Labor Market Responses to Payroll Tax Reductions*

Thomas Breda† Luke Haywood‡ Haomin Wang§

June 3, 2019

Abstract

Payroll tax reductions are a popular tool to lower the minimum labor cost and encourage employment and job creation. Effects of these tax reductions go beyond the directly affected. A particular concern about such policies is that more productive jobs may be replaced with less productive ones. We examine payroll tax reductions using an equilibrium search-and-matching model estimated using French administrative data. We find that lowering taxes on low-paid work induces workers to enter the labor market who otherwise prefer not to participate and low-productivity firms to post more vacancies. These worker and firm reactions lead to congestion in the labor market, slower job-finding and lower employment among high-skill workers thereby potentially negatively affecting aggregate production. For a given budget, restricting payroll tax reductions to minimum wage jobs rather than reducing taxes for a wide range of jobs is more beneficial to low-skill workers, but is accompanied by stronger negative spillovers for high-skill workers. Taking this trade-off into account, we determine the optimal targeting of payroll tax reductions.

Keywords: Payroll Tax, Minimum Wage, Job Search, Productivity Distribution

JEL Classification: J64, E24, H24, J38

*We would like to thank François Fontaine, François Langot, Jean-Marc Robin, John Kennan, Rasmus Lentz, Robert A. Miller, Matthew Wiswall, Naoki Aizawa, Xiaodong Fan, and seminar and workshop participants at the Paris School of Economics, the University of Wisconsin-Madison, DIW Berlin, Australia National University, Monash University, University of Potsdam, *Rencontres d'Aussois*, and DTMC conference on markets with search frictions for their comments and insights. We are grateful for funding through the DFG grant "Labour market responses to taxes: a structural approach" (project HA 7464/1-1).

†Paris School of Economics, CNRS, and Institut des Politiques Publiques. Address: 48 Boulevard Jourdan, 75014 Paris, France. Email: thomas.breda@ens.fr.

‡Mercator Research Institute on Global Commons and Climate Change (MCC Berlin) and DIW Berlin. Address: Torgauer Straße 12-15, 10829 Berlin, Germany. Email: haywood@mcc-berlin.net.

§Department of Economics, University of Konstanz. Address: Universitätsstraße 10, 78464 Konstanz, Germany. Email: haomin.wang@uni-konstanz.de.

1 Introduction

Payroll tax reductions for low-wage jobs are a popular tool to boost job creation and expand the employment opportunities for low-skill workers. By lowering payroll taxes, policy makers relax the constraint that statutory minimum wages impose on labor costs without reducing the minimum net income for workers. Evaluations of low-wage tax reductions have mainly focused on workers who are directly targeted. However, there are potential spillover effects on workers in higher-paid jobs whose employment opportunities and wages may be impacted. The spillover effects can be driven by labor market competition between different workers or changes in labor demand. In this paper, we ask two questions. First, are spillover effects quantitatively large enough to impact employment and aggregate production output? Second, what is the optimal design of a tax reduction policy that aims to create significant employment opportunities for targeted workers while limiting negative spillover effects on other workers?

To answer these questions, we construct and estimate an equilibrium model in which ex-ante heterogeneous workers and firms are brought together pairwise via a Diamond-Mortensen-Pissarides (DMP) matching function. We assume that the wage determination mechanism follows Dey and Flinn (2005) and Cahuc et al. (2006), where employers engage in sequential auctions for workers and wages are determined by bargaining over the after-tax match surplus. In equilibrium, productivity and wage distributions depend on two labor market policies: payroll taxes and a minimum wage. Payroll taxes distort bargaining outcomes by reducing the potential match surplus. In addition, as in Flinn (2006), the statutory minimum wage acts as a side constraint to the bargaining problem that effectively shifts the match surplus toward minimum-wage workers.

In our model, low-wage payroll tax reductions have direct effects on low-skill workers by increasing their match surplus, thereby expanding the set of firms that are willing to hire them. Meanwhile, the tax reductions have spillover effects on other workers for two reasons. The first reason is that job-seeking workers compete with one another for opportunities to meet potential employers.[1] Since a low-wage tax reduction promotes labor force participation of low-skill workers, it creates congestion that reduces meeting opportunities for all workers, including the high-skill ones. The second reason for spillovers concerns equilibrium labor demand responses to policy changes. Specifically, we allow firms that are heterogeneous in productivity to optimally set the number of posted vacancies in equilibrium. A low-wage tax reduction typically incentivizes low-productivity firms to open more vacancies, which also creates congestion by crowding out the meeting opportunities with high-productivity firms for workers.

