5. In Section 6, we simulate and analyze the first major low-wage payroll tax reduction in France. In Section 7, we study the optimal payroll taxation and the minimum wage. Finally, we conclude in Section 8.

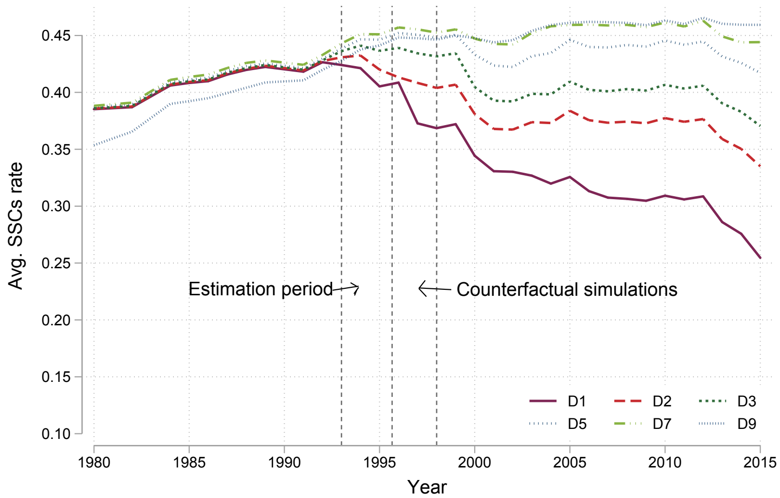
2 Institutional background and descriptive statistics on the French labor market

2.1 Payroll tax reductions

After the second world war, the French government organized the construction of a generous social security system financed through contributions levied on earnings. More precisely, employers pay contributions on contractual (or posted) earnings and withhold employee contributions from these earnings. In this paper, we focus exclusively on policies that vary employer social security contributions as they have been subject to significant revisions and play a key role in shaping the labor cost of low-wage earners. Indeed, the French minimum wage, first introduced in 1950, is defined in terms of the contractual wage, which is net of employer SSCs. This implies that employer SSCs cannot be shifted to employees and are, therefore, mechanically incident on employers at the minimum wage. In Appendix A, we provide further details on institutional background.

In the early 1990s, social security contributions (SSCs) in France represented around 45% of the labor cost for almost all workers, including those with low wages. Meanwhile, the French unemployment rate rose from 8% in 1990 to about 11% in 1994. The high unemployment rate has often been attributed to the policy combination of a high statutory minimum wage and high employer SSCs. In a political context where the minimum wage cannot easily be reduced, reducing employer SSCs for low-wage earners is an appealing solution to lower their cost. The first major reduction in employer SSCs for low-wage jobs, which we refer to as the payroll tax reduction, was implemented

Figure 1: Social Security Contributions.



Source: DADS 1980-2015. Full-time workers only. Data provided by Bozio et al. (2016).
Notes: Average SSC rate is the ratio of the average total social security contributions (employer and employee) to the average labor cost in six deciles of the labor cost distribution.

in September 1995.[6] As can be seen from Figure 1, the reductions in 1995 resulted in a divergence of SSCs rates among different types of workers, with workers hired at lower labor costs facing significantly lower SSC rates. Reductions in employer SSCs were maintained and even extended between 1995 and 2020, with the largest reductions occurring in 1998, 2005, 2013 and 2019. Over this entire period, the combination of a high minimum wage and large payroll tax reductions for low incomes has been the favored policy mix to maintain high net wages while limiting labor costs in the French economy.

2.2 Job mobility in the French labor market

An important assumption in our theoretical framework is that workers of different productivity levels cannot exclusively direct their search to a specific job type, so there is overlap in the jobs for which they compete. Low-wage payroll tax reductions can lead to more job vacancies in low-productivity firms and higher labor market participation of low-skilled workers. In this case, the random search assumption implies that high-skilled workers may find it harder to find jobs from high-productivity firms. We here provide some empirical evidence on job-to-job mobility in the French labor market, suggesting that such a mechanism is plausible.[7]

[6] Small reductions were already implemented in 1993 but they were very limited both in terms of magnitude and affected wage brackets.

[7] Of course, job search is neither completely random (with all workers applying to all job offers) nor completely directed (with a given worker applying only to a specific type of job). Establishing which of these two archetypal

First, labor market transitions are an essential feature of the French labor market, although the frequency of transition is more limited in France than in the United States (Picart, 2008). Amossé et al. (2011) show that around 10% of salaried workers experience at least one transition each year (i.e., a transition to unemployment or another firm following a voluntary quit or a redundancy). Moreover, labor market mobility is higher for younger and lower-skilled workers (we do not consider executives here, as we exclude them from our empirical analysis). For example, 30% of unskilled blue-collars or clerks with less than ten years of professional experience change employers each year (Amossé, 2003).

Second, a large fraction of employees experiences occupational mobility. Dubost and Tranchant (2019) find that, in France, about 30% of job-to-job transitions are accompanied by a change in occupation and 20% by a change in industry.[8] Amossé et al. (2011) present further evidence that workers search for jobs across a large spectrum of occupations. They observe outcomes of displaced individuals four years after exiting a firm in the early 2000s and find that while 63% remain in the same broad occupational rank, 24% move on to a higher- and 13% to a lower-rank occupation, respectively. These statistics suggest that there is competition for jobs among workers with different skill levels. Unemployment is often followed by downward mobility among both low-skilled occupations such as clerks or skilled blue-collar workers and high-skilled ones such as technicians, intermediate managers, and executives (see Chapoulie, 2000; Bianco et al., 2020).

Third and most importantly for our purpose, there is evidence of considerable discrepancies between the jobs that unemployed individuals initially sought and those they eventually end up accepting. Lizé et al. (2009) present results from a survey of about 10,000 registered job seekers in France and find that a striking 73% of workers do not end up in the kind of job they initially sought. While around half of job-seekers move to jobs requiring similar skill levels as the jobs they were looking for, a quarter move to higher-level jobs and a quarter to lower-level jobs. Transitions to jobs requiring fewer skills than anticipated are more frequent among highly-skilled workers but also prominent among unskilled workers (Lizé et al., 2009, Table 7). These statistics provide evidence that in the French labor market at least job search is often not strongly targeted.

We conclude that competition indeed exists across workers of various skill levels in the job search process.

modeling assumptions is the more appropriate approach is beyond the scope of the paper. We only provide statistics suggesting that the patterns we find in the data are consistent with at least some random search in the French labor market, with different types of workers competing for similar jobs.

[8] Occupational mobility has also been rising over time. See Kambourov and Manovskii (2008) for the United States and Lalé (2012) for France.

3 Model

3.1 Environment

We consider a Diamond-Mortensen-Pissarides (DMP) style search and matching model with heterogeneous individuals and firms, labor taxes, and a minimum wage. Time is continuous and agents live infinitely. There is a continuum of individuals that are risk-neutral, unable to save or borrow, and derive utility from consumption. We normalize the population of individuals to a unit measure and index them by x according to the rank of their productivity level, so that x is uniformly distributed on the interval $[0, 1]$. Non-employed individuals can choose to participate in the labor force by searching for jobs at a flow search cost q. The group of non-employed therefore consists of both unemployed jobseekers and non-participants. The search cost captures the difference between the discomfort of search and the stigma of not looking for a job. Employed workers search on-the-job at zero cost.[9] The difference between on- and off-the-job search is captured by the difference in search intensity. Without loss of generality, we normalize search intensity to 1 for unemployed workers and let employed workers' search intensity be s_1, a parameter to be estimated.[10] Employed workers supply an indivisible unit of labor. Let $e(x)$ and $u(x)$ the fraction of employed and unemployed workers among type-x workers, with the fraction of non-participants being $1 - e(x) - u(x)$.

There is a continuum of firms that also differ in productivity. We index firms by y according to the rank of their productivity level, so that y is uniformly distributed on the interval $[0, 1]$. Firms choose the number of vacancies $v(y) \geq 0$ they post subject to a vacancy-posting cost.

Workers and firms are brought together pairwise via a DMP aggregate meeting technology. That is, meetings between workers and firms are one-to-one, and the meeting rate depends on the aggregate search intensity ($\xi = \int_0^1 [e(x) + s_1 u(x)]\, dx$) and the aggregate measure of vacancies ($V = \int_0^1 v(y)\, dy$). We assume that the meeting technology displays constant returns to scale such that the flow measure of contacts between workers and firms is

$$M(\xi, V) = m_0 \sqrt{\xi V}. \tag{1}$$

For convenience, we define $\kappa(\xi, V) \equiv \frac{M(\xi,V)}{\xi V}$ so that $\kappa(\xi, V)V$ is the contact rate of an unemployed worker and $\kappa(\xi, V)\xi$ is the contact rate of a vacancy.

Although the DMP assumption implies that the meeting rate per unit of search intensity is the same for all individuals, the rate at which a match is formed varies. A match is viable if the

[9] On-the-job search can be seen as passive search: While unemployed workers have to search actively to meet potential employers, employed workers face a positive meeting rate without explicit efforts.

[10] Alternatively, the deviation of s_1 from 1 can be interpreted as a difference in search efficiency between employed and unemployed workers.

worker-firm pair can find a wage that is mutually agreeable and greater than the minimum wage. In the subsequent subsections, we describe match formation and wage determination in detail and explain which combinations of workers and firm types can form viable matches together.

If worker x and firm y form a match, they produce flow output $f(x, y)$ with $f_x(x, y) > 0$ and $f_y(x, y) > 0$ for all x and y. The worker receives net wage w while the firm collects flow revenue $f(x, y)$ and pays the labor cost.[11]

Wage is determined in equilibrium via bargaining between the worker and the firm. We assume that workers in the same firm have the same bargaining power $\alpha(y)$, but it can vary across firms. This reflects collective bargaining that commonly takes place in France at the firm level (see Breda, 2015). To hire a worker at net wage w, firms have to bear labor cost $w + T(w)$, where $T(w)$ is the labor tax, the sum of employer and employee SSCs. We assume that $T(\cdot)$ is differentiable and $T'(w) > 0$ for all w. This accommodates a wide range of tax functions, including ones with non-monotone marginal tax rates. We also consider a wage floor on net wages, w_{min}, calculated by subtracting employee SSCs from the statutory minimum gross wage. Since both $T(w)$ and w_{min} remain constant in a steady state equilibrium, the assumption that taxes nominally falls on employers is without loss of generality.

Non-employed workers receive net income $b(x)$ regardless of their job search decision, where $b'(x) \geq 0$. We interpret $b(x)$ as the sum of non-employment transfers. In practice, the most important component concerns unemployment benefits are linked to previous wages. For tractability, we assume that non-employment incomes depend solely on x so that individuals' job search decision is time-invariant.[12]

The measure of filled jobs, or matches, of type (x, y) is given by $h(x, y)$ such that $e(x) = \int_0^1 h(x, y)\, dy$. A match may be destroyed exogenously at rate δ, or endogenously if a worker transitions to another job. Finally, we assume that all agents have a common subjective discount rate r.

3.2 Meetings Involving Unemployed Individuals

When an unemployed worker meets a recruiting firm, the worker-firm pair first determines a provisional wage by bargaining over the match surplus, which is net of taxes. Then, the pair compares the

[11] The fact that match output only depends on the individual and firm involved in the match implies that there is no complementarity between different workers within a firm. This is commonly assumed in the literature to keep models tractable. As we explain in section 4, we exclude workers who mainly work in professional and executive positions from our empirical analysis, making the assumption of no complementarity more plausible.

[12] We implicitly assume that payroll-tax reductions do not affect non-employment incomes. The rule for calculating non-employment income may change if a policy change affects tax revenue. However, as we discuss in Appendix A, the link between SSCs and benefits is weak. In particular, the payroll tax reduction we study is not accompanied by modifications to benefit entitlements for workers.

provisional wage to the statutory minimum wage and determines if a match is viable. Specifically, the match surplus over which the worker-firm pair bargain is given by

$$S(w,x,y) = W_e(w,x,y) - W_{ne}(x) + J_f(w,x,y) - J_u(y) \tag{2}$$

where $W_e(w,x,y)$ and $J_f(w,x,y)$ are the present values the worker and the firm, respectively. The worker's outside option is the value of non-employment $W_{ne}(x)$. The firm's outside option is the value of an unfilled position $J_u(y)$. Because the tax burden increases in wage, the net surplus shrinks with higher wages.

We assume that the match surplus is split with each party receiving a proportion of the surplus according to their bargaining power.[13] The wage bargaining outcome ϕ must satisfy the following system:

$$\begin{cases} W_e(\phi,x,y) - W_{ne}(x) = \alpha\left(y\right) S(\phi,x,y) \\ S(\phi,x,y) \geq 0 \end{cases} . \tag{3}$$

For any match (x, y), Proposition 1 states that the value of the match to the worker increases with the wage level while the value to the firm decreases in w. Section 3.4 provides the associated value functions.

Proposition 1. *$W_e(w,x,y)$ monotonically increases in w while $J_f(w,x,y)$ monotonically decreases in w for all x and y.*

The worker-firm pair (x, y) may fail to find a bargaining solution ϕ if workers outside option $W_{ne}(x)$ is too high (in this case, the worker would demand a high wage, which shrinks the net surplus because of the high labor tax burden). We show that if ϕ exists, it must be unique (Appendix C.1). If so, the pair proceeds to compare ϕ to the minimum wage w_{min}. As in Flinn (2006), we assume that, if $\phi \geq w_{min}$, a match is immediately realized; otherwise, if $\phi < w_{min}$, a match is only realized if both parties agree to form the match at w_{min}. Formally, we define match viability as follows.

Definition 1. A match is viable if a ϕ that solves Eq. 3 exists and either of the following holds: (1) $\phi \geq w_{min}$, or (2) $\phi < w_{min}$, $W_e(w_{min},x,y) - W_{ne}(x) \geq 0$ and $J_f(w_{min},x,y) - J_u(y) \geq 0$.

Let $\mathcal{A}_u(x) \subseteq [0,1]$ be the subset of firms with whom worker x can form a viable match, such that

$$\mathcal{A}_u(x) = \{y \in [0,1] : (x,y) \text{ is viable}\}. \tag{4}$$

[13] The proportional bargaining scheme simplifies our problem by ensuring a unique bargaining solution even if the marginal tax rate is non-monotone. See Appendix B for a discussion on Nash bargaining and proportional bargaining.

If match (x,y) is viable, the out-of-unemployment wage for worker x is $\phi_u(x,y) = \max\{\phi, w_{min}\}$. Proposition 1 implies workers in matches such that $\phi < w_{min}$ receive strictly more than $\alpha(y)$ of the match surplus. Thus, the minimum wage effectively shifts the match surplus toward workers.

3.3 Meetings Involving Employed Workers

When an employed worker is approached by another firm, we follow Dey and Flinn (2005) and Cahuc et al. (2006) in assuming that the poaching firm engages in a second price auction with the incumbent firm. This is followed by a wage negotiation between the worker and the highest bidder of the auction. Let $\bar{\phi}(x,y)$ be the maximum wage that firm y can pay to worker x, such that $J_f\left(\bar{\phi}(x,y), x, y\right) = J_u(y)$. Assume that worker x is currently employed at firm $y_0 \in \mathcal{A}_u(x)$. An auction takes place if the poaching firm y_1 can pay at least the minimum wage, i.e. $\bar{\phi}(x,y_1) \geq w_{min}$.

For any two bidding firms y and y', firm y outbids y' if and only if the maximum value that the worker x can attain in firm y is higher, i.e. $W_e(\bar{\phi}(x,y),x,y) \geq W_e(\bar{\phi}(x,y'),x,y')$. If the incumbent firm y_0 outbids the poaching firm y_1, the worker remains in y_0; she renegotiates her wage with y_0 if y_1 could have made the worker better-off compared to the worker's current state (i.e., $W_e(\bar{\phi}(x,y_1),x,y_1) \geq W_e(w_0,x,y_0)$, where w_0 is the worker's current wage). If, instead, y_1 outbids y_0, the worker moves to the poaching firm and bargains with it.

The surplus that an employed worker x and the winning firm y divide in wage bargaining is

$$S_e(w,x,y,y') = W_e(w,x,y) - W_e(\bar{\phi}(x,y'),x,y') + J_f(w,x,y) - J_u(y) \tag{5}$$

where $W_e(\bar{\phi}(x,y'),x,y')$ is the employed worker's outside option. As before, we apply proportional bargaining so that the bargained wage ϕ must solve the following system:

$$\begin{cases} W_e(\phi,x,y) - W_e(\bar{\phi}(x,y'),x,y') = \alpha(y)\, S_e(\phi,x,y,y') \\ S_e(\phi,x,y,y') \geq 0 \end{cases} \tag{6}$$

If a wage ϕ satisfying Eq. 6 exists, and if $\phi \geq w_{min}$ or $J_f(w_{min},x,y) \geq J_u(y)$, the match (x,y) is formed at wage $\phi_e(x,y',y) = \max\{\phi, w_{min}\}$, where we refer to y' as the "reference firm". Let $\mathcal{A}_e(x,y_0)$ be the subset of firms that can poach worker x from firm y, such that

$$\mathcal{A}_e(x,y_0) \quad = \quad \left\{ y \in [0,1] \,|W_e(\bar{\phi}(x,y),x,y) > W_e(\bar{\phi}(x,y_0),x,y_0) \right\}. \tag{7}$$

3.4 Value Functions

A non-employed worker can either stay out of the labor force or participate by searching for jobs. The value of non-employment, W_{ne}, is defined as follows:

$$rW_{ne}(x) = \max_{s\in\{0,1\}} \left\{ b(x) + s\left[\kappa(\xi, V) \int_{y'\in\mathcal{A}_u(x)} v(y')\left[W_e(\phi_u(x,y'),x,y') - W_{ne}(x)\right] dy' - q \right] \right\} \quad (8)$$

where $\kappa(\xi, V)\, V$ is the rate at which an unemployed worker meets a vacancy.[14] The policy function $s(x)$ denotes the optimal job search decision of a non-employed worker, where $s(x) = 1$ indicates unemployment and $s(x) = 0$ indicates non-participation.[15]

The value of employment is defined as follows:

$$\begin{aligned} &[r + \delta + s_1\kappa(\xi, V)V]W_e(w, x, y) = w + \delta W_{ne}(x) \\ &+s_1\kappa(\xi, V) \textstyle\int_{y'\in\mathcal{A}_e(x,y)} W_e(\phi_e(x, y, y'), x, y')v(y')dy' \\ &+s_1\kappa(\xi, V) \textstyle\int_{y'\in[0,1]\setminus\mathcal{A}_e(x,y)} W_e(\max\{w, \phi_e(x, y', y)\}, x, y)v(y')dy' \end{aligned} \quad (9)$$

An employed worker may be exogenously separated from her employer y at rate δ. She may also meet a vacancy at rate $s_1\kappa(\xi, V)V$, which she can either accept or reject. If the worker makes a job-to-job transition to the poaching firm $y' \in \mathcal{A}_e(x, y)$, she receives the new wage $\phi_e(x, y, y')$ from y'. If the worker stays with her employer y, she renegotiates her wage only if it can be increased, so that the wage can be expressed as $\max\{w, \phi_e(x, y', y)\}$. Since the flow utility of an employed worker is simply the wage w, the value function W_e is increasing with wage by the contraction mapping theorem.