[1]We assume a standard DMP matching technology where job-seekers' meeting rate negatively depends on the number of job seekers.

Spillover effects have implications for the aggregate production output; if workers and firms are highly complementary in the production process, negative spillover effects that limit high-skill workers' employment opportunities can give rise to strong reductions in average job productivity.[2] The goal of the paper is to quantitatively assess the consequences of payroll tax policies considering both direct and spillover effects in equilibrium.

We apply our model to studying payroll tax reductions in France. France has one of the highest minimum wages and one of the highest payroll taxes (or, employer social security contributions) among OECD countries.[3] The combination of a high minimum wage and high payroll taxes is often regarded as a cause for low employment levels in France.[4] When downward adjustments of the minimum wage is politically unattractive, the combination of high labor costs and an unemployment rate of over 10% in the early 1990s motivated a series of reforms to reduce employer contributions for low-wage jobs. These reductions have been progressively increased and extended to more workers; they are still in place today.

We estimate our model based on French social security records (*Déclarations Annuelles de Données Sociales,* henceforth *DADS*). We focus on men aged 30 to 55 who are primarily employed in full-time, private sector, non-executive jobs.

Executives (*cadres* in the French list of occupations) include occupations such as business managers, professionals, or artists. About a quarter of the French workforce belong to these occupations. We exclude them because they are barely in competition for jobs with workers in other occupations. In doing so, we restrict the analysis to a more homogenous group of workers who are plausibly in competition with one another for labor market opportunities, as our model assumes.

We estimate the structural parameters of the model via Simulated Method of Moments. Central to our empirical analysis are parameters governing productivity distributions of workers and firms and the production complementarity. To identify these parameters, we target moments by individual and firm productivity levels. Computing these moments requires a ranking step, for which we select individual- and firm-level statistics constructed from wages that are, according to our model, monotone in individual and firm productivity levels respectively.

Based on the model estimated on the period January 1993-August 1995, we simulate the first payroll tax reductions that took place in France between late 1995 and 1997. According to our simulation, in equilibrium, employment increases by 2.5% and aggregate production increases by 1.2%. These results are in line with the findings of Crépon and Desplatz (2003) and Chéron et al.

[2]Job productivity is jointly determined by worker and firm productivity levels.
[3]See Section 2 for further details.
[4]This is in part because the legal minimum wage is defined net of employer contributions, implying that these contributions are necessarily incident on firms at the minimum wage.

(2008). We find substantial spillover effects. The employment rate declines by 0.6% among workers in the top productivity quartile, which is accompanied by a 2.1% increase in labor force participation of low-productivity workers and a 4.8% increase in vacancies from low-productivity firms. If high-productivity individuals were not impacted by the low-wage payroll tax reduction, aggregate production would have increased by 1.4% instead of 1.2%.

Compared to a policy that offers tax reduction for a wider range of jobs, a generous payroll tax reduction that specifically targets low-wage jobs is more redistributive toward less productive workers, but it is also more likely to create negative spillover effects on more productive workers and therefore more likely to reduce aggregate productivity. Using our estimated model, we study the optimal design of payroll tax reductions while taking this efficiency-equity tradeoff into account. We examine alternative tax reduction programs that grant the highest tax reduction to minimum wage jobs and phase out linearly for higher wages at different rates.[5] Our results show that tax reductions can even result in a drop in aggregate production due to a lower average job productivity despite an increase in employment. Adopting a social welfare criterion that accounts for both aggregate consumption and inequality, we find that the optimal way of achieving a substantial increase in equilibrium employment requires tax reductions that are not strongly targeted and therefore benefit a wide range of jobs.

We contribute to a small but growing literature that studies labor taxes using equilibrium job-search models. Chéron et al. (2008) and Shephard (2017) assume that individuals are ex-ante homogenous. We complement them by considering both worker and firm heterogeneity and structurally estimating the degree of complementarity between workers and firms in the production technology. Estimating the degree of complementarity in production is important for determining the extent of the spillover effects of low-wage payroll tax reductions. In addition, by taking into account differences in worker productivity, we can study the redistributive effects of tax policies.

Chéron et al. (2008) is closest to our paper as they also study the equilibrium distortionary effects of French payroll tax reductions. They highlight a quantity-quality tradeoff of payroll tax reductions: On the one hand, lower taxes reduce labor costs and lead to more employment opportunities; on the other hand, there is more job turnover which discourages firms from investing in specific human capital. In our model, a similar quantity-quality tradeoff is present but arises from different channels. Although firms in our model do not make human capital investment decisions, low-wage payroll tax reductions shift the equilibrium distribution of job productivity to the left through changes in the productivity distribution of job seekers and vacancies.[6] In assessing alternative payroll tax reductions, Chéron et al. (2008) differ from our paper in that they consider policies with the same

[5]We make these programs budget neutral by redistributing any surplus as a lump-sum transfer, and impose them to raise employment to a fixed target level.

[6]One can view the productivity levels associated with a vacancy as firm's capital investment, similar to Acemoglu (1999). In our model, although the firms cannot change the capital investment level of their vacancies, they can post

ex-ante fiscal cost whereas we consider policies with the same equilibrium employment effects. We show that ex-ante fiscal costs, which are computed based on employment and wage distributions before the economy transitions to the new steady state, can be vastly different from ex-post, or equilibrium, fiscal costs.

Our methodological contribution is to offer a numerically tractable model to study the effects of payroll taxes on equilibrium job productivity and wage distributions in the presence of a minimum wage. Because workers' and firms' incomes are taxed differentially, utility is not perfectly transferable between workers and firms as in a standard DMP framework even though all agents are risk-neutral.[7] As a result, the wage of a match cannot be expressed as an exogenous share of the gross value of the match as in Cahuc et al. (2006) because the exact share depends the wage. Moreover, sorting arises in equilibrium as certain worker-firm matches are not viable due to a high minimum wage, high taxes, or high non-employment benefits. Although these features of our model prevent us from seeking an analytical solution, the model can be solved numerically.

Our finding that a low-wage payroll tax reduction substitutes employment opportunities for high-productivity workers with those for low-productivity workers is supported by empirical evidence. Crépon and Desplatz (2003) examine the effects of French payroll tax reductions in the mid-1990s on firm-level decisions, and find that it leads to lower average labor cost, higher shares of unskilled workers, and a decrease in the productivity of capital and labor in most sectors.[8] We provide a more direct validation of our results by comparing the predictions of our estimated model with the actual evolution of the French labor market around the period of the tax reduction. Consistent with key model predictions, we observe employment growth is concentrated among the least productive workers and firms.

Our study of a policy that reduces the minimum labor cost has implications beyond France. A binding minimum labor cost has become increasingly prevalent worldwide. Germany introduced a minimum wage in 2015. In 2016, the U.K. has started to implement a gradual increase of its minimum wage by 40% over 5 years. In the U.S., states and municipalities have imposed local minimum wages that are substantially higher than the federal one. Seattle is one example. The city has raised its minimum wage from $9.47 to $13 in 2016, and will continue to raise it to $15 by 2021.[9] The combination of a relatively high minimum wage – guaranteeing people to get a minimal

more or less vacancies depending on the likelihood of meeting a suitable worker and the expected returns of posting a vacancy.

[7] Burdett and Wright (1998) is one of the few papers considering non-transferrable utility in a DMP framework.

[8] Based on reduced-form estimates, Rothstein (2008) and Leigh (2010) find that the Earned Income Tax Credit (EITC), a tax reduction program that targets low-income working individuals in the U.S., negatively affects wages for low-productivity workers who do not participate in the program. Azmat (2019) finds similar spillover effects from the Working Family Tax Credit (the UK payroll tax reduction program).

[9] For an analysis of the Seattle minimum wage, see Jardim et al. (2017).

revenue from their work – with targeted payroll tax reductions that limit the effects of the minimum wage on the labor costs is a policy mix that is likely to gain interest in the coming years.

The rest of the paper is organized as follows. In Section 2, we give an overview of the institutional background related to payroll tax reductions in France. In Section 3, we present the search and matching model and characterize the steady state equilibrium. We describe the data we use to estimate the model in Section 4 and discuss our estimation strategy and results in Sections 5 and 6. In Section 7, we compare the equilibrium effects of different tax reduction coverages and simulate the welfare implication. Finally, we conclude in Section 8.