The value of a filled position to a firm is defined as follows:

$$\begin{aligned} &[r + \delta + s_1\kappa(\xi, V)V]J_f(w, x, y) = f(x, y) - w - T(w) + \delta J_u(y) \\ &+s_1\kappa(\xi, V)J_u(y) \textstyle\int_{y'\in\mathcal{A}_e(x,y)} v(y')dy' \\ &+s_1\kappa(\xi, V) \textstyle\int_{y'\in[0,1]\setminus\mathcal{A}_e(x,y)} J_f(\max\{\phi_e(x, y', y), w\}, x, y)v(y')dy' \end{aligned} \quad (10)$$

The firm collects the match output and pays the labor cost. It faces separation if there is an exogenous shock or if the worker is poached by another firm, and it may be compelled to offer a higher wage if the worker meets a firm that can trigger a wage renegotiation. The flow profit,

[14] It would be possible to include transitions between participation and non-participation. However, in equilibrium, we would need to add preference shocks to generate such transitions, which would increase the computation burden. Note that our model accounts for changes in participation as a result of changes in the steady state, for example after the change in social security contributions.

[15] We can rule out mixed strategies because each worker type x is atomless and thus the search decision $s(x)$ does not influence the contact rate.

$[f(x, y) - w - T(w)]$, is strictly decreasing in w since $T'(w) > 0$. By the contraction mapping theorem, J_f is decreasing with wage.

3.5 Vacancy Creation

A firm is the collection of jobs, filled and unfilled, of productivity y. Following Lise and Robin (2017), we assume that each firm buys the advertising of vacancies from job placement agencies.[16] In equilibrium, the free entry of vacancies ensures firms have no expected profits from opening further vacancies.

Specifically, we assume that the marginal cost of posting v vacancies of type y is $c'(v, y)$, which is strictly increasing in v. This is consistent with the typical assumption of convex costs and guarantees a non-degenerate distribution of vacancies. The present value of an unfilled position to a firm is defined as follows:

$$
\begin{aligned}
rJ_u(y) = {} & -c'(v, y) + \kappa(\xi, V) \int_{x \in \mathcal{B}_u(y)} J_f(\phi_u(x, y), x, y) u(x) dx \\
& + s_1 \kappa(\xi, V) \iint_{(x, y') \in \mathcal{B}_e(y)} J_f(\phi_e(x, y, y'), x, y) h(x, y') dy' dx.
\end{aligned} \tag{11}
$$

The firm meets an unemployed worker at rate $\kappa(\xi, V) \int u\,(x)\, dx$ and an employed worker at rate $\kappa(\xi, V) \int s_1 e\,(x)\, dx$. $\mathcal{B}_u(y) = \{x : s(x) = 1 \text{ and } y \in \mathcal{A}_u(x)\}$ is the set of unemployed workers with whom firm y can form a viable match, and $\mathcal{B}_e(y) = \{(x, y') : s(x) = 1 \text{ and } y \in \mathcal{A}_e(x, y')\}$ is the set of matches from which firm y can successfully poach a worker. If $\mathcal{B}_u(y) \neq \emptyset$ or $\mathcal{B}_e(y) \neq \emptyset$, firm y posts a positive number of vacancies such that $J_u(y) = 0$. In equilibrium, the free-entry condition yields

$$
\begin{aligned}
c'(v, y) = {} & \kappa(\xi, V) \int_{x \in \mathcal{B}_u(y)} J_f(\phi_u(x, y), x, y) u(x) dx \\
& + s_1 \kappa(\xi, V) \iint_{(x, y') \in \mathcal{B}_e(y)} J_f(\phi_e(x, y, y'), x, y) h(x, y') dy' dx,
\end{aligned} \tag{12}
$$

and any job opening that does not result in a match or any filled position that loses its employee ceases to exist and has no continuation value.

[16] There is free entry of job placement agencies such that they make zero profits from selling advertisements in equilibrium.

3.6 Steady State Equilibrium

In a steady state equilibrium, the distribution of individuals across labor force states and firms, characterized by $\{u(\cdot), h(\cdot,\cdot)\}$, is stationary. For workers who do not participate in the labor market ($s(x) = 0$), $h(x, y) = 0$ and $u(x) = 0$; for labor market participants, the steady state levels of $h(x, y)$ and $u(x)$ are determined by equating inflows with outflows. Thus, we have the following steady-state conditions for all x such that $s(x) = 1$ and all y such that $v(y) > 0$:

$$u(x) = \frac{\delta}{\delta + \kappa(\xi, V) \int_{y' \in \mathcal{A}_u(x)} v(y')dy'}, \tag{13}$$

$$h(x, y) = \frac{v(y)\kappa(\xi, V) \left[u(x) + s_1 \int_{(x,y') \in \mathcal{B}_e(y)} h(x, y')dy'\right]}{\delta + s_1\kappa(\xi, V) \int_{y' \in \mathcal{A}_e(x,y)} v(y')dy'}. \tag{14}$$

Stationarity of $\{u(\cdot), h(\cdot,\cdot)\}$ ensures that the wage distribution is also stationary. We relegate the details to Appendix C.2.

Definition 2. A steady state equilibrium is a collection of optimal decisions and distributions $\{s(\cdot), \mathcal{A}_u(\cdot), \mathcal{A}_e(\cdot,\cdot), v(\cdot), u(\cdot), h(\cdot,\cdot)\}$ such that

1. $s(x)$ maximizes the value of non-employment (Eq. 8) for all $x \in [0, 1]$;
2. $\mathcal{A}_u(x)$ is defined by Eq. 4 for all $x \in [0, 1]$;
3. $\mathcal{A}_e(x, y)$ is defined by Eq. 7 for all $x \in [0, 1]$ and $y \in [0, 1]$;
4. $v(y)$ satisfies Eq. 12;
5. $u(x)$ and $h(x, y)$ satisfy Eqs. 13 and 14 for all $x \in [0, 1]$ and $y \in [0, 1]$.

Due to the presence of sorting in equilibrium and the fact that utility is not perfectly transferable between workers and firms, solving for the steady state equilibrium analytically is not feasible.[17] In Appendix D, we describe the numerical solution algorithm.

3.7 Direct and Indirect Impacts of Payroll Taxes and Minimum Wages

While payroll taxes and minimum wages do not change the fact that workers prefer matching with more productive firms (Appendix C.3), they directly impact wages and match viability. We

[17] The inability to solve the model analytically is common in the search literature allowing for sorting, see e.g. Lise et al. (2016) or Bagger and Lentz (2019).

can characterize the set of viable matches with a reservation firm-type policy, $\underline{y}(x)$, which defines the least productive firm with which worker x is willing to form a match (Appendix C.4). This threshold is akin to the reservation wage decision in the sequential search literature (McCall, 1970). A payroll tax reduction for low-wage jobs or a reduction of the minimum wage lead to lower $\underline{y}(x)$, particularly for low-x workers. Lower reservation firm types allow for more matching possibilities for low-y firms. Thus, the direct impacts of the two policies most likely fall on the least productive workers and firms.

Importantly, payroll taxes and minimum wages also have indirect impacts such that even those who are not directly impacted can be affected. The policies affect the value of non-employment, which is unemployed workers' outside option in wage bargaining. Specifically, if a policy change increases the returns to job search by, for example, increasing the measure of viable matches, the value of non-employment is higher and so is the bargained wage. When the returns to job search become sufficiently higher such that the value of unemployment rises above the value of non-participation, individuals who are non-participants before the policy change will start to participate in the labor force. Increased labor force participation negatively affects the rate at which all job seekers meet vacancies. Moreover, if low-y firms choose to post more vacancies as a result of more matching possibilities, workers of all productivity types are more likely to encounter low-productivity firms; they may also lower their reservation firm-type because the distribution of vacancies becomes more right-skewed.

4 Data

Our main data source is the "*Déclarations Annuelles de Données Sociales*" (*DADS*), French social security data maintained by the French National Statistical Institute (*INSEE*). In order to obtain more complete employment biographies of sample individuals, we merge two raw datasets provided by INSEE, *panel DADS* and *panel tous salariés*. These datasets are available to us from 1988 to 2010 and cover French salaried workers born in October of even-numbered years (from 2002 onwards, everyone born in October).

Our data contains information about each job spell, including firm identifier, start and end date, region, occupation, and part-time/full-time status. The data also reports "net taxable yearly earnings" for each job, from which we compute employee and employer SSCs using the tax simulator TAXIPP.[18] To keep the model tractable, we ignore the modest variations in SSCs across industries

[18]The tax simulator TAXIPP (Jelloul et al., 2018), developed by the *Institut des Politiques Publiques*, combines the official tax tables with available information on hours worked, occupation, sector, and region of work to simulate the precise level of SSCs for different individuals.

and regions and model SSC as a function of earnings only. To this aim, we fit a linear spline to the relationship between SSC simulated with TAXIPP and the net wage (see Table E.2).

Since one of the goals of this paper is to analyze the reduction in employer SSCs ("payroll tax") implemented in September 1995, we estimate the steady state model mainly based on the preceding period, January 1993 - August 1995. The SSCs and the minimum wage remained relatively stable in this baseline period (see Appendix A). However, as we explain later, we use a more extended sample period (1988 - 2010) to identify time-invariant worker and firm productivity.

Our sample contains prime-age men aged 25-64 because their labor force participation decisions are less likely to be influenced by lifecycle events such as education, child-care, or retirement, which we do not account for in our model. While younger adults (age 18-24) are more likely to hold low-wage jobs and may be more directly impacted by the payroll tax reduction, our age selection allows us to capture 70% of low-wage employment (wage below 1.1 times the minimum wage) among adult men. Another reason for excluding younger adults is that many of them hold apprenticeship contracts; these contracts only cover workers below age 25 and are exempt from the minimum wage.

We further restrict our sample to those primarily working full-time, private-sector, non-executive jobs (see Appendix E.1 for descriptive statistics). Let us detail the reasons behind these restrictions. First, we choose to exclude part-time jobs from our model and quantitative analyses because part-time workers account for only less than 1/5th of total employment. In addition, the hours information is absent from the DADS data before 1993 (and subject to errors in years 1993 and 1994), preventing us from correctly recovering hourly wages from annual earnings and hours worked in these years.

Second, in our model, the aggregate meeting technology $M(\xi, V)$ implies that all workers and firms are in potential competition in the search and matching process. Moreover, we do not consider the potential productive complementarity between high- and low-skilled workers. Thus, we consider a sample of workers with similar qualifications and potentially compete for similar jobs (see details in Section 2.2). This is why we exclude public-sector and executive jobs; the latter includes occupations such as professors, engineers, business managers, and artists.

We convert the spell-based *DADS* raw data into a monthly panel dataset (see Appendix E.2). The *DADS* records only employment spells of salaried employees; individuals who become jobless or self-employed are absent from the data, creating "gap spells" which potentially correspond to unemployment, non-participation, or self-employment. We use additional data from the French labor force survey *Enquête Emploi* (*EE*) to predict individuals' status during these "gap spells". The *EE* allows us to observe transitions across all employment statuses (i.e. employed in private sector, employed in public sector, self-employed, unemployed, and non-participant) at the individual level.

We can therefore use it to predict the likelihood of unemployment in gap spells based on variables observed both in the *DADS* and the *EE*. The variables include the duration of the gap spell, the age of the individual, and the type of job (public or private sector, industry, and occupation) following a gap spell. Based on this prediction, we compute the probability that a gap spell in the *DADS* panel data corresponds to an unemployment spell. Appendix E.3 provides details on this imputation procedure.

To estimate data on non-employment incomes, we use the legal rules regarding unemployment benefits and social welfare entitlements during our sample period. Legal entitlements depend on past earnings, which we observe in *DADS*. We provide details on our procedure in Appendix E.5.

5 Estimation Strategy and Results

5.1 Simulated Method of Moments

Let θ denote the vector of structural parameters of the model. We estimate θ using simulated method of moments (SMM), which involves finding the parameters that minimize the distance between moments computed using the actual data and those computed from model simulation.[19] The SMM estimator is defined as:

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

where $\hat{m}_{data}$ and $\hat{m}_{sim}(\theta)$ are vectors of M moments computed from the actual data and the simulated data, and the weighting matrix Ω is a diagonal $M \times M$ matrix such that entry (m, m) of Ω is the bootstrap variance of the m^{th} moment. In Appendix G, we provide more details on simulation.

5.2 Parametrization and Identification

We briefly discuss our choice of moments for the SMM. Although the structural parameters are jointly identified in the SMM procedure, we offer insights on which parameters mostly impact which each of the targeted moments.

[19] As we explain in Section 3.6, the complications induced in our model by minimum wages and taxes prevent us from solving the model analytically. Therefore, estimating θ requires a simulation-based method.

5.2.1 Productivity Distributions

Given worker and firm types, x and y, we assume their respective productivity levels are $\mathfrak{h}(x)$ and $\mathfrak{p}(y)$. $\mathfrak{h}(x)$ follows a log-Normal distribution such that $x = \Phi_x(\ln \mathfrak{h})$, where Φ_x is the cumulative distribution function of the Normal distribution $N(0, \sigma_x)$. $\mathfrak{p}(y)$ follows a standard Pareto distribution with parameter σ_y such that $y = \Phi_y(\mathfrak{p}) = 1 - \left(\frac{1}{\mathfrak{p}}\right)^{\sigma_y}$. In the numerical implementation, we discretize the support of x and y with evenly spaced grids.

The parameters σ_x and σ_y govern, respectively, worker and firm productivity dispersions. To identify these parameters, we group workers and firms into bins according to their productivity ranks (see Section 5.3). We target median wages by worker and firm bins.[20] In addition, we target moments of the unconditional wage distribution including wage deciles and the share of workers with jobs paying within specific wage intervals that are relevant for the SSCs and tax treatment (i.e., below and above 1.3 w_{min}). The larger the dispersion in worker and firm productivities, the larger the wage dispersion would be, ceteris paribus.

5.2.2 Production Function

We specify a match production function that exhibits constant elasticity of substitution (CES) between individual and firm productivity levels:

$$f(x,y) = \begin{cases} f_0 \left[\frac{1}{2}\mathfrak{h}(x)^{\gamma} + \frac{1}{2}\mathfrak{p}(y)^{\gamma}\right]^{1/\gamma} & \text{if } \gamma \neq 0 \\ f_0 \mathfrak{h}(x)^{\frac{1}{2}} \mathfrak{p}(y)^{\frac{1}{2}} & \text{if } \gamma = 0 \end{cases} \tag{15}$$

with $f_0 > 0$ and $\gamma \leq 1$. f_0 is total factor productivity and can be identified from the average wage level as reflected in wage decile moments. γ governs the degree of complementarity between individuals and firms. If $\gamma = 1$, worker and firm productivities are perfect substitutes. A lower value of γ indicates a greater degree of production complementarity between worker and firm productivities. γ influences the shape of the "reservation firm type" function $\underline{y}(\cdot)$, and thus the set of firms with which workers of different types will match. It therefore influences how job finding rates vary across workers of different productivity ranks. To identify γ, we use job finding rates conditional on worker productivity bins.

[20] Note that we do not estimate the mean productivity levels because our data do not offer separate identification of worker and firm productivity *levels*. Nevertheless, this is without loss of generality because we estimate the productivity dispersion parameters, the bargaining power, and the total factor productivity.

5.2.3 Vacancy Posting Cost

We consider the following cost function

$$c'(v, y) = c_0 \mathfrak{p}(y)^{c_1} v \tag{16}$$

with $c_0 > 0$ and $c_1 \geq 0$. We use the vacancy rate, defined as the number of vacancies divided by the sum of vacancies and jobs, to discipline c_0. Our data for the vacancy rate is based on the number of vacancies in the non-public and non-agricultural sectors reported by the Employment Orientation Board from 2003 to 2010. The rate is calculated according to the European definition of a vacancy as a job to be filled immediately or at short notice and for which there is an active search for candidates the firm (Conseil d'Orientation pour l'Emploi, 2013).

The exponent parameter c_1 influences the vacancy distribution across firms; a greater value suppresses vacancy-posting by highly productive firms relative to less productive firms. The vacancy distribution, in turn, affects the employment distribution across firms. Since we do not have firm-level vacancy data, we rely on employment shares by firm bins to identify c_1.