2 Institutional Background

Our modeling choices are tailored to study the reductions in payroll taxes in France. We therefore start with a quick presentation of the institutional context and the reforms we study.

Earnings and minimum wage concepts There are three main types of contributions or taxes levied on labor income: employer Social Security Contributions (SSCs), nominally paid by employers; employee SSCs, nominally paid by employees; and income taxes, paid on both labor and capital income. We define labor cost as the total cost of employing a worker. This cost includes employer and employee SSCs as well as the income tax. The gross wage, or posted wage, then corresponds to the labor cost net of employer SSC, but including employee SSC and income tax.[10] Gross wage is the wage concept stipulated on contracts and constitutes the basis for individual or collective wage bargaining. The net wage is equal to the gross wage minus employee SSC. Finally, disposable labor income is income from which employee SSCs and income tax have been subtracted.

To compute the income taxes for a given worker, one needs to make assumptions about the amount of household earings, its composition (labor and capital income) and how household members share the tax burden. Such assumptions are always debatable. As 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), we ignore it and assume that labor supply decisions and search behavior depend on the net wage rather than disposable income.

[10]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.)

In general, the legal distinction between employer and employee SSCs does not affect the economic incidence as employers care about labor costs while employees care about net wages. However, the legal minimum wage is expressed as a gross minimum wage, meaning that it is net of employer SSCs but gross of employee SSCs. This imposes a constraint on the effects of SSC changes around the minimum wage. In particular, it implies that increases in employer SSCs are mechanically shifted to employers while reductions in employee SSCs are captured by employees at the minimum wage. In this paper, we study reductions in employer SSCs. These reductions nominally benefit employers, but nothing prevents workers from partly capturing them in equilibrium through adjustments in net wages. Over the period we study, employee SSC remains almost constant, implying that their nominal incidence does not need to be modeled because it will not play any role for the response to the reforms we study. Therefore, we focus on total SSCs in our model while taking the minimum net wage as fixed.[11] This leaves us with only two wage concepts - the wage net and gross of total SSCs.[12]

Tax-benefit linkage 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 a third of total contributions, can be considered as taxes. By contrast, the contributions funding unemployment insurance and pension schemes are partly linked to entitlements, although the link is often weak (see Bozio et al. (2017) for details). Most importantly, the reforms we study only change contributions and are not linked to changes in entitlements. This is why we do not model the linkage between contributions and benefits.

Computation and magnitude of SSCs in France in the absence of reductions In recent years, SSCs represent around 37% of total French tax revenues and 17% of French GDP, highest among OECD countries. The tax base is gross earnings below a contributions cap. Historically, this cap was low enough to affect most workers' contributions. However, contributions have been progressively uncapped in the 1970s and 1980s, so that by the early 1990s they represented around 45% of the labor cost for almost all workers.[13] For example, in 1993, the net statutory monthly minimum wage was 912 Euros (in 2010 Euros), with SSC at the minimum wage of around 750 Euros.

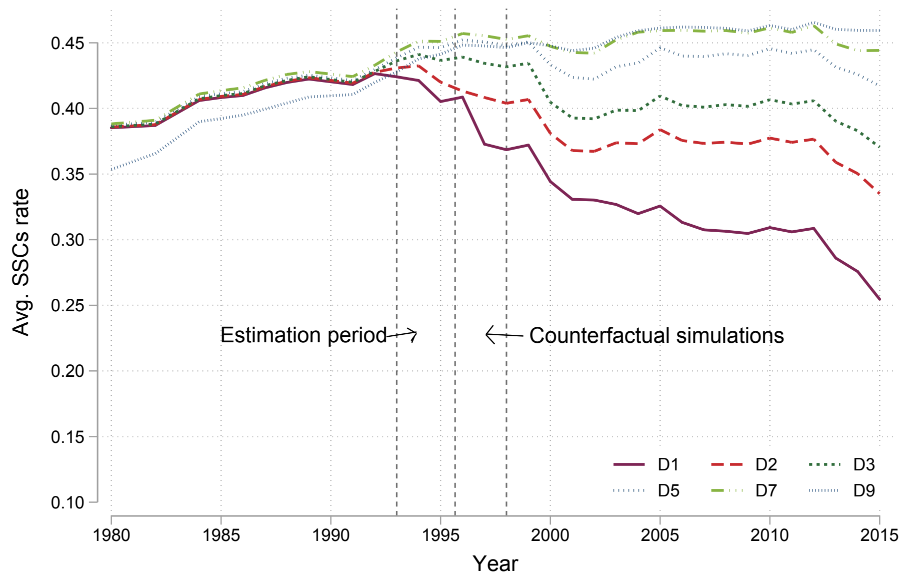
[11] We transform the gross minimum wage into a net minimum wage by subtracting employee SSCs paid at the minimum wage.