5.2.4 Bargaining Power

Recall that we assume the bargaining power depends on firm productivity y (see Section 3.1). We parametrize workers' bargaining power as follows:

$$\alpha(y) = \frac{1}{\exp(-(\alpha_0 + \alpha_1 y)) + 1}. \tag{17}$$

That is, $\alpha_0 + \alpha_1 y$ is the logit transformation of $\alpha(y)$. Workers' bargaining power influences the level of their starting wages out of unemployment relative to the maximum wage they receive in the same firm after subsequent negotiations. A low bargaining power leads to larger within-firm-bin wage dispersion as a result of a relatively low wage when coming out of unemployment and more rapid wage increases when workers receive outside offers. Exploiting the within-firm wage growth to identify bargaining powers is common in the literature (for example, see Postel-Vinay and Robin, 2002b; Bagger and Lentz, 2019).

The parameters α_0 and α_1 can therefore be identified from the comparison between starting wages out of unemployment and later wages by firm bins. As moments in estimation, we use the median out-of-unemployment wage by firm bins and the median of all wages by firm bins.

5.2.5 Non-employment Benefit

We parameterize the non-employment benefit function $b(x)$ to be a linear function such that

$$b(x) = b_0 + b_1 \mathfrak{h}(x) \tag{18}$$

and estimate the parameters b_0 and b_1 by targeting the average benefit level in each worker bin.

5.2.6 Other Parameters

In the aggregate matching function (Eq. 1), the scale parameter m_0 determines the speed with which the unemployed find jobs. A higher m_0 would shorten unemployment durations and result in a lower level of unemployment across all worker types. Thus, the unemployment rate, defined as the fraction of unemployed workers among labor force participants, disciplines the parameter m_0. The search cost q discourages non-employed individuals from searching for a job. Since non-employed individuals who do not search are classified as non-participants, the labor force participation rate helps identify q. We take the official unemployment and labor force participation rates of French men aged 25-49 computed by *INSEE* as our target moments because the *DADS* only contains employment spells.[21] The parameter s_1 influences the job-to-job transition rate relative to the unemployment-to-job transition rate; we therefore use the ratio of these rates as a moment a moment for estimation.[22]

5.3 Ranking Workers and Firms

The estimation strategy outlined in Section 5.2 requires us to assign workers and firms to productivity bins according to their ranks in the respective productivity distributions in the model as well as the data. However, we only observe wages and labor market stocks and flows in our data, all of which are joint outcomes of the underlying productivity distributions of workers and firms. In order to recover the productivity ranks, we estimate worker and firm fixed effects based on an AKM regression model *à la* Abowd et al. (1999). Specifically, we estimate the following model

$$\ln(w_{it}) = \psi_{J(i,t)} + \alpha_i + \lambda_t + \mathbf{x}'_{it}\beta + \epsilon_{it}$$

[21] The rates are reported by *INSEE* and computed based on the French Labor Force Survey according to International Labour Organization's (ILO) definitions.

[22] We measure the job-to-job transition rate as the fraction of workers who change jobs from month to month among those who are employed in both months. The unemployment-to-employment transition rate is the fraction of unemployed workers that are not unemployed the following month.

where $\psi_{J(i,t)}$ is the fixed effect of firm $J(i,t)$, the employer of worker i in year t. α_i is the individual fixed effect and λ_t is the year fixed effect. $\mathbf{x}_{it}$ include the linear, quadratic, and cubit terms of age. w_{it} is worker i's hourly wage in year t. The AKM model is estimated based on data from 1988 to 2010, a time window that encompasses our baseline period, 1993 to 1995. Enlarging the sampling window is necessary to obtain a large enough connected set of workers and firms that is key to this type of regression model. Additional details on the AKM estimation are provided in Appendix F.

In computing moments based on simulated data from our model, we rely on the true productivity levels of workers and firms rather than estimated fixed effects. We are able to do so because the estimated AKM fixed effects based on the simulated dataset almost perfectly correlate with the true types of the simulated workers and firms: The correlation between AKM worker fixed effects and true worker types is indeed 0.99 and the correlation between AKM firm fixed effects and true firm types is 0.98.[23] Thus, ranking simulated workers and firms based on their true types rather than their estimated fixed effects makes little quantitative difference, but it avoids raising significantly computational costs.[24]

5.4 Estimation Results

Table 1 shows results from SMM estimation. The estimated value of the parameter γ is -0.029, indicating that workers and firms are complementary in production with an elasticity of substitution close to one. The estimated search cost q is 555€ per month, or 61% of the minimum wage. The estimated value of c_1 is 14.21, suggesting that the marginal cost of posting vacancies is substantially higher in highly productive firms compared to less productive ones. The parameters m_0 and s_1 imply that, on average, it takes 3.4 months for an unemployed worker to find a job vacancy, and 4.4 months for an employed worker.

The estimated values of α_0 and α_1 suggest that there is workers' bargaining power increases only modestly with firm productivity. Workers' bargaining power is 0.55 in the least productive firm and 0.6 in the most productive firm. On average, these values are higher than those estimated by Cahuc et al. (2006), who also use French data over a similar period. Since dispersion in wages is

[23] This is also the reason we choose to use AKM fixed effects for ranking workers and firms over other statistics. One potential firm-level statistics that is consistent with firm productivity based on our model is the maximum possible within-firm wage. However, the estimated maximum possible wage is imprecise for firms with a small number of wage observations, and the majority of firms are small. Even in the dataset with the entire population of salaried workers in France, only less than 30% of firms have 10 or more employees per year on average. Moreover, based on data simulated from our model, the correlation between the maximum within-firm wage and the true firm type is less than 0.4. Other firm-level statistics such as the poaching index (Bagger and Lentz, 2019) are also in practice ineffective in correctly ranking firms in data simulated from our model.

[24] Ranking simulated workers and firms using fixed effects requires estimating an AKM model on the simulated dataset at each iteration of the optimization process, which is computationally unfeasible given our resources.

Table 1: Parameter Estimates

Parameter	Value	S.E.*
Production function and productivity distributions:		
f_0	2618.89	6.87
γ	-0.029	0.004
σ_x	0.309	0.003
σ_y	5.277	0.170
Search cost and meeting technology:		
q	555.17	24.67
c_0 (10^3)	242.16	11.29
c_1	14.21	0.33
s_1	0.774	0.01
m_0	2.205	0.08
Non-employment benefit:		
b_0	563.94	6.98
b_1	514.70	5.67
Bargaining power:		
α_0	0.207	0.01
α_1	0.221	0.03

* Standard errors are estimated by bootstrap with 30 iterations.

the main source of identification for bargaining power in both Cahuc et al. (2006) and this paper, the discrepancy in the estimated value might be in part because we explicitly model taxation. The wage moments that we use for estimation are computed based on net wages both in the data and in our model. The extent of wage dispersion in net wages is different from that in gross wages due to the non-linear labor taxes.

The exogenous separation rate δ is calibrated directly based on the frequency of transitions from employment to unemployment observed in the DADS data. We calibrate the separation rate δ to 0.021 per month.[25]

5.5 Model Fit

Despite a parsimonious parametrization with only 13 estimated parameters, our model can fit the 61 targeted moments well. Our model performs well in terms of aggregate moments (see Table 2) and the unconditional wage distributions (see Figure 2e).

[25] The transition rate is computed as the fraction of employed workers who become unemployed in the following month conditional on remaining in the labor force (employed or unemployed). Employment includes all jobs that can be observed in the DADS data.

Table 2: Model fit

Moment	Data	Model
Labor force participation rate	0.958	0.960
Unemployment rate	0.077	0.078
Vacancy rate	0.011	0.015
Job-to-job vs. unemp-to-job	0.187	0.131
Frac. empl. workers with wage $\leq 1.3w_{min}$	0.237	0.220

See Figure 2 for the model fit of additional targeted moments.

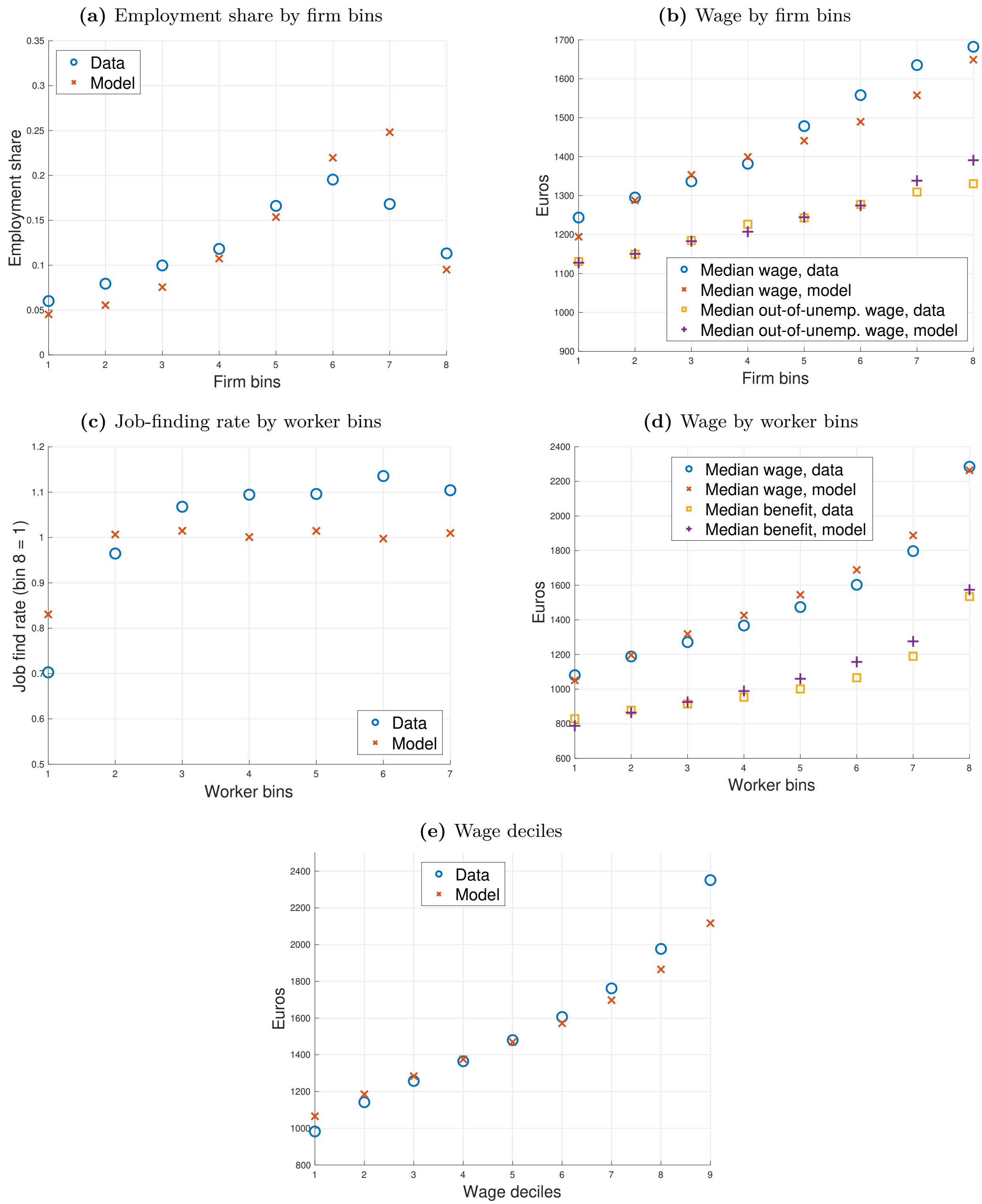
In both the *DADS* data and data simulated from our model, we group workers and firms into eight equal-sized bins according to the estimated AKM fixed effects (in the *DADS* data) or actual types (in the simulated data). The model captures the hump shape in employment share across firm bins (except in the 7th bin, see Figure 2a). Figure 2b shows that the model not only matches the wage dispersion across firm bins, but also the within-firm-bin difference between out-of-unemployment wages and unconditional wages. We also replicate the pattern that the job-finding rate is lower among the lowest ranked workers (Figure 2c) and closely matches the wage dispersion and benefit dispersion across worker bins (Figure 2d).

6 Equilibrium Effects of Payroll Tax Reductions

In this section, we use our model to simulate the first large employer SSC (i.e. payroll tax) reduction in France was implemented in September 1995, the so-called *Ristourne Juppé*. We quantify the equilibrium spillover and reallocation effects of the policy using our estimated model. The tax reduction was the most generous for minimum wage earners, reaching 18% of the gross wage for these workers. It phases out linearly in wage until 1.33 times the minimum wage. In our analysis, since payroll taxes nominally fall on employers, a payroll tax change is equivalent to a corresponding change in the tax schedule $T(\cdot)$ while holding constant w_{min}, the floor on net wage. We simulate data from our steady-state model under the two tax schedules prevailing in the baseline period (January 1993 to August 1995) and after the payroll tax reduction was implemented (January to December 1997) while fixing the model parameters and the minimum wage at their values in the baseline period.[26]

[26] Between 1995 and 1997, there was also a slight increase in the SSC rates for higher-paying jobs. We also include this feature in our simulation. See Figure 1 for changes in the payroll tax schedule. The parameters of the tax function after the policy change are shown in Column (2) of Table E.2.

Figure 2: Model Fit



Notes: For "data" moments, worker and firm bins are based on estimated fixed effects from AKM regressions; a higher bin corresponds to higher fixed effects (which positively correlate with productivity based on our model). For "model" moments, the bins are based on actual productivity ranks.

Table 3: Simulated aggregate effects of payroll tax reform

	(1) Both vacancy and partic. adjustments	(2) No adjustment	(3) Only vacancy adjustment	(4) Only partic. adjustment
Employment	2.18%	0.19%	0.28%	2.10%
Total output	1.14%	0.10%	0.11%	1.16%
Output per job	-1.01%	-0.09%	-0.17%	-0.93%
LF participation	2.08%	0.00%	0.00%	2.08%
Vacancies	2.72%	0.00%	2.87%	0.00%
Job finding rate	1.11%	2.16%	3.34%	0.07%

Notes: values in the table show percentage changes from the baseline due to the payroll tax reform. Column (1) shows equilibrium effects; Column (2) shows the effects when both vacancy $v(y)$ and labor force participation $s(x)$ are held at the baseline levels; Columns (3) and (4) show the effects when only $v(y)$ or $s(x)$ is allowed to adjust. See Section 6 for details. Output of a job filled by worker x in firm y is $f(x, y)$.

6.1 Results

Column 1 of Table 3 shows the aggregate effects of the payroll tax reduction in equilibrium. The tax reduction leads to an increase in employment and consumption; output increases despite a lower output per job. Labor supply and demand both increase: labor force participation increases by 2.1% while the number of vacancies increases by 2.7%. As vacancies increase slightly more than labor force participation in percentage terms, the equilibrium job finding rate is 1.1% higher.

To quantify the roles of labor supply and demand adjustments, we simulate the payroll tax reform under counterfactual scenarios in which we shut down adjustments in labor force participation $s(\cdot)$ and vacancy posting $v(\cdot)$. Under the scenario where neither labor force participation nor vacancy posting was allowed to adjust, the tax reduction only affects the set of viable matches between job seekers and vacancies. Lower payroll taxes reduce labor costs in low-wage matches, giving low-productivity workers and firms more opportunities to form viable matches. We refer to this as the direct effect of the policy change. From column 2 of Table 3, we can see that the direct effect is modest as there is little change in aggregate employment and output.

Column 3 of Table 3 shows the effect of labor demand adjustment. Specifically, we allow firms to change their vacancy posting in response to the tax reform while assuming that workers' labor force participation decisions do not change. In contrast, column 4 shows the effect of labor supply adjustment, allowing changes in workers' labor force participation but not in firms' vacancy posting decisions. The results in these two columns indicate that labor supply adjustment is more important in driving the aggregate effects of the payroll tax reform on employment and output. Even though the number of vacancies increases by 2.87% and the job finding rate increases by 3.34% (column 3), aggregate employment and output increase by only 0.28% and 0.11%, respectively. The lack of aggregate effects is because it is mostly low-productivity firms that increase their vacancies while high-productivity firms slightly reduce theirs (Figure 3a). Since low-productivity firms they are less likely to form viable matches, they have lower vacancy filling rates and the effect of vacancy creation on employment and output remains moderate.

The increase in labor force participation in response to the tax reduction also concentrates among low-productivity workers. Based on our model, only low-x workers are non-participants in the baseline economy. Since the payroll tax reduction lowers the cost of hiring low-wage workers, allowing for more viable matches for low-x workers and a higher return to job search for these workers. Thus, some non-participants decide to participate in the labor force after the reform. The payroll tax reduction leads to a 2.08% increase in labor force participation (column 4). The new labor-force participants contribute to significant increases in employment (2.10%) and output (1.16%) in the steady state because the tax reduction expanded their set of viable matches.

The fact that only low-productivity firms and workers increase their labor demand and supply gives rise to reallocation and spillover effects. To see this, we show the effects of the tax reduction by worker productivity quartiles in Figures 3b to 3d, in which we use different scales for the first and top three quartiles. The blue bars represents the equilibrium effect on each quartile. The reallocation and spillover effects can be examined in turn by looking at yellow and purple bars, where one adjustment is shut down.

The reallocation effect refers to the fact that a policy reform leads to workers' reallocation to different firms due to a change in the vacancy distribution, which can be seen from the yellow bars. The low-wage payroll tax reduction leads to more vacancies in low-productivity firms and fewer in high-productivity firms (Fig. 3a). This change causes a negative reallocation effect because workers are more likely to match with low-productivity firms and less likely to climb up the job ladder in terms of firm productivity. The negative reallocation effect can be observed from the drop in the average output per job in all productivity quartiles by around 0.1% (see Fig. 3d). This effect echoes the finding in Dustmann et al. (2022) that a higher minimum wage leads to a positive reallocation. The small decrease in the average output per job is offset by a modest increase in employment in all quartiles (see Fig. 3b), resulting in little effect on total output in any quartile (see Fig. 3c).

Spillover effects refer to the fact that a policy reform that targets one group of workers causes unintended effects on other workers because of changes in the targeted group's labor supply, which can be seen from the purple bars representing the scenario with only labor force participation adjustments. In the case of the low-wage payroll tax reduction, the increased labor force participation by low-productivity workers leads to a negative spillover effect. Specifically, both employment and output per job among workers in the top three quartiles fall (Figures 3b and 3d), resulting in a fall in total output from these workers (Fig. 3c). The fall in their employment rate is due to the fact that low-productivity workers congest the labor market. That is, the higher labor force participation of low-productivity workers leads to an increase in the aggregate search intensity ξ, which lowers the contact rate for all unemployed workers $\kappa(\xi, V)V$. The fall in the average output is due to workers' willingness to match with less productive firms as they lower the job acceptance threshold $\underline{y}(x)$. The fact that workers and firms are complementary in production amplifies the negative spillover effect.

In equilibrium (see yellow bars), the bottom quartile of workers contributes to a 1.26% increase in total output. However, workers in the top three quartiles contribute to a 0.11% *decrease* in total output (Fig. I.4d). That is, workers in the top three quartiles offset the output gain of the bottom quartile by 9% even though the payroll tax reduction does not directly impact them. In sum, the increased labor force participation of low-productivity workers substantially increases aggregate output, and the negative spillover effect on other workers is modest.

6.2 Discussion and Robustness Checks

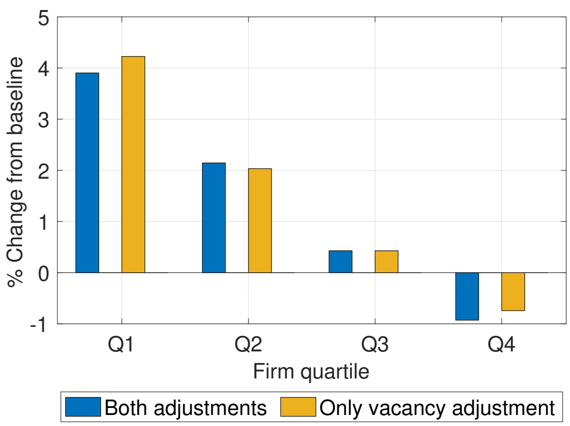
Our finding that the payroll tax reform leads to higher aggregate employment and vacancy is in line with Crépon and Desplatz (2003), who find evidence that firms substitute high-skilled labor for low-skilled labor in response to the policy change. However, without using the lens of a structural model, it is difficult to empirically estimate the causal effect of the tax reform on more productive workers and firms that the reform does not directly impact.

Our findings that the tax reform skews employment and vacancy distributions toward low-productivity workers and firms are consistent with the observed changes in employment distribution in the aftermath of the tax reform. In Appendix H, we compare the observed employment distribution by worker- and firm-productivity ranks in the baseline and post-reform periods. We find that low-productivity workers and low-productivity firms account for a more significant share of employment in the post-reform period compared to the baseline period. These results confirm that the broad model predictions regarding the reform's effects are supported by the data.

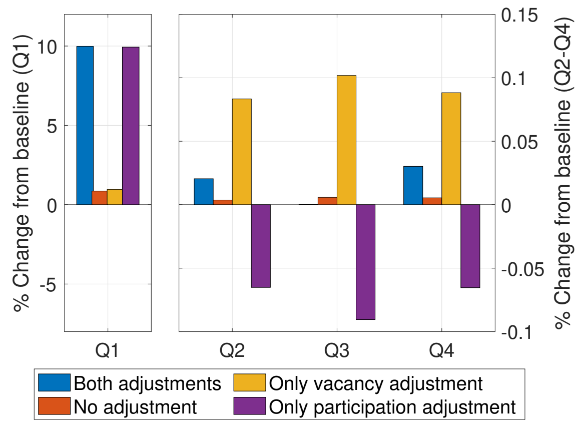
One potential concern is that, contemporaneous to the tax reform, there may be changes in the macroeconomic environment such that the results from our policy simulation based on the baseline model are no longer valid in the post-reform era. In Appendix I.1, we re-estimate the model using the post-reform period (1997) and simulate the effect of removing the tax reform. The estimated parameter values based on post-reform data are close to those in our baseline estimation, suggesting

Figure 3: Simulated distributional effects of payroll tax reform

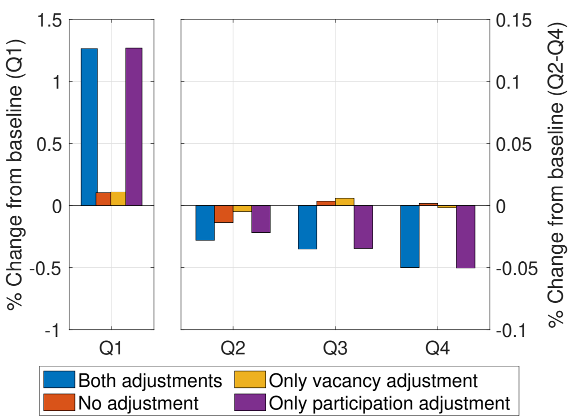
(a) Vacancy by firm productivity quartile



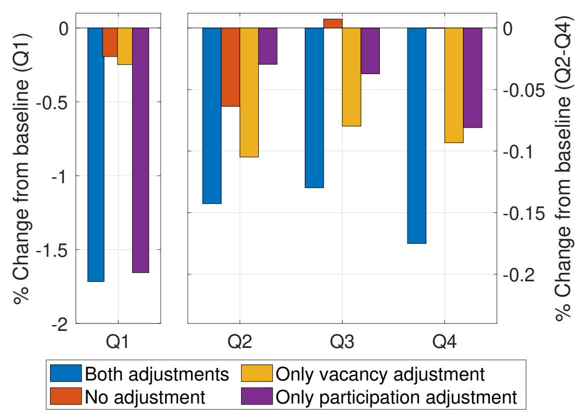
(b) Employment by worker productivity quartile



(c) Total output by worker productivity quartile



(d) Output per job by worker productivity quartile



that the macroeconomic environment was stable in the period around the implementation of the payroll tax reform. As a result, the simulated effects the tax reform do not depend on using the pre- or post-reform estimation of the model.

Another concern is that our model does not capture the potential complementarity between workers of different productivity levels in the production function. If high- and low-x workers are complements within a firm, an increase in low-x workers may increase the marginal productivity of high-x workers. We already exclude workers who are professionals and executives from our baseline sample; our results apply to workers of similar qualifications, and our model cannot speak to the effects on highly skilled workers. In Appendix I.2, we consider a more restricted sample of workers that are more homogeneous in terms of their occupation. We show that aggregate and distributional effects based on this sample are similar to those found using the baseline sample. The tax reduction's spillover effect on highly productive workers' output is still present, even though it is smaller than the baseline model.

Finally, we note that we do not model human or physical capital investment decisions by workers and firms. These investment decisions may respond to changes in labor market policies and alter the underlying productivity distributions of workers and firms in the long-run. However, the shift in the vacancy distribution due to the payroll tax reduction in our model can be viewed as a shift toward lower capital intensity firms, giving rise to more "bad jobs" relative to "good jobs".[27] The increased participation of low-productivity workers also lowers the average worker productivity, which can be viewed as a deterioration in average human capital of the workforce. In addition, changes in payroll taxation or the minimum wage could also affect the underlying distributions of individual and firm productivitys ($\mathfrak{h}(x)$ and $\mathfrak{p}(y)$). For example, a low-wage payroll tax reduction may discourage young individuals from accumulating human capital. We leave such considerations for future work.

7 Optimal Design of Payroll Taxation and Minimum Wage

In this section, we turn to the optimal design the two policy tools: payroll taxation and the minimum wage. We explain the social welfare criteria in Section 7.1. In Section 7.2, we study a limited policy reform that only reduces payroll taxes for low-wage jobs while holding the minimum wage constant. Such a reform has merits in a political environment where lowering the minimum wage is widely unpopular. However, a more general welfare evaluation should focus on the joint

[27] Postel-Vinay and Robin (2002a) show that, in a model like ours, the distribution of firm productivity can be endogenously generated by assuming that firms make capital investment decisions. See also Acemoglu (1999). Hence, firm types can be interpreted as a measure of firms capital intensity.

design of the two policy instruments, payroll taxation and the minimum wage. The two policy tools interact in setting the lower bound on incomes and labor costs. We examine the joint design of the two policy tools in Section 7.3.

7.1 Government Budget and Welfare Criteria

To make different policy regimes comparable, we assume that the government keeps a balanced budget. That is, tax revenues are first used to finance non-employment benefit payments ($b(x)$ in the model), and the remaining revenue is redistributed to the entire population as a flow lump-sum transfer (or tax if negative) D, where

$$D = \int T\left(w\right) g\left(w, x, y\right) dw dx dy - \int b(x) \left(1 - e(x)\right) dx, \tag{19}$$

where $g\left(w, x, y\right)$ is the measure of type-x workers matched with type-y firms with wage w with $\int g\left(w, x, y\right) dw = h(x, y)$. $1 - e(x)$ is the non-employment rate among workers of type-x.

Since individuals in our model are risk-neutral, D does not influence any decisions or equilibrium outcomes. As we explain in Appendix A.2, social security contributions are only loosely linked to various types of social security benefits, so that assuming a lump-sum transfer is a plausible simplification.

Since individuals in our model are risk-neutral, adopting a utilitarian welfare criterion would not penalize inequality. We consider a more general social welfare function that allows for different degrees of inequality aversion, with zero inequality-aversion being a special case. Specifically, we assume that the welfare weight placed on an individual is a strictly-concave transformation of her discounted lifetime utility and that the policymaker maximizes the sum of weighted individual welfare.[28] Social welfare $\mathcal{W}$ is computed as follows:

$$\mathcal{W} = \int \omega_e(w, x, y) g\left(w, x, y\right) dw dx dy + \int \omega_{ne}(x) \left(1 - e(x)\right) dx, \tag{20}$$

where $\omega_e(w, x, y)$ is individual welfare of employed workers, defined as

$$\omega_e(w, x, y) = \begin{cases} \frac{\left[rW_e(w,x,y)+D\right]^{1-\theta}}{1-\theta} & \text{if } \theta{\neq}1 \text{ and } \theta{\geq}0 \\ \log\left[rW_e\left(w, x, y\right) + D\right] & \text{if } \theta{=}1 \end{cases}, \tag{21}$$

[28] Alternatively, one can assume that individuals are risk-averse and the policymaker is utilitarian. Adding risk aversion to our model is unlikely to alter our main results related to the distributional effects of payroll tax policies because individuals in our model do not make job search decisions at the intensive margin. If we allow search intensity to vary, as in Bagger et al. (2018), payroll taxes affect sorting between individuals and firms. In that case, individuals respond differently to payroll tax policies, resulting in heterogeneous effects on the job-to-job transition rate.

and $\omega_{ne}(x)$ is individual welfare of non-employed workers, which can be similarly defined by replacing $W_e(w, x, y)$ with $W_{ne}(x)$ in Eq. 21. The social welfare criteria only considers workers' value because firms make zero profit ex-ante due to the free entry condition. Nevertheless, labor market policies impact firms' vacancy-posting decision, which in turn affect workers' value of employment and non-employment. The parameter θ governs the policymaker's aversion for inequality. If $\theta = 0$, the policymaker is utilitarian; a greater value of θ implies stronger preference for equity. Our formulation of the social welfare function follows Atkinson et al. (1970), with θ akin to the inequality aversion parameter in the Atkinson index. Saez (2002) uses a value of $\theta = 4$ as an upper-bound scenario in analyzing an optimal tax schedule.

7.2 Optimal Design of Payroll Tax Reduction

In this subsection, we examine how to optimally reduce payroll taxes in order to reach a given employment target, taking into consideration the spillover and reallocation effects of such policies. To simplify our analysis, we restrict our attention to a framework in which the payroll tax reduction is most significant for minimum wage jobs, decreases linearly with the wage, and vanishes at a given wage threshold. Such a framework encompasses many major payroll-tax reduction programs implemented in France in recent decades. We refer to the tax reduction as a payroll tax subsidy and assume the following functional form

$$\mathcal{S}(w; a_{\mathcal{S}}, b_{\mathcal{S}}) \quad = \quad \begin{cases} (b_{\mathcal{S}} \times w_{min} - w) \cdot a_{\mathcal{S}} & \text{if } w \leq b_{\mathcal{S}} \times w_{min} \\ 0 & \text{otherwise} \end{cases} \tag{22}$$

where $a_{\mathcal{S}}$ is the generosity parameter and $b_{\mathcal{S}}$ is the coverage parameter. The effective tax schedule is

$$T(w; a_{\mathcal{S}}, b_{\mathcal{S}}) = \max\{0, T(w) - \mathcal{S}(w; a_{\mathcal{S}}, b_{\mathcal{S}})\} \tag{23}$$

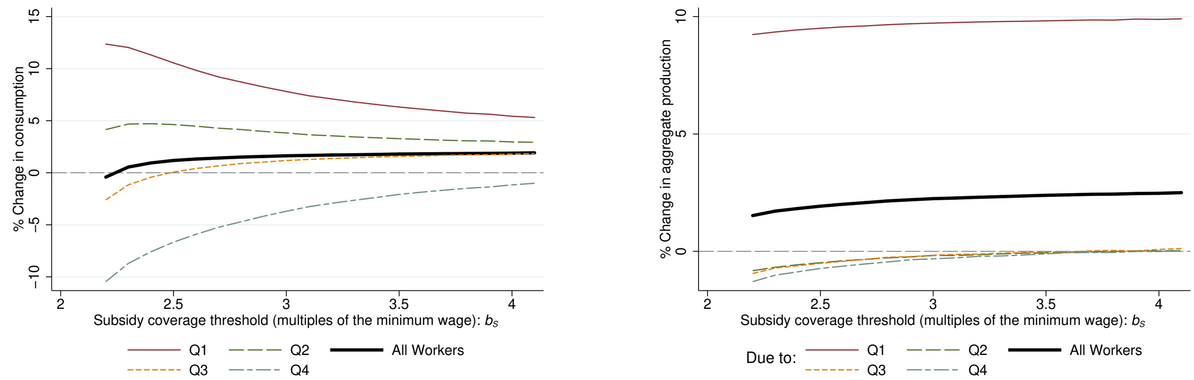
where $T(w)$ is the baseline tax schedule in the baseline model. We compare the equilibrium outcomes of subsidy programs that increase aggregate employment by 2% and 5%. As a reference, the employment increase under the payroll tax reform in Section 6 has a simulated effect of 2.1%.[29]

To understand the trade-offs between efficiency and redistribution implied by the various policy options, we now focus specifically on the set of policies that reach the 5% employment increase target and show in Figure 4 how these policies affect consumption and output in each quartile of the worker productivity distribution. Figure 4a shows the effect of subsidy programs of varying coverage ($b_{\mathcal{S}}$) on consumption. Programs that heavily subsidize a small set of low-wage jobs (high $a_{\mathcal{S}}$

[29]Figure J.1 shows that for each subsidy coverage ($b_{\mathcal{S}}$), the generosity ($a_{\mathcal{S}}$) that is required to achieve the set employment increase and the associated fiscal cost (or fiscal surplus if negative) in equilibrium.

Figure 4: Equilibrium effects of expanding tax reduction coverage

(a) Consumption **(b)** Output

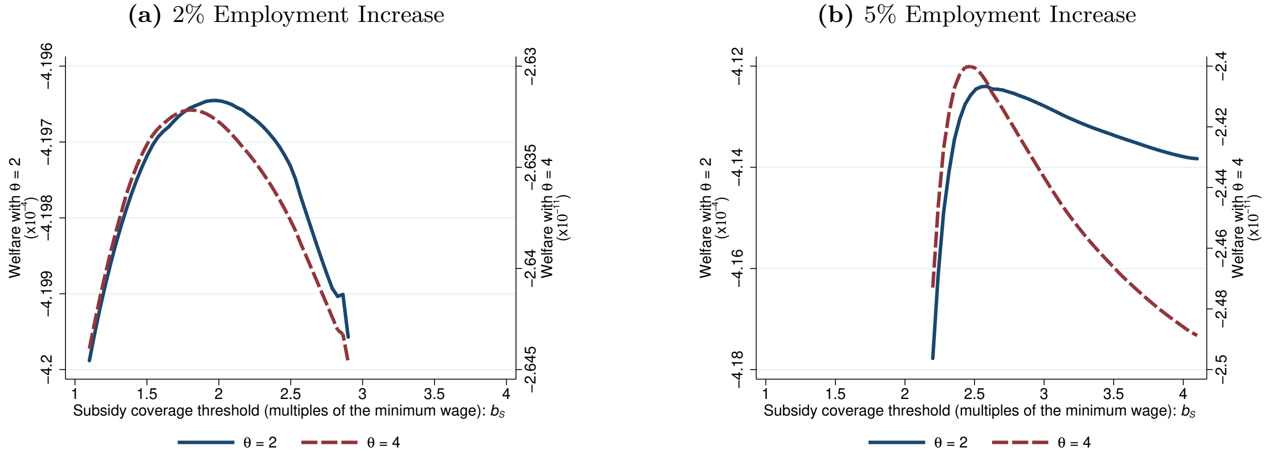


Notes: Subsidy generosity suba varies with coverage parameter subb such that all subsidy programs raise baseline employment by 5% (see Figure J.1a). The thick solid line shows aggregate effects and the lines "Q1-Q4" correspond to individual productivity quartiles. The graph has been smoothed using a third-degree polynomial. Changes refer to the difference between the counterfactual and the baseline.

and low b_S) lead to lower average consumption than a broader but less generous subsidy; however, the former are more redistributive toward low-productivity individuals. Under *all* programs that increase employment by 5%, labor force participation is 100%, and the employment rate of each quartile of workers is higher than the baseline economy. However, subsidy programs with a narrower coverage lead to lower output per job and, thus, lower total output (Figure 4b). This is due to the negative reallocation effect: a generous but narrowly targeted subsidy program leads to a more skewed vacancy distribution favoring low-productivity firms, which results in the reallocation of workers toward less productive firms. Even though a narrower subsidy is more redistributive toward the less-productive workers, the negative reallocation effect can dominate and may translate into lower welfare.