[12] Note that we use the U.S. terminology "payroll taxes" interchangeably with the term SSCs.

[13] Those at the very top of the distribution still benefit from a cap at the highest threshold which is around the 99.95th percentile, see Bozio et al. (2016).

Figure 1: Social Security Contributions.

(a)



Source: DADS 1980-2015. Full-time workers only. Data provided by Bozio, Breda and Guillot (2016).
Note: The figure provides the ratio of the average total social security contributions (employer and employee part) to the average labour cost in six deciles of the labour cost distribution.

(b)

Source: Tax simulator TAXIPP (Jelloul et al., 2018).
Note: 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.

Reductions of employer SSCs around the minimum wage starting in the 1990s From 1990 to 1994, the French unemployment rate rose from 8% to about 11%. The combination of an already high gross minimum wage with an increasing level of employer SSC increased the cost of employing a worker at the minimum wage by 40% and was seen as a major concern for employment. In a political context where the minimum wage cannot be easily adjusted downward, reducing employer SSCs for low-wage earners appeared as an appealing solution to lower the labor cost of low-wage earners. Three consecutive public reports called for such reductions in the early 1990s, which were eventually implemented in July 1993. First modest reductions took place from July 1993 to August 1995 with reductions in SSC payments by 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. In September 1995, the so-called *Ristourne Juppé* strongly increased the value of SSC reductions to 18% of the gross wage for minimum wage earners, with a phase-out for individuals earning more than 1.33 times the minimum wage. Since part of our data starts in 1993, we cannot study the presumably small effects of the first reductions. Instead, we neglect these effects and assume that the economy is in steady-state during the period between July 1993 and August 1995 to estimate our model with data from that period. We then evaluate the effect of the *Ristourne Juppé*. Larger reductions followed in the early 2000s but they were first conditional on the adoption of the policy that reduced working time to 35 hours a week by the social partners in the firm. This feature makes it difficult to study the more recent reductions, explaining our choice to focus on those that were implemented in the mid-1990s in line with most of the previous literature.[14]

3 Model

In this Section, we describe an equilibrium model with heterogeneous individuals and firms who are brought together via a DMP matching function. Individuals make job search decisions whereas firms make vacancy posting decisions. Matches are bilateral and are formed when it is profitable for the worker-firm pair. We also discuss the implications of a statutory minimum wage and payroll taxes for the steady state equilibrium.

3.1 Environment

We normalize the population of risk-neutral individuals to a unit measure. We index individuals by x according to the rank of their productivity level, so that x is uniformly distributed in the interval $[0, 1]$. Time is continuous and individuals live infinitely.

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

Non-employed individuals can choose to participate in job search by paying a flow cost q. Non-employed individuals who search are classified as unemployed and those who do not search are classified as non-participants. The search cost captures the difference between the discomfort of search and the stigma of not looking for jobs. Employed workers search on-the-job at zero cost.[15] The difference between on- and off-the-job search is captured by the difference in search intensity; we normalize search intensity to 1 for unemployed workers and let employed workers' search intensity be s_1.[16] Employed workers supply an indivisible unit of labor.[17]

On the other side of the labor market, 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 over $[0, 1]$. Similar to the participation decision of workers, firms choose to stay active by posting vacancies. The cost of posting $v(y) > 0$ vacancies is $c(v(y))$. The lower bound of the set of active firms, $y_l \in [0, 1]$, is endogenously determined in equilibrium.

Let E, U, and NP, with $E+U+NP = 1$, denote the measures of the workers that are, respectively, employed, unemployed, and non-participating in the labor force. The set of non-employed is defined as $NE \equiv NP + U$. Let $u(x)$ denote the measure of unemployed workers of type x such that $\int_0^1 u(x)dx = U$. The aggregate search intensity in the labor market is denoted by $\xi = U + s_1 E$. The total measure of vacancies across all firms is $V = \int_0^1 v(y)dy$.