Figure 5 shows the social welfare of subsidy programs that raise employment by 2% and 5%. Achieving a greater increase in employment requires a broader subsidy. The optimal subsidy to achieve a 2% employment increase has a coverage of around 2 times the minimum wage; the optimal subsidy to achieve a 5% employment increase has a coverage of around 2.5 times the minimum wage. In addition, a more inequality-averse policymaker (higher θ) would opt for a more narrowly targeted low-wage subsidy, trading efficiency for equity. The payroll tax reduction implemented at the end of 1995 covers jobs that pay up to 1.3 times the minimum wage and results in an employment increase of about 2%. The coverage is considerably narrower than the optimal coverage that we find under $\theta = 4$, suggesting that the French policymakers may have a high degree of inequality aversion.

Figure 5: Simulated Welfare



Notes: Subsidy generosity suba varies with coverage parameter subb such that all subsidy programs raise baseline employment by 5%.

7.3 Optimal Joint Design

We begin this section by showing how the government-free decentralized economy is inefficient. Thus, policy intervention not only can reduce inequality but also can potentially improve economic efficiency. We demonstrate the extent to which each policy instrument can improve the efficiency in the decentralized economy and the gain of mixing them. Finally, we compute the optimal policy mix at various levels of inequality aversion.

7.3.1 Inefficiency of the Decentralized Economy

The extent of entry into markets with search frictions is often inefficient; our model is no exception. When workers and firms make labor force participation and vacancy posting decisions, they do not internalize the congestion and thick-market externalities they impose on others in the labor market. Congestion externality refers to the fact that one's entry lowers the matching probability for those on the same side of the labor market. Thick-market externality refers to the fact that one's entry increases the matching probability for those on the opposite side of the market. When workers and firms are respectively ex-ante identical, the Hosios condition ensures constraint efficiency by setting the bargaining power equal to the elasticity of the aggregate matching function (Mortensen, 1982; Hosios, 1990).

Our model is much more complex than the one Hosios (1990) considers. To show how our decentralized economy with no payroll taxation or minimum wages is inefficient, we show how the bargaining power function in our model deviates from the optimal one. To this end, we estimate the values of the bargaining power function parameters (α_0 and α_1 in Eq. 17) that maximize economic efficiency in an environment with no taxes and no minimum wages. Economic efficiency is measured by the welfare criteria (Eq. 20) with $\theta = 0$.

Our results show that, in the government-free decentralized economy, changing the bargaining power function from the one empirically estimated to the optimal one achieves an efficiency improvement of 0.37%. Figure 6a shows that the efficiency-maximizing bargaining power function is different from that in the baseline economy estimated in the French labor market in the 1990s: for all firm types, the optimal worker bargaining power is higher than the one in the baseline economy, and this is especially the case for low-productivity firms. This is because, the more productive a firm is, the higher its bargaining power should be to incentivize the firm to post vacancies. Indeed, high-productivity firms' vacancies bring substantial benefits to workers, outweighing the harmful congestion effect they impose on other firms.[30] Since the bargaining power function in our baseline economy is not optimal, there is space for policy intervention to increase economic efficiency.

We also find that the payroll taxation and the minimum wage that were in place in France in the early 1990s do not improve economic efficiency. Specifically, compared to the government-free economy, the economy in our baseline model with these policies lowers economic efficiency by 1.85%. Nevertheless, the policy mix increases social welfare given sufficiently high inequality-aversion. For example, the policy mix increases social welfare by 2.38% if $\theta = 2$, and by 18.25% if $\theta = 4$. This suggests that the French policymakers in this period are indeed inequality-averse, consistent with our finding in Section 7.2.

7.3.2 Efficiency and Welfare Maximizing Policies

We consider a parametrized tax function $T(w)$ as follows:

$$T(w) = \left(\frac{w}{\lambda}\right)^{\frac{1}{1-\tau}} - \lambda w, \quad \text{with } \tau < 1, 0 < \lambda \leq 1, \tag{24}$$

where w is the net wage and $T(w)$ is the total labor tax such that $[w + T(w)]$ is the labor cost. A greater value of τ indicates stronger tax progressivity: the tax schedule is progressive (i.e. the average tax rate $\frac{T(w)}{w}$ increases in w) if $\tau > 0$, and regressive if $\tau < 0$.[31] We use the social welfare

[30] This result is in line with Shimer and Smith (2001), who show that the decentralized economy with heterogeneous productivity is inefficient because highly productive agents search too little and low productivity agents search too much.

[31] In practice, we further restrict τ and λ to values such that $T'(w) > 0$ for all potential wages in equilibrium. For each λ, this restriction sets a lower bound on τ.

criteria described in Eq. 20 as the policymaker's objective function. Under $\theta = 0$, the social welfare also measures the efficiency of the economy.

We first solve for, in turn, the optimal minimum wage and the payroll tax function by numerically maximizing economic efficiency while setting the other policy tool to zero. Table 4 summarizes the policy parameters and welfare levels under various optimal policy scenarios, and Figure 6b shows the optimal payroll tax schedules. In the absence of payroll taxation, the optimal minimum wage is 1254 euros per month in terms of the net monthly wage, 37.5% higher than the net minimum wage of 912 euros in France in the early 1990s. This minimum wage is binding for low-productivity firms, disincentivizing them from posting vacancies. In doing so, the minimum wage offsets the congestion externality that arises from low-productivity firms and achieves an overall efficiency improvement of 0.11% compared to the government-free economy.

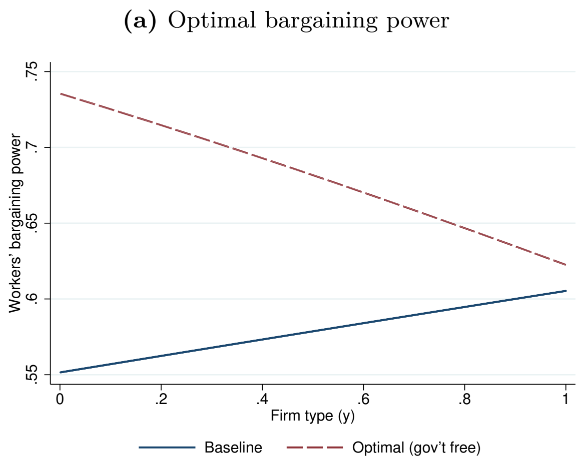
In the absence of minimum wages, the efficiency-maximizing payroll taxation is moderately regressive, with a higher average tax rate on low-wage jobs relative to high-wage jobs. The regressive tax disproportionally increases labor costs in low-wage jobs, disincentivizing low-productivity firms from posting vacancies. The optimal payroll taxation (without any minimum wage) achieves a more substantial efficiency improvement of 0.39% compared to the case with only the minimum wage.

Consider, now, the optimal joint design of the two policy instruments. In this case, the optimal minimum wage is binding but is only 61% as high as that in the minimum-wage-only case. Meanwhile, the payroll tax function in the optimal policy mix is similar to the tax-only case (see Fig. 6b). The efficiency gain under the optimal policy mix is 0.40%, only slightly higher than that in the tax-only case. These results suggest that a minimum wage can hardly further improve efficiency when the policymaker already sets payroll taxation optimally.

Given inequality aversion ($\theta = 2$ or 4), the optimal policy mix does not involve a binding minimum wage but calls for less regressive payroll taxation. Figure 6b shows that the optimal payroll tax schedule in these two scenarios imposes a higher average tax rate on high-wage jobs than the baseline tax function. The higher tax levels allow for a more significant lump-sum transfer, which helps to achieve a greater level of equality across households.

Even though our model suggests a somewhat limited role for the minimum wage, we note that setting a minimum wage may benefit the economy in aspects we do not consider in this paper. For example, we do not consider the political feasibility of lowering the minimum wage or the short-run fiscal cost of payroll tax reductions. Higher minimum wages may also inspire long-term innovation and human capital accumulation. Nevertheless, our study offers valuable insights into the joint design of the two policy instruments in the presence of heterogenous workers and firms that are potentially subject to reallocation and spillover effects induced by policies.

Figure 6



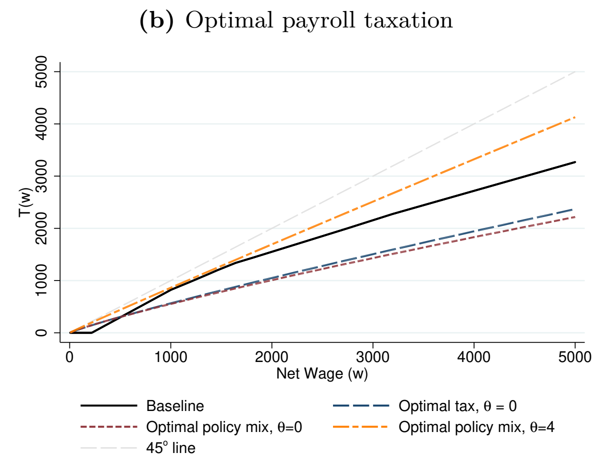


Table 4: Policy parameters and welfare

	w_{min}	λ	τ	Welfare Gain
Efficiency-maximizing ($\theta = 0$):				
Min. wage only	1254	-	-	0.11%
Payroll tax only	-	0.591	-0.054	0.39%
Policy mix	766	0.556	-0.069	0.40%
Welfare-maximizing:				
Policy mix, low inequality aversion ($\theta = 2$)	378*	0.594	-0.020	4.87%
Policy mix, standard inequality aversion ($\theta = 4$)	473*	0.606	-0.016	25.37%

* *The minimum wage is not binding.*
Notes: θ is the inequality-aversion parameter (see Eq. 20). λ and τ are parameters of the tax function (see Eq. 24). Welfare gain is the percentage difference in social welfare (given θ) from the government-free economy. See Section 7.3 for details.

8 Conclusion

Recent empirical literature documents that targeted tax reductions or minimum wages have unintended spillover and reallocation effects on workers not directly targeted by the policies. This paper quantifies these unintended policy effects and sheds light on the optimal policy design. We consider an equilibrium search-and-matching model with workers and firms who are respectively heterogeneous in productivity. Workers make labor force participation decisions, and firms make vacancy-posting decisions. Different workers and firms respond to changes in labor market policies differently; these uneven labor supply and demand adjustments have equilibrium repercussions that extend to all workers.

We estimate our model based on French social security data and use the estimated model to analyze the low-wage payroll tax reduction implemented in France at the end of 1995. We find that the tax reduction increases vacancies posted by low-productivity firms and the labor force participation of low-productivity workers. The shift in the vacancy distribution leads to a negative reallocation effect for all workers because they are now more likely to match with firms with lower productivity levels. In addition, the increased participation of low-productivity workers leads to a negative spillover effect: as these workers start searching in the frictional labor market, they create congestion and lower the job finding rate for all job searchers. As a result, more productive workers find employment at a lower rate, and their total production output drops. In equilibrium, the low-wage payroll tax reduction leads to a decrease in output from the top three quartiles of workers, offsetting 9% of the output gain made by the bottom quartile. While the negative spillover effect is small, the increase in labor force participation contributes to a substantial increase in aggregate employment and output. The results suggest that payroll tax reduction policies should incentivize low-productivity workers to participate in the labor force while minimizing the shift in the vacancy distribution toward low-productivity firms.

We next turn to the question of how to optimally design employment-boosting payroll tax reductions for low-wage workers while taking the French payroll taxation and minimum wage in the early 1990s as given. We find that, even when the policymaker is inequality-averse, the optimal payroll tax reduction should cover a relatively large set of low-wage jobs. This is because policies that offer large tax reductions for a small set of minimally paid jobs lead to a drop in average job "quality" as low-productivity firms post more jobs relative to high-productivity ones. Although a narrower tax reduction targeting minimally-paid jobs can potentially lead to more significant redistribution, the negative reallocation effects dominate and translate to lower welfare. We find that, to increase employment by 2%, an inequality-averse policymaker should reduce payroll taxes for jobs that make less than twice the minimum wage, a much broader range than the 1995 payroll tax reduction.

Finally, we study the optimal joint design of the minimum wage and payroll taxation. We show that the decentralized economy with no minimum wages or payroll taxes is inefficient because workers' bargaining power in low-productivity firms is lower than the efficiency-maximizing value. The result suggests that policy interventions that disincentivize low-productivity firms from posting vacancies and therefore limit the creation of "bad jobs" can improve economic efficiency. Jointly optimizing payroll taxation and minimum wage to maximize economic efficiency, we find the optimal policy mix to be moderately regressive payroll taxation and a low but binding minimum wage. If the policymaker is inequality-averse, the optimal policy mix features a less regressive payroll taxation and a non-binding minimum wage.

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Table A.1: Earnings Concepts

	Employer SSC	Employee SSC	Income Tax
Labor Cost	Included	Included	Included
Gross Wage	Not Included	Included	Included
Net Wage	Not Included	Not Included	Included
Disposable Income	Not Included	Not Included	Not Included

Appendix

A Institutional Background

A.1 Earnings Concepts

In France, two main types of taxes are levied on labor income: social security contributions (SSCs) and income taxes. SSCs are levied on both employers and employees, the larger part being the employer one. Income taxes are paid by households on both labor and capital incomes. Various earnings concepts involve different combinations of SSCs and income taxes. These are summarized in Table A.1. Labor cost is the total cost of employing a worker, including employer and employee SSCs and the income tax. The gross wage corresponds to the labor cost net of employer SSCs, but including employee SSCs and income taxes.[32] The net wage is equal to the gross wage minus employee SSCs. Finally, to obtain disposable labor income, income tax is subtracted from the net wage.

In the equilibrium model introduced in Section 3, wages refer to net wages. The statutory minimum wage is a wage floor for gross wages. In our quantitative analyses, we subtract employee SSCs from the statutory minimum wage to obtain the minimum net wage w_{min}.

We ignore the effects of SSC changes on income taxes for two reasons. First, to compute the income taxes for a given worker, one needs to make assumptions about the amount of household earnings, its composition (labor and capital income) and how household members share the tax burden, which are not observable in administrative data. Second, the income tax is modest compared to SSCs (representing only around 10% of the total tax wedge on labor earnings), especially around the minimum wage (individuals working full-time, living alone and without capital income start paying the income tax when their earnings exceed 1.2 times the minimum wage).

[32]The term "gross" may appear inappropriate as this concept does not include employer SSCs. It is nevertheless the most commonly used term (*salaire brut* in France, *Bruttoverdienst* in Germany, *gross earnings* in the U.K.)

A.2 Tax-benefit linkage

As contributions are only loosely linked to benefits, we treat SSCs as labor taxes. Revenues from SSCs are mainly used to finance health insurance, child care benefits, unemployment insurance and pension programs. There is no direct link between health or child care contributions and the actual benefits these contributions provide, implying that these contributions, which correspond to approximately one third of total contributions, can be considered as taxes. The contributions funding unemployment insurance and pension schemes are partly linked to entitlements, but the link is not systematical (see Bozio et al. (2017) for details). Most importantly, the payroll tax reduction reforms we study in the paper only change contributions and are not linked to changes in entitlements. They can therefore be considered as pure tax reforms.

A.3 Minimum Wage and Payroll Tax Reductions

The statutory minimum wage in France is expressed as a minimum gross wage, meaning that it is net of employer SSCs but gross of employee SSCs. As a result, an employer SSC reduction is different from an employee SSC reduction around the minimum wage; in the short-run, the former lowers the labor cost of a minimum-wage worker whereas the latter increases the minimum-wage worker's net wage without lowering the labor cost. Since the French policymakers are interested in reducing labor costs for low-wage workers, they implemented a series of reductions in employer SSCs since the late 1990s, which we also refer to as payroll tax reductions.

Besides low-wage payroll tax reductions, an alternative approach to limit labor costs while protecting net wages is to remove or reduce the minimum wage while offering a tax credit directly to low-wage workers. This policy mix is more prevalent in Anglo-Saxon countries. For example, the U.S. and the U.K. both have a low minimum wage and such a tax credit: the EITC in the U.S. and the WFTC in the U.K. The main advantage of these systems is that the tax credits can depend on workers' other sources of income and family situations, so that they can be well targeted to actual working-poor individuals. The main drawback is that the economic incidence is uncertain, since the employer may capture part of the credits intended to boost workers' pay. Existing evidence suggests that this effect is indeed large (Rothstein, 2008; Azmat, 2019). To avoid this consequence, and because reducing the statutory minimum might be politically unpopular, France does not adopt this approach and instead maintains a high minimum wage while limiting payroll taxes. Although low-wage payroll tax reductions do not allow precise targeting of working-poor individuals, it has the strong advantage of perfectly controlling both the minimum net wage and the minimum labor cost.

Figure A.1: Social Security Reductions

Source: Tax simulator TAXIPP (Jelloul et al., 2018).
Notes: The figure shows the successive schemes of reduction of SSCs that were put in place by the French government from 1993 (fist reduction) to the end of 1997.

Figure A.1 provides an overview of the early payroll tax reductions in France (see Jelloul et al. (2018)). As shown in the figure, the first modest reductions took place from July 1993 to August 1995 with reductions in SSCs payments of 5% of the gross wage for individuals earning up to 1.1 times the minimum wage, 2.5% for individuals earning between 1.1 and 1.2 times the minimum wage and no reductions for anyone earning more than 1.3 times the minimum wage.