Job seekers and firms are brought together pairwise via an aggregate meeting technology *à la* Diamond-Mortensen-Pissarides (DMP). The undirected search assumption implies that individuals cannot target whom they meet when searching for jobs. Given the aggregate search intensity ξ and the total measure of vacancies V, $M(\xi, V)$ represents the flow measure of contacts between individuals and job vacancies. We assume that the meeting technology is constant returns to scale and takes the following form:

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

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.

Upon meeting each other, an individual and a firm form a match if the two parties find a wage that is mutually agreeable. We consider two labor market policies that influence the determination of match formation and wages. The first is a statutory wage floor on net wages, w_{min}. The second is a tax on net wages $T(w)$, which includes employer and employee SSCs. We assume that $T(\cdot)$ is differentiable and $T'(w) \in (0, 1)$ for all w. This accommodates a wide range of tax functions,

[15] 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.

[16] Alternatively, the deviation of s_1 from 1 can be interpreted as a difference in search efficiency between employed and unemployed workers. The specific interpretation is irrelevant as far as the model is concerned.

[17] We do not consider hours choice in this paper and focus on full-time workers in our empirical applications.

particularly ones with non-monotone marginal tax rates. We describe match formation and wage determination in detail in Sections 3.2 and 3.3. When matched, a worker-firm pair (x, y) produces $f(x, y)$ output per unit of time 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 wages and taxes.

Non-employed workers receive flow income $b(x)$ regardless of their job search decision, where $b'(x) \geq 0$. We view $b(x)$ as non-employment transfers, which, in practice, are linked to previous wages. For tractability, we let non-employment income depend solely on x so that individuals' job search decision is time-invariant.[18]

The measure of filled jobs, or matches, of type (x, y) is given by $h(x, y)$, and the total measure of matches is equal to the measure of employed workers; that is, $E = \int_0^1 \int_0^1 h(x, y) dx dy$. 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 the subjective discount rate r.

3.2 Meetings involving non-employed individuals

When a non-employed individual is approached by a recruiting firm, the worker-firm pair first determines a provisional wage by bargaining over the match surplus, where match surplus is defined net of taxes. Then, the pair compares the provisional wage to the statutory minimum wage and determines if a match is viable.

More specifically, we use $W_e(w, x, y)$ and $J_f(w, x, y)$ to denote the present values of a match of wage w to worker x and firm y respectively. When non-employed workers meet a potential employer, their outside option is the value of non-employment $W_{ne}(x)$. The firm's outside option is the value of an unfilled position $J_u(y)$. We derive the value functions below. The surplus of a match between non-employed worker x and firm y at wage w is the total value of the match of the worker-firm pair net of the values of their respective outside options. The surplus is given by

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

In general, utility is not perfectly transferable between the worker and the firm because the amount of taxes depends on the wage. To ensure a unique bargaining solution, we assume that the match

[18] We implicitly assume that payroll-tax reductions do not affect non-employment incomes. Note that the rule for calculating non-employment income may change if a policy change affects tax revenue. However, as we discuss in Section 2, the link between social security contributions and benefits is weak. In particular, the payroll tax reduction we study is not accompanied by modifications to benefit entitlements for workers.

surplus is split so that each party receives a proportion of the surplus according to her bargaining power, which is α and $1-\alpha$ for workers and firms respectively.[19]

Formally, the wage bargaining outcome ϕ must satisfy the following system:

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

In Appendix B.1, we use the value functions defined in Section 3.5 to show the following proposition.

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

Proposition 1 implies that $\frac{W_e(\phi,x,y)-W_{ne}(x)}{S(\phi,x,y)}$ monotonically increases with ϕ, so that we can rule out multiple solutions to the wage bargaining problem. If ϕ exists, the worker-firm pair proceeds to the second step of wage determination that involves the minimum wage w_{min}. The minimum wage influences wage determination in the same way as in Flinn (2006): If $\phi \geq w_{min}$, a match is immediately realized. If $\phi < w_{min}$, a match is only realized if both workers and firms agree to match at this 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 a worker x can form a viable match, such that

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

If a match is viable, the wage of the match is $\phi_u(x, y) = \max\{\phi, w_{min}\}$. Proposition 1 implies that the minimum wage effectively shifts the match surplus toward workers who would otherwise earn less than the minimum wage. This shift of the surplus due to the minimum wage will more likely happen when workers have little bargaining power.