The first large payroll tax reduction was implemented in September 1995 (the so-called *Ristourne Juppé*). The value of SSC reductions was made more generous, reaching 18% of the gross wage for minimum wage earners, with a linear phase-out for individuals earning more than 1.33 times the minimum wage. The One of the main goals in this paper is to simulate the equilibrium effects of this reduction. Further large SSC reductions followed in the early 2000s. However, they were introduced jointly with the reduction of the working time to 35 hours a week, making these difficult to analyze independently. Thus, we choose to focus on the SSC reductions that were implemented in the mid-1990s in line with most of the previous literature.[33]

[33] For further institutional details, see Bunel and L'Horty (2012) and André et al. (2015).

B Nash Bargaining

Suppose that an unemployed worker and a firm engage in Nash bargaining. We follow the notation defined in Section 3, and write $\alpha(y)$ as α and $\alpha_{Nash}(y)$ as α_{Nash} for brevity. The Nash bargaining problem is

$$\phi_u^{Nash}(x,y) = \arg\max_w [W_e(w,x,y) - W_{ne}(x)]^{\alpha_{Nash}} [J_f(w,x,y) - J_u(y)]^{(1-\alpha_{Nash})}, \tag{25}$$

where α_{Nash} is the Nash bargaining power of workers. The first order condition is

$$W_e(w,x,y) - W_{ne}(x) = -\frac{\alpha_{Nash}}{1-\alpha_{Nash}} \frac{\partial W_e(w,x,y)/\partial w}{\partial J_f(w,x,y)/\partial w} [J_f(w,x,y) - J_u(y)]. \tag{26}$$

Without taxes, utility is perfectly transferable between the worker and the firm with $\frac{\partial W_e/\partial w}{\partial J_f/\partial w} = -1$. Whenever $\alpha_{Nash} = \alpha$, the wage under Nash bargaining coincides with the wage under proportional bargaining.[34] With labor taxes, bargained wages diverge.

We now derive $\frac{\partial W_e(w,x,y)}{\partial w}$ and $\frac{\partial J_f(w,x,y)}{\partial w}$ using results derived in Appendix C: (i) workers make job-to-job transitions only to more productive firms, $\mathcal{A}_e(x,y) = \{y' \in [0,1] : y' > y\}$; (ii) employed workers only renegotiate their wage with their current employer if they meet a vacancy from an outside firm $y' \geq y_0(w,x,y)$. Taking partial derivatives of Eqs. 9 and 10 with respect to w gives

$$\begin{aligned} &[r+\delta+s_1\kappa V]\frac{\partial W_e(w,x,y)}{\partial w} = 1 \\ &+s_1\kappa\frac{\partial\left[\int_{y_0(w,x,y)}^{y} W_e(\phi_e(x,y',y),x,y)v(y')dy'\right]}{\partial w} \\ &+s_1\kappa\frac{\partial\left[\int_0^{y_0(w,x,y)} W_e(w,x,y)v(y')dy'\right]}{\partial w} \end{aligned} \tag{27}$$

and

$$(r+\delta+s_1\kappa V)\frac{\partial J_f(w,x,y)}{\partial w} = -1 - \frac{dT(w)}{dw}$$

$$+s_1\kappa\frac{\partial\left[\int_{y_0(w,x,y)}^{y} J_f(\phi_e(x,y',y),x,y)v(y')dy'\right]}{\partial w}. \tag{28}$$

$$+s_1\kappa\frac{\partial\left[\int_0^{y_0(w,x,y)} J_f(w,x,y)v(y')dy'\right]}{\partial w} \tag{29}$$

[34] l'Haridon et al. (2013) and Jacquet et al. (2014) also present this result.

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

$$\frac{\partial W_e(w,x,y)}{\partial w} = \frac{1}{r + \delta + s_1 \kappa \int_{y_0(w,x,y)}^{y_h} v(y')dy'} \tag{30}$$

and

$$-\frac{\partial J_f(w,x,y)}{\partial w} = \frac{1 + \frac{dT(w)}{dw}}{r + \delta + s_1 \kappa \int_{y_0(w,x,y)}^{y_h} v(y')dy'} \tag{31}$$

Substitute the partial derivations in Eq. 26 using the above, we have

$$\frac{W_e(w,x,y) - W_u(x)}{J_f(w,x,y) - J_u(y)} = \frac{\alpha_{Nash}}{[1 - \alpha_{Nash}]} \frac{1}{\left[1 + \frac{dT(w)}{dw}\right]} \tag{32}$$

which states that, under Nash bargaining, the match surplus is split according to the Nash bargaining power and the marginal tax rate. If the marginal tax rate is continuously increasing in w, the Nash wage is unique. However, the tax schedule that we study exhibits decreasing marginal tax rate, and thus the uniqueness of the Nash wage is not guaranteed. This creates theoretical and numerical challenges to solving the model. Therefore, we opt for the simpler proportional bargaining scheme.

The choice of the bargaining scheme affects the estimates of the bargaining power parameters and their interpretation. When $\alpha_{Nash} = \alpha$, the Nash wage ϕ_u^{Nash} must be smaller than the proportionally bargained wage ϕ_u because $\frac{1}{\left[1+\frac{dT(w)}{dw}\right]} \leq 1$. This implies that, all else equal, the estimated bargaining power under proportional bargaining must be smaller than under Nash bargaining. The intuition is that, with Nash bargaining, workers realize that higher wages increase the tax burden. They partially compensate firms for this effect. In proportional bargaining, the two parties remain ignorant about how the tax burden comes about.

C Theory Appendix for Equilibrium Results

C.1 Uniqueness of Bargaining Solution

Since the surplus sharing equation in Eq. 2 can be written as

$$W_e(w,x,y) - W_{ne}(x) = \frac{\alpha(y)}{1 - \alpha(y)} [J_f(w,x,y) - J_u(y)], \tag{33}$$

Proposition 1 implies that $\frac{W_e(w,x,y) - W_{ne}(x)}{J_f(w,x,y) - J_u(y)}$ monotonically increases with w. Since a bargaining solution ϕ must satisfy $\frac{W_e(\phi,x,y) - W_{ne}(x)}{J_f(\phi,x,y) - J_u(y)} = \frac{\alpha(y)}{1-\alpha(y)}$, monotonicity of $\frac{W_e(w,x,y) - W_{ne}(x)}{J_f(w,x,y) - J_u(y)}$ in wage implies that the bargaining solution, if it exists, must be unique.

C.2 Steady State Wage Distribution

Wages are fully determined by worker and firm types, x and y, and workers' "reference" in wage bargaining (y' or non-employment). Given the steady state conditions for the distribution of unemployment and matches (Eqs. 13 and 14), the wage distribution is stationary as long as the conditional distribution of y' on (x, y) is stationary for each type of viable match (x, y).

Let $G(y'|x, y)$ represent the fraction of type (x, y) matches such that the worker's reference firm type is y' or lower. Let $y' = -1$ denote the case that the worker's outside option is non-employment. For a viable match (x, y) and for $y' \geq \underline{y}(x)$, equating inflow into and outflow from $G(y'|x, y)h(x, y)$ gives us

$$v(y)\kappa(\xi, V)\left[u(x) + s_1 \int_0^{y'} h(x, y'')dy''\right] = G(y'|x, y)h(x, y)\left[\delta + s_1\kappa(\xi, V)\int_{y'}^1 v(y'')dy''\right]. \quad (34)$$

For a viable match (x, y) and a reference value given by $y' = -1$, the equal flow equation is

$$v(y)\kappa(\xi, V)u(x) = G(y'|x, y)h(x, y)\left[\delta + s_1\kappa(\xi, V)\int_{\underline{y}(x)}^1 v(y'')dy''\right]. \quad (35)$$

C.3 Job-to-Job Transitions

In this section, we show that employed workers make job-to-job transitions to more productive firms and that, for each (w, x, y), there exists a threshold firm type $y_0(w, x, y)$ such that a wage renegotiation is triggered by firm $y' > y_0(w, x, y)$. In an auction for an employed worker x, the firm that can offer a higher $W_e(\bar{\phi}(x, y), x, y)$ succeeds. Thus, workers prefer more productive firms if and only if $\frac{dW_e(\bar{\phi}(x,y),x,y)}{dy} \geq 0$. Recall that $\bar{\phi}(x, y)$ is the maximum wage in match (x, y) such that $J_f\left(\bar{\phi}(x, y), x, y\right) = J_u(y)$. In the next Proposition, we show that the maximum potential wage $\bar{\phi}$ is increasing in worker and firm productivities.

Proposition 2. *Given the assumptions that $f_x(x, y) > 0$ and $f_y(x, y) > 0$ for all x and y and $T'(w) \geq 0$ for all w, we have $\bar{\phi}_x(x, y) > 0$ and $\bar{\phi}_y(x, y) > 0$ for all x and y.*

Proof. Given $J_f(\bar{\phi}(x, y), x, y) = J_u(y)$ and the free-entry condition, we have $J_f(\bar{\phi}(x, y), x, y) = 0$. Therefore, it must be the case that

$$\bar{\phi}(x, y) + T(\bar{\phi}(x, y)) = f(x, y). \quad (36)$$

Taking the derivative of Eq. 36 with respect to y and rearranging, we have

$$\frac{\partial \bar{\phi}(x,y)}{\partial y} = \frac{\frac{\partial f(x,y)}{\partial y}}{1 + T'(\bar{\phi}(x,y))}.$$

By assumption, $\frac{\partial f(x,y)}{\partial y} > 0$ and $T'(\bar{\phi}(x,y)) \geq 0$. Therefore, $\frac{\partial \bar{\phi}(x,y)}{\partial y} > 0$. Similarly, we can show that $\frac{\partial \bar{\phi}(x,y)}{\partial x} > 0$. □

In other words, more productive firms can offer higher wages conditional on the worker type. Together with the fact that W_e increases in wage (Proposition 1), we know that $\frac{\partial W_e(\bar{\phi}(x,y),x,y)}{\partial w} \frac{\partial \bar{\phi}}{\partial y} \geq 0$.

It remains to be shown that the option value of matching with a more productive firm is higher, that is, $\frac{\partial W_e(w,x,y)}{\partial y} \geq 0$ at $w = \bar{\phi}(x,y)$. Substituting w with $\bar{\phi}(x,y)$, we can rewrite the value function in Eq. 9 as

$$\begin{gathered} [r + \delta + s_1 \kappa(\xi, V) V] W_e(\bar{\phi}(x,y), x, y) = \bar{\phi}(x,y) + \delta W_{ne}(x) \\ + s_1 \kappa(\xi, V) \int_0^1 \max \left\{ W_e(\bar{\phi}(x,y), x, y), W_e(\phi_e(x,y,y'), x, y') \right\} v(y') dy' \end{gathered} \tag{37}$$

At the maximum potential wage, workers do not renegotiate their wages as long as they stay with their current employer. Thus, when an employed worker meets a vacancy from a poaching firm, she either remains with her current employer at the same wage, or makes a job-to-job transition. By the contraction mapping theorem, the value function $W_e(\bar{\phi}(x,y), x, y)$ must be increasing in the third argument since $\bar{\phi}(x,y)$ is increasing in y. Therefore, we have

$$\frac{dW_e(\bar{\phi}(x,y), x, y)}{dy} = \frac{\partial W_e(\bar{\phi}(x,y), x, y)}{\partial w} \frac{\partial \bar{\phi}(x,y)}{\partial y} + \frac{\partial W_e(\bar{\phi}(x,y), x, y)}{\partial y} \geq 0.$$

In addition, due to the fact that $\bar{\phi}(x,y)$ increases in y, the outbidding firm in an auction is also able to offer at least the minimum wage if the losing firm can form a viable match with the worker. This implies that matches between an employed worker and an outbidding firm are always viable and employed workers make job-to-job transitions only toward more productive firms. We can then conveniently express the set of firms that can poach worker x from firm y, $\mathcal{A}_e(x,y)$, as

$$\mathcal{A}_e(x,y) \quad = \quad \left\{ y' \in [0,1] : y' > y \right\}. \tag{38}$$

Finally, Propositions 1 and 2 imply that there exist a threshold firm type $y_0(w,x,y)$ such that for any $y' \geq y_0(w,x,y)$, $W_e(\bar{\phi}(x,y'), x, y') \geq W_e(w,x,y)$. In summary, given a match (x,y) and a poaching firm y', there are three possible scenarios. If $y' > y$, the worker makes a job-to-job transition to firm y'. If $y_0(w,x,y) < y' \leq y$, the worker remains in firm y but renegotiates her wage. If $y' \leq y_0(w,x,y)$, the match remains at the same wage w.

C.4 Reservation Firm-Type and Policy Impacts

Results from Appendix C.3 suggest that a match with a more productive firm can always yield a higher surplus. Thus, the set of viable matches for a worker of type x, $\mathcal{A}_u(x)$, can be fully characterized by a threshold $\underline{y}(x) \in [0,1]$ such that $\mathcal{A}_u(x) = \left\{ y \geq \underline{y}(x) \right\}$. The threshold $\underline{y}(x)$ arises from two constraints. The first constraint is related to the minimum wage. We use $y_{min}(x)$ to denote the lowest firm type y that can offer at least w_{min} to a worker x and characterize $y_{min}(x)$ in the next Proposition.

Proposition 3. *For any $y \in \mathcal{A}_u(x)$, we have $y \geq y_{min}(x)$ where*

$$y_{min}(x) = \arg\min_{y \in [0,1]} \left\{ y : f(x,y) \geq w_{min} + T(w_{min}) \right\}.$$

Proof. In equilibrium, $J_u(y) = 0$. By Definition 1, we have $J_f(\phi_u(x,y), x, y) \geq 0$ for any $y \in \mathcal{A}_u(x)$. Given this, the value function of a filled position (Eq. 10) implies that $f(x,y) \geq w_{min} + T(w_{min}) \geq 0$. □

Thus, a higher minimum wage or a higher tax at the minimum wage shrinks the set $\mathcal{A}_u(x)$ by making matches with low-productivity firms unviable. This is likely to affect low-productivity workers more strongly because the condition $f(x,y) \geq w_{min} + T(w_{min}) \geq 0$ is more likely to bind for them.

The second constraint stems from the match viability condition that the net match surplus must be positive (Definition 1). We use $y_u(x)$ to denote the lowest y satisfying the system of equations in Eq. 3 given x. A higher tax shrinks the set $\mathcal{A}_u(x)$ because it lowers the value of employment relative to the value of non-employment, which results from the fact that non-employment income $b(x)$ is not taxed. Since the difference between the value of employment and the value of non-employment increases with firm type, the constraint is more likely to bind for matches involving low productivity firms.

In combination, the above two constraints define the least productive firm with which worker x can form a viable match. That is, $\underline{y}(x) = \max \left\{ y_{min}(x), y_u(x) \right\}$.

D Numerical Solution of Steady State Equilibrium

Solving for the steady state equilibrium requires knowledge of the value functions of workers and firms because the net match surplus varies as a function of how the surplus is shared. Below, we describe the iterative numerical algorithm that solves for the fixed point. We discretize the supports of x and y with evenly spaced grids between 0.01 and 0.99 with 100 and 50 grid points, respectively. We also discretize the space of w with 100 grid points. We make an initial guess for the values W_e, W_{ne}, J_f and the distributions u, h on each grid point and the total measure of vacancies V. With inputs W_e, W_{ne}, J_f, u, h, and V, each iteration proceeds as follows:

1. Given u, and h, compute the aggregate search intensity $\xi = \sum u(x) + s_1 \sum\sum h(x,y)$.

2. Given W_e, W_{ne}, J_f, solve for the set of viable matches, Ω, such that

$$\Omega = \{(x,y) : \exists w \text{ s.t. } w \geq w_{min} \text{ and } W_e(w,x,y) - W_{ne}(x) \geq 0 \text{ and } J_f(w,x,y) \geq 0\}.$$

3. For each $(x,y) \in \Omega$, solve the following equation for the bargained wage ϕ:

$$W_e(\phi,x,y) - W_{ne}(x) = \frac{\alpha(y)}{1-\alpha(y)} J_f(\phi,x,y).$$

   Save the match wage $\phi_u(x,y) = \max\{w_{min}, \phi\}$. Then, find $\bar{\phi}(x,y)$ such that $J_f(\bar{\phi}(x,y),x,y) = 0$. For each (x,y',y) such that $(x,y) \in \Omega$ and $(x,y') \in \Omega$, solve the following equation for the bargained wage ϕ:

$$W_e(\phi,x,y') - W_e(\bar{\phi}(x,y),x,y) = \frac{\alpha(y)}{1-\alpha(y)} J_f(\phi,x,y').$$

   Save the match wage $\phi_e(x,y',y) = \max\{w_{min}, \phi\}$.

4. Let $mobility(x,y',y) = 1$ if worker x would make a job-to-job transition from firm y to y'. That is, $mobility(x,y',y) = 1$ if either of the following criteria is satisfied.

   (a) $(x,y) \in \Omega$, $(x,y') \in \Omega$, $\phi_e(x,y',y) \leq \bar{\phi}(x,y')$, and $W_e(\bar{\phi}(x,y'),x,y') - W_e(\bar{\phi}(x,y),x,y) \geq 0$.

   (b) $(x,y) \notin \Omega$ but $(x,y') \in \Omega$.

5. Given $v(\cdot)$, solve for the search decision $s(x)$ for all x, such that

$$s(x) = \arg\max_{s\in\{0,1\}} \left\{ b(x) - sq + s\kappa \int_{y' \in \mathcal{A}_u(x)} [W_e(\max\{w_{min}, \phi_u(x,y')\},x,y') - W_{ne}(x)] v(y') dy' \right\},$$

   where $\kappa = \frac{M(\xi,V)}{\xi V}$ and $\mathcal{A}_u(x) = \{y : (x,y) \in \Omega\}$. Update $u(\cdot)$, ξ, and κ.

6. Update $v(\cdot)$ using Eq. 12 with $\mathcal{B}_u(y) = \{x : (x,y) \in \Omega\}$ and $\mathcal{B}_e(y) = \{(x,y') : mobility(x,y,y') = 1\}$. Update κ.

7. Update value functions W_{ne}, W_e, J_f using Eq. 8, 9, and 10.
8. Update the unemployment distribution $u(\cdot)$ using Eq. 13 and the match distribution $h(\cdot, \cdot)$ using Eq. 14.
9. Evaluate the criterion function and compare the value with the pre-set tolerance level. The algorithm continues until the tolerance level is met.

E Data appendix

E.1 Sample selection

Table E.1 compares summary statistics of workers before and after sample selection based on the primary type of employment. Specifically, we consider workers primarily employed in full-time, private-sector, non-executive jobs. That is, an individual is "primarily employed in full-time, private-sector, non-executive jobs" if he holds such jobs as the primary job for at least 50% of the time throughout his entire observed employment biography. Note that the sample selection takes place at the individual level instead of the job level. Individuals selected into our sample may occasionally hold jobs that are not full-time, private-sector, and non-executive. Moreover, since we exclude executive occupations, the median and mean wages are lower after the sample selection.

E.2 Procedures to Convert Spell Data into Monthly Data

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

Correcting Missing Spell-Dates. Around 0.5% of employment spells contain 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 start and end 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.

Table E.1: Summary statistics of sample workers

Variable	(1) Non-Sample	(2) Sample
# unique individuals	112,244	301,155
% Full-time	0.813	0.904
% Private sector	0.625	0.915
% Non-executive	0.595	0.936
% Sample	0.229	0.856
Wage, 25th percentile	39.95	40.38
Wage, 50th percentile	62.13	50.13
Wage, 75th percentile	95.27	63.15
Mean wage	74.42	54.08

Notes: "Non-sample" and "sample" are both drawn from the merged DADS dataset restricted to men aged 25-64 in the years 1993-1995. "Sample" is restricted to individuals that satisfy the sample selection criteria described in Section 4 and Appendix E.1; "Non-sample" contains those not in "sample". "% Full-time", "% Private sector", "% Non-executive" are, respectively, the fractions of employment that are full-time, in the private sector, and in non-executive occupations. "% Sample" is the fraction of employment that satisfy all three requirements. Wage is the gross daily wage in euros.

Correcting Overlapping Spells. Multiple spells of the same worker at the same or different firms may overlap. About 40% of the individuals have overlapping jobs. In these cases, we need to identify a main job and define a wage. During the time window that two jobs overlap, we assume that 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.

Correcting Whole-Year Gaps. For years 1994, 2003, and 2005 many individuals are missing for the entire year but are observed 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 occur in 1.4% of sample individuals' biographies. 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 whole-year gaps in the three years can be corrected using this technique.

Transforming Spell Data to Monthly Data In the monthly data, there is one observation per individual-month. If an individual has several job spells in a given month, we use the one that occupies the largest fraction of the month.

E.3 Imputing Labor Force Status in Employment History

We use the French labor force survey *(Enquête Emploi*, hereafter *EE*), to impute the status of an individual in a gap spell in the *DADS*. Within the *EE*, we label unemployment, self-employment and non-participation spells as "non-working", with the indicator nw; these would appear as gap spells in the *DADS*. The aim is to identify the probability that a non-working spell is actually an unemployment spell using individual and job characteristics that are available in both the *EE* and the *DADS*.

The first step is to select an *EE* sample to resemble the sample in *DADS*. This entails restricting the sample to men aged 25-64 and dropping individuals who are not employed prior to and following a 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 by two employment spells. We also drop nw spells that last for more than 3 years. We then estimate the likelihood of unemployment among nw spells. We use information on the individual's age, the duration of the nw spell, and the following information of the employment spell following the nw spell: socio-professional status, industry, and an indicator for private or public sector. We denote this information by Ω_s. Using a Probit model, we estimate $P(u_s|nw_s, \Omega_s)$, where $u_s = 1$ indicates unemployment. The final step is to impute the unemployment status for gap spells in *DADS*. Based on analogous data, we 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.

We test our imputation method by imputing the unemployment status of non-employment spells in the EE data. We can correctly identify 68.99% of non-employment spells as unemployment or other non-employment; this is an improvement over a purely random assignment of the unemployment status.

E.4 Payroll tax schedules

We obtain our tax function $T(w)$ by fitting a linear spline to the relationship between simulated SSCs and the net wage. Table E.2 shows the parameters of the fitted tax function in the baseline period (January 1993 to August 1995) and in the post-reform period (1997). All wages and taxes are expressed in 2010 Euro.

Table E.2: Tax Function Parameters

	(1) Baseline	(2) 1997
p_0	-229.25	-916.72
p_1	1.050	1.676
p_2	0.799	0.915
p_3	0.821	0.841
p_4	0.842	0.882
p_5	0.778	0.840
p_6	0.585	0.639
p_7	0.601	0.625
p_8	0.601	0.608
p_9	0.615	0.606
p_{10}	0.551	0.676

Notes: The table shows the parameters of various tax functions used in this paper. All tax functions are linear spline functions with 9 nodes. Specifically, the tax function takes the form:

$$T(w) = \sum_{k=1}^{10} P_k(w)$$

where $P_1(w) = p_0 + p_1 \cdot w$ *if* $w \leq w_1$; $P_k(w) = P_{k-1}(w_{k-1}) + p_k \cdot (w - w_{k-1})$ *if* $w_{k-1} < w \leq w_k$ *for each* $k = 2, ..., 9$; *and* $P_{10} = P_9(w_9) + p_{10} \cdot (w - w_9)$ *if* $w > w_9$. *The nodes* $w_1, ..., w_9$ *are respectively 1.1, 1.3, 1.5, 1.6, 1.8, 2.0, 2.5, 3.0, and 3.5 times the minimum wage in the baseline period.*

E.5 Computing Non-Employment Benefits

Since non-employment incomes are not directly observed in the *DADS* data, we compute them based on rules governing unemployment benefits and social welfare in France. Unemployment benefits, denoted by $\tilde{b}$, depend on the average daily gross wage $\tilde{w}$ in the year preceding the unemployment spell. Specifically, $\tilde{w}$ is equal to total gross earnings divided by the number of days worked in that year. $\tilde{b}$ can then be calculated as a function of a series of observed policy parameters $\tilde{f}$, $\tilde{m}$, $\tilde{s}_0$, $\tilde{s}_1$, and $\tilde{s}_2$ as follows:

1. First, compute $\tilde{b}_0(\tilde{w}) = \max\left\{\tilde{f} + \tilde{s}_0\tilde{w}, \tilde{s}_1\tilde{w}\right\}$.
2. Then, compute $\tilde{b}_1(\tilde{w}) = \max\left\{\tilde{b}_0(\tilde{w}), \tilde{m}\right\}$.
3. If $\tilde{b}_1(\tilde{w}) = \tilde{m}$, we have $\tilde{b} = \tilde{m}$. Otherwise, $\tilde{b} = \min\left\{\tilde{b}_0(\tilde{w}), \tilde{s}_2\tilde{w}\right\}$.

Table E.3 shows the evolution of $\tilde{f}$ and $\tilde{m}$ over the relevant period. The values of $\tilde{s}_0$, $\tilde{s}_1$, and $\tilde{s}_2$ are fixed over the entire sample period from 1991 to 2008, $\tilde{s}_0 = 40.4\%$, $\tilde{s}_1 = 57.4\%$, and $\tilde{s}_2 = 75\%$. We compute unemployment benefits for each worker according to the algorithm above. We then average $\tilde{b}$ per worker bin x. b_0 and b_1 are finally determined from the regression

$$\tilde{b} = b_0 + b_1\mathfrak{h}(x) \tag{39}$$

Note that workers are eligible to receive unemployment benefits for two years (during which they are supposed to be looking for a job but in practice there is little monitoring of this conditionality). After this period, benefits are reduced to a fixed social minimum that we do not model.

F Ranking

The AKM regression is an empirical method to estimate the fixed effects of workers and firms, which are proxies for their respective productivity levels. The fixed effects can be identified on a network of workers and firms that are connected over time as workers move across firms. To estimate the AKM model, we first identify the largest connected set in our data. As described in Section 4, our data from the *DADS* contains only a 1/24 (1/12 in some years) sample of the population of workers in France. Given the relatively low frequency of job-to-job mobility, we require a longer panel to construct a reasonably large connected set, based on which we can estimate our AKM model. For this reason, we use all years that the *DADS* data is available to us, from 1988 to 2010.

Table E.3: 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 Euro (€) 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 €

Our final sample, based on which we compute data targets used for the simulated method of moments estimation, contains individuals that both satisfy our sample selection criteria laid out in Section 4 and have an estimated fixed effect. In computing data targets that are based on firm rank, we only consider firms that have an estimated AKM firm effect. In computing data targets that are not based on firm rank, we include all firms.

Tables F.1 and F.2 compare summary statistics of ranked and unranked workers and firms. We are able to estimate AKM fixed effects for a large fraction of workers and the majority of firms. Over half of the individuals who satisfy our sample selection criteria in the baseline period have an estimated worker fixed effect. About 80% of firms (that is, establishments) in our data in the baseline period have an estimated firm fixed effect, accounting for 91% of total employment. Moreover, workers and firms that have an estimated AKM fixed effect are similar in terms of their wage distribution to those without an AKM fixed effect. This reassures us regarding the representativeness of our final sample.

G Simulation Method

For each set of parameters, we solve the equilibrium model and generate a simulated panel dataset. The simulated data is based on one cohort of $100,000$ individuals and 2,000 firms whose productivity is drawn from discretized worker and firm productivity distributions, respectively. We consider a discrete time version of our model by aggregating to the monthly level. We assume that all individuals are non-employed initially. Individuals and firms make decisions regarding job search,

Table F.1: Summary statistics of ranked workers

Variable	(1) Ranked	(2) Unranked
# unique individuals	153,263	147,892
Wage, 25th percentile	39.60	41.57
Wage, 50th percentile	48.93	51.82
Wage, 75th percentile	61.54	65.32
Mean wage	52.81	55.84

Notes: "Ranked" contains individuals who satisfy our sample selection criteria and have an estimated AKM fixed effect; this is the sample based on which we compute our moments for baseline estimation. "Unranked" contains individuals who satisfy our sample selection criteria but do not have an estimated AKM fixed effect because they are not part of the largest connected set. The sample is based on the panel data from the DADS, 1993-1995. Wage is the gross daily wage in euros. See Appendix F for details.

Table F.2: Summary statistics of firms

Variable	(1) Ranked	(2) Unranked
# unique firms	173,745	48,539
Employment Share	0.913	0.087
Wage, 25th percentile	40.64	37.24
Wage, 50th percentile	52.15	48.60
Wage, 75th percentile	69.69	67.05
Mean wage	60.04	56.98

Notes: "Ranked" and "Unranked" refers to, respectively, firms that have an estimated AKM fixed effect and firms that do not. The sample is based on the panel data from the DADS, 1993-1995. Wage is the gross daily wage in euros. See Appendix F for details.

vacancy posting, wage determination, and match formation and separation according to the equilibrium solution of the model. We record individuals' labor market outcomes, including labor force participation, employment, and the firm identifier of the employer in each period. We simulate these labor market outcomes for 480 months in total. Since the initial distribution is different from the steady state distribution and the convergence to the steady state distribution is not instantaneous due to labor market frictions, we discard the first 444 months of the simulated data and keep only the last 36 months. The reason for keeping 36 months of simulated data is that it is the duration of the sample window based on which we compute our moments in the *DADS* data.

H Employment distribution before and after payroll tax reform

In this Appendix, we show changes in the observed employment distribution after the low-wage payroll tax reduction in France implemented at the end of 1995. See Section 4 and Appendix E for details on the data and sample. Specifically, we compare the baseline period (January 1993 to August 1995) to the post-reform period (January to December, 1997) and examine the changes in employment distribution across worker or firm productivity ranks defined by AKM fixed effects (see Section 5.3).

As shown in Table H.1, the post-reform employment distribution is more skewed toward less productive workers and firms. The bottom quartile of workers experience a 6% increase in the employment rate while the top quartile experiences a drop in the employment rate of similar magnitude. Similarly, the share of employment in the bottom quartile of firms increases by 10% while the share of employment in the top quartile decreases.

We do not interpret these changes as the causal effects of the payroll tax reform because we do not control for contemporaneous changes in other policies such as the minimum wage and in the macroeconomic environment. Nevertheless, the observed changes in employment distribution are consistent with our simulation results from the model (Section 6.1). In particular, we find that, due to the reform, the vacancy distribution becomes more skewed toward less productive firms and the employment rate increases significantly only among low productivity workers.

I Robustness checks

I.1 Estimation and results based on post-reform data

In this section, we estimate the model based on data and policies in 1997, which is after the payroll tax reform we consider in Section 6. We then feed the pre-reform payroll tax schedule to the

Table H.1: Post-reform employment distribution

(a) Employment rate by worker productivity

Worker productivity quartiles	Baseline (1993-1995)	Post-Reform (1997)	Change from Baseline
Q1	0.669	0.710	6.13%
Q2	0.745	0.782	4.97%
Q3	0.800	0.819	2.37%
Q4	0.861	0.812	-5.69%

(b) Employment share by firm productivity

Firm productivity quartiles	Baseline (1993-1995)	Post-Reform (1997)	Change from Baseline
Q1	0.124	0.137	10.48%
Q2	0.209	0.227	8.61%
Q3	0.359	0.357	-0.56%
Q4	0.308	0.279	-9.42%

Notes: Worker and firm productivity quartiles are based on AKM fixed effects. Employment rate is the ratio between employed workers and the population, and employment share is ratio between employment in a firm quartile and total employment.

Table I.1: Estimated Parameter Values

Parameter	(1) Post-reform sample	(2) Restricted sample
Production function and productivity distributions:		
f_0	2623.31	2489.59
γ	-0.034	-0.035
σ_x	0.328	0.252
σ_y	4.920	6.728
Search cost and meeting technology:		
q	513.43	470.63
c_0 (10^3)	298.72	306.31
c_1	12.94	16.17
s_1	0.874	0.801
m_0	2.311	2.961
Non-employment benefit:		
b_0	554.51	610.40
b_1	530.632	320.62
Bargaining power:		
α_0	0.205	0.199
$\alpha 1$	0.273	0.317

estimated model to compute the effects of removing the payroll tax reform that was implemented at the end of 1995. Despite small differences in the values of the structural parameters and the small different in the level of the minimum wage, the results in this section closely match those in Section 6.1.

Column (1) of Table I.1 shows the estimated parameter values; Table I.2 and Figure I.1 shows the fit of the model. Table I.3 and Figure I.2 show the aggregate and distributional effects of removing the payroll tax reform; the values are of similar magnitude but the opposite sign as those reported in Table 3 and Figure 3.

I.2 Estimation and results based on a more restricted sample of workers

In this section, we estimate the model based on a subsample of the data used for the baseline estimation (see Section 4). Our baseline sample includes individuals in three occupational categories: (i) intermediate professionals (*professions intermédiaires*), which is an intermediate category between

Table I.2: Model fit: Post-Reform Sample

Moment	Data	Model
Labor force participation rate	0.956	0.960
Unemp. rate	0.083	0.082
Vacancy rate	0.011	0.012
Job-to-Job vs. unemp-to-job rate	0.285	0.142
Wage distribution relative to w_{min}:		
$Pr(w \leq 1.05w_{min})$	0.116	0.050
$Pr(1.05w_{min} < w \leq 1.3w_{min})$	0.183	0.224
$Pr(1.3w_{min} < w \leq 1.6w_{min})$	0.258	0.219
$Pr(1.6w_{min} < w \leq 2.5w_{min})$	0.353	0.456

See Figure I.1 for the model fit of additional targeted moments.

Notes: see Appendix I.1 for details.

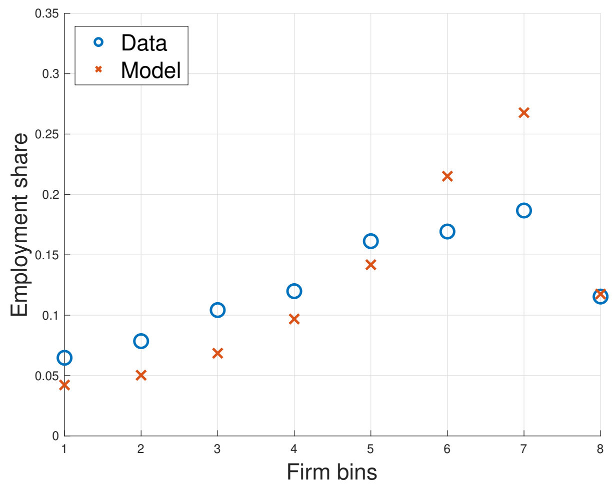
Table I.3: Simulated aggregate effects of removing the payroll tax reform in 1997

Employment	-2.17%
Total output	-1.21%
Output per job	0.99%
Consumption	-1.17%
LF participation	-2.08%
Vacancies	-1.86%
Job finding rate	-0.55%
Lump-sum transfer	-2.76%

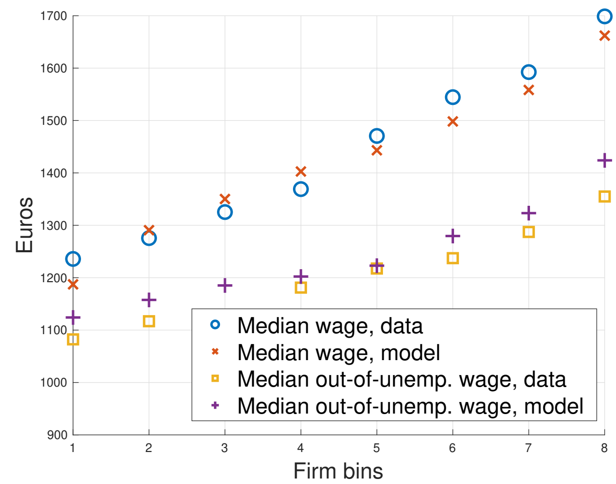
Notes: values in the table show percentage changes from the post-reform environment due to the removal of the payroll tax reform.

Figure I.1: Model Fit, continued

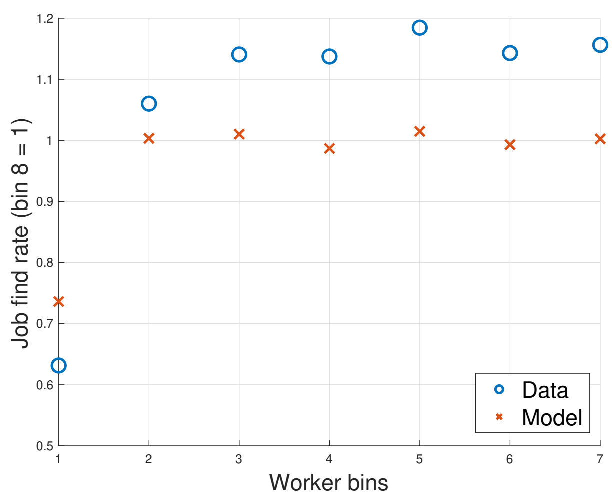
(a) Employment share by firm bins



(b) Wage by firm bins



(c) Job-finding rate by worker bins



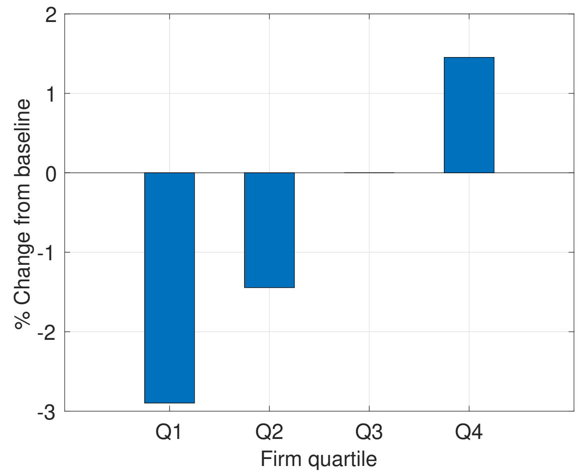
(d) Wage by worker bins

(e) Wage deciles

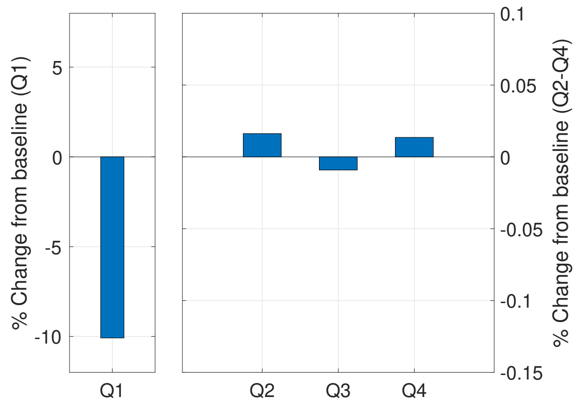
Notes: see Appendix I.1 for details.

Figure I.2: Simulated distributional effects of removing the payroll tax reform in 1997

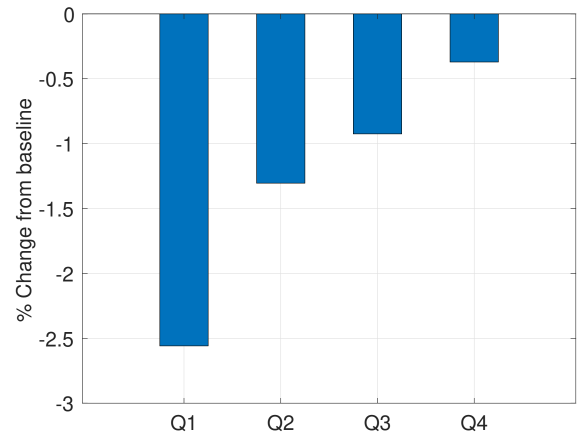
(a) Vacancy by firm productivity quartile



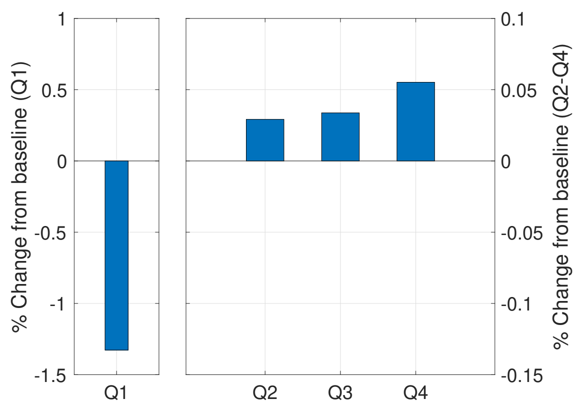
(b) Employment by worker productivity quartile



(c) Consumption by worker productivity quartile



(d) Total output by worker productivity quartile



(e) Output per job by worker productivity quartile

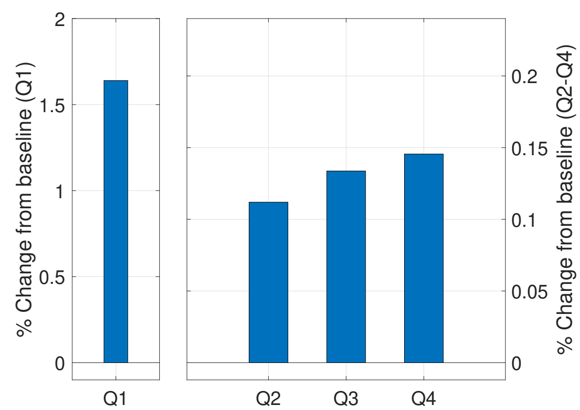


Table I.4: Model fit: Further Restricted Sample

Moment	Data	Model
Labor force participation rate	0.958	0.960
Unemp. rate	0.077	0.080
Vacancy rate	0.011	0.011
Job-to-Job vs. unemp-to-job rate	0.203	0.135
Wage distribution relative to w_{min}:		
$Pr(w \leq 1.05w_{min})$	0.112	0.048
$Pr(1.05w_{min} < w \leq 1.3w_{min})$	0.190	0.232
$Pr(1.3w_{min} < w \leq 1.6w_{min})$	0.300	0.250
$Pr(1.6w_{min} < w \leq 2.5w_{min})$	0.355	0.443

See Figure I.3 for the model fit of additional targeted moments.

Notes: see Appendix I.2 for details.

managers or executives and employees, (ii) employees (*employés*), including non-manual workers who are not a professional or manager, and (iii) laborers (*ouvriers*), or manual workers. Here, we consider a sample with only employees and laborers (categories ii and iii).

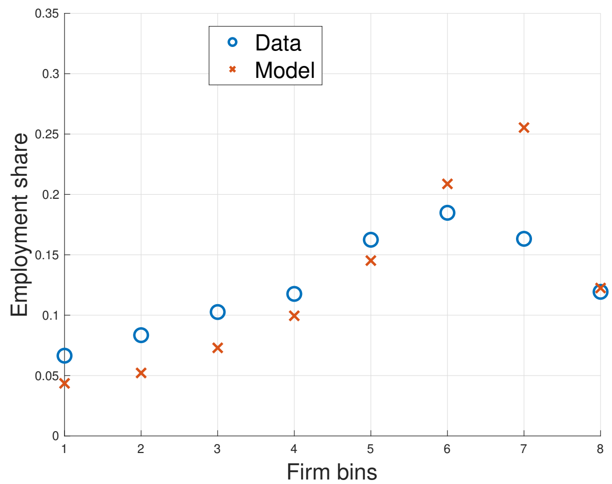
Column (2) of Table I.1 shows the estimated parameter values; Table I.4 and Figure I.3 shows the fit of the model. Because there is less worker heterogeneity in the restricted sample, the estimated dispersions of worker and firm productivity distributions are smaller compared to those from the baseline model. Other parameter values remain similar.

Table I.5 show the aggregate effects of the payroll tax reform; the values in the table closely match those from the baseline sample (Table 3). Figure I.4 shows the distributional effects of the payroll tax reform on the restricted sample, which are again comparable to those from the baseline sample (Figure 3).

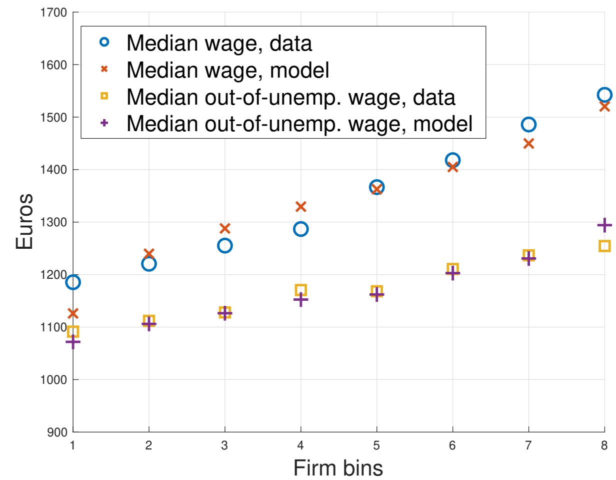
The tax reduction's unintended spillover effect on output from relatively productive workers is present, but smaller in magnitude compared to the baseline model. In particular, the bottom quartile of workers in the restricted sample contribute to a 1.39% increase in total output, but workers in the top three quartiles contribute to a 0.09% decrease in total output. Whereas the more productive workers offset the output gain of the bottom quartile by 9% in the baseline model, the offset here is 6%.

Figure I.3: Model Fit: Further Restricted Sample

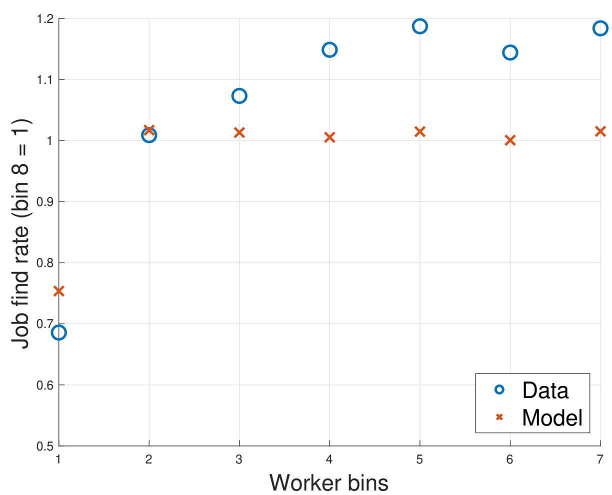
(a) Employment share by firm bins



(b) Wage by firm bins



(c) Job-finding rate by worker bins



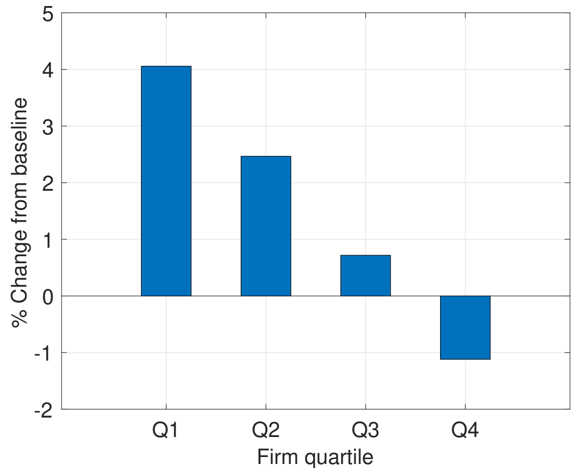
(d) Wage by worker bins

(e) Wage deciles

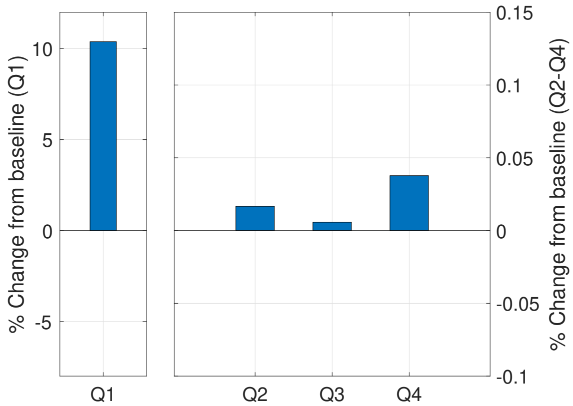
Notes: see Appendix I.2 for details.

Figure I.4: Simulated distributional effects of payroll tax reform based on restricted sample

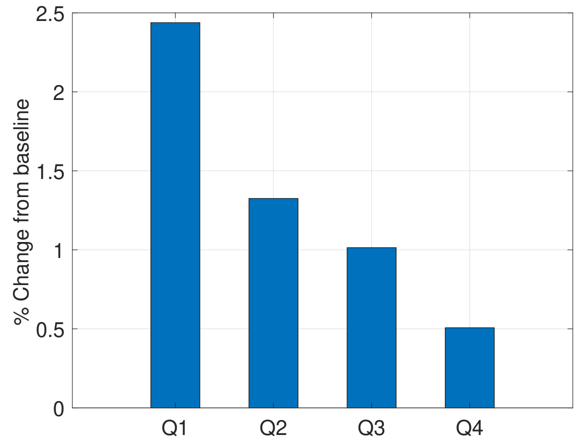
(a) Vacancy by firm productivity quartile



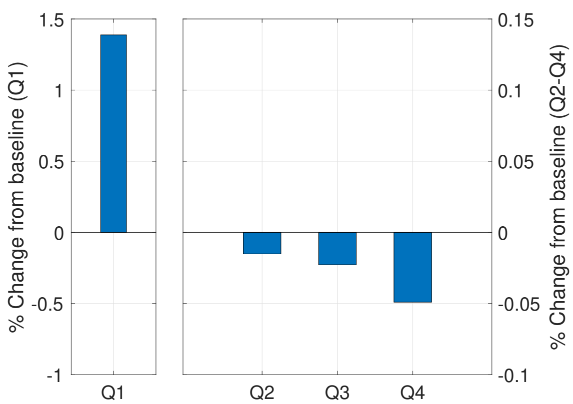
(b) Employment by worker productivity quartile



(c) Consumption by worker productivity quartile



(d) Total output by worker productivity quartile



(e) Output per job by worker productivity quartile

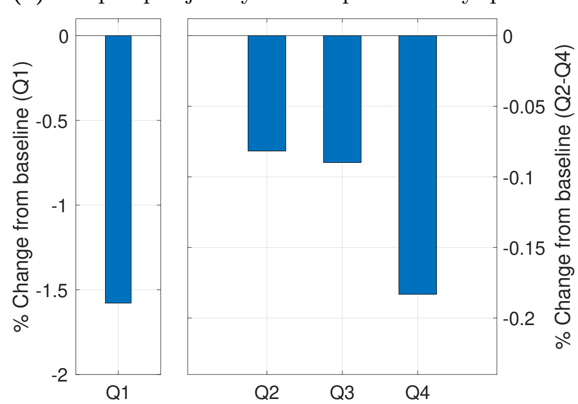


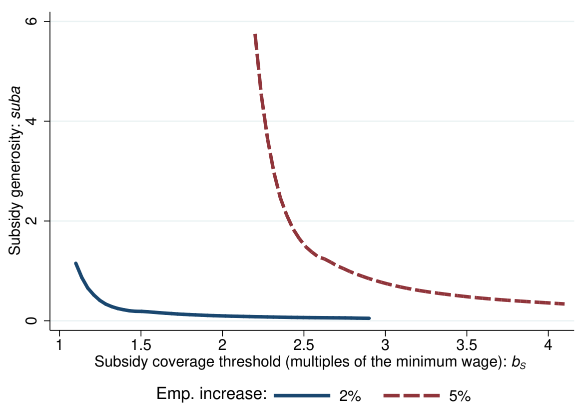
Table I.5: Simulated aggregate effects of payroll tax reform based on restricted sample

Employment	2.26%
Total output	1.29%
Output per job	-0.95%
Consumption	1.23%
LF participation	2.08%
Vacancies	2.88%
Job finding rate	1.82%
Lump-sum transfer	1.12%

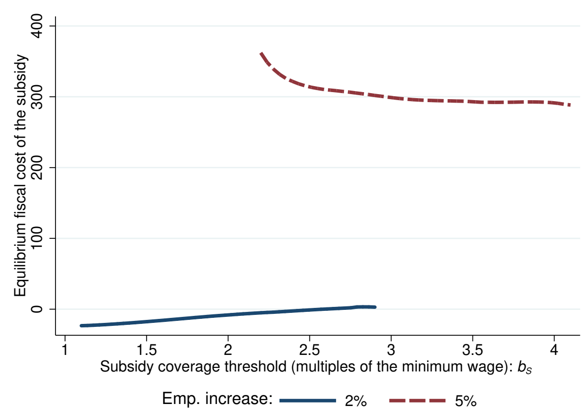
Notes: values in the table show percentage changes from the post-reform environment due to the removal of the payroll tax reform.

Figure J.1: Subsidy generosity and fiscal cost by employment target and subsidy coverage

(a) Generosity of subsidy programs



(b) Fiscal cost



J Addition Figures for Optimal Design of Payroll Tax Reductions

Figure J.1 shows that for each subsidy coverage ($b_{\mathcal{S}}$), the generosity ($a_{\mathcal{S}}$) that is required to achieve the set employment increase and the associated fiscal cost (or fiscal surplus if negative) in equilibrium. To achieve the same level of employment increase, a narrower subsidy (lower $b_{\mathcal{S}}$) must be more generous (higher $a_{\mathcal{S}}$). A higher employment rate means to a larger tax base and fewer benefit recipients, allowing the government to offset the direct cost of giving the payroll subsidies. Subsidy programs that achieve a 2% employment increase are largely self-financed; those that increases employment by 5% generates a fiscal cost that decreases with the breadth of the coverage ($b_{\mathcal{S}}$).