[19] Without labor income taxes, Nash bargaining and proportional bargaining lead to identical wage solutions. However, in our model, utility is not perfectly transferable between the worker and the firm because a marginal increase in wage leads to a decrease in the net surplus. This causes the solutions of the two bargaining schemes to diverge (l'Haridon et al., 2013; Jacquet et al., 2014). Appendix A shows that under Nash bargaining we may encounter multiple solutions if the marginal tax rate is not monotonically increasing. The insight is that a scenario of a low wage combined with high marginal tax rate may render the same Nash surplus as a scenario with a high-wage and a low marginal tax rate. Given that our marginal tax rate is not monotonically increasing, we opt for the proportional bargaining scheme for simplicity.

3.3 Meetings involving employed workers

When an employed worker is approached by a recruiting 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 for the worker, which is then followed by a wage negotiation between the worker and the highest bidder of the auction.

Define $\bar{\phi}(x,y)$ as the maximum potential wage of a match (x,y) such that

$$\begin{aligned} \bar{\phi}(x,y) &= \arg\max_{w} W_e(w,x,y) \\ \text{subject to} \quad & J_f(w,x,y) - J_u(y) \geq 0. \end{aligned} \tag{5}$$

An auction takes place if the poaching firm y_1 is able to pay the minimum wage, that is $\bar{\phi}(x,y_1) \geq w_{min}$. We use y and y' to denote the two firms involved in an auction without specifying incumbency. Firm y outbids y' if and only if $W_e(\bar{\phi}(x,y),x,y) \geq W_e(\bar{\phi}(x,y'),x,y')$. If the incumbent firm outbids the poaching firm, the worker remains in her current firm. In this case, the worker renegotiates her wage with her current employer if the losing bidder could have made the worker better-off compared to her current state. In other words, wage bargaining takes place if $W_e(\bar{\phi}(x,y_1),x,y_1) \geq W_e(w_0,x,y_0)$, where y_0 and w_0 are worker x's current employer and wage, respectively, and the worker's outside option is $W_e(\bar{\phi}(x,y_1),x,y_1)$. If, instead, the poaching firm outbids the incumbent, the worker transitions to the poaching firm and bargains with it using $W_e(\bar{\phi}(x,y_0),x,y_0)$ as her outside option. The surplus of a match between a firm y and an employed worker x is given as:

$$S_e(w,x,y,y') = W_e(w,x,y) - W_e(\bar{\phi}(x,y'),x,y') + J_f(w,x,y) - J_u(y) \tag{6}$$

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

$$\begin{cases} W_e(\phi,x,y) - W_e(\bar{\phi}(x,y'),x,y') = \alpha S_e(\phi,x,y,y') \\ S_e(\phi,x,y,y') \geq 0 \end{cases} \tag{7}$$

If ϕ exists, the match is formed and the wage $\phi_e(x,y,y') = \max\{\phi, w_{min}\}$ is agreed upon if the match (x,y) is viable given ϕ. Let $\mathcal{A}_e(x,y_0)$ be the subset of firms that can poach worker x from firm y_0, such that

$$\mathcal{A}_e(x,y_0) = \left\{ y \in [0,1] \,|W_e(\bar{\phi}(x,y),x,y) > W_e(\bar{\phi}(x,y_0),x,y_0) \right\}. \tag{8}$$

3.4 Value of Non-Employment and Job Search Decision

If a non-employed worker decides to conduct job search, she pays cost q and meets a vacancy at rate $\kappa(\xi, V)V$. The value of non-employment, W_{ne}, is defined as follows:

$$rW_{ne}(x) = \max_{s\in\{0,1\}} \left\{ b(x) + s\left[\kappa(\xi, V)\int_{y'\in\mathcal{A}_u(x)} v(y')\left[W_e(\phi_u(x, y'), x, y') - W_{ne}(x)\right] dy' - q\right]\right\} \quad (9)$$

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.[20]

3.5 Value of Employment and Filled Positions

An employed worker faces exogenous separation shocks that arrive at rate δ. If the match continues, the employed worker meets a vacancy at rate $s_1\kappa(\xi, V)V$. The value of employment is defined as follows:

$$\begin{aligned}[r + \delta + s_1\kappa(\xi, V)V]W_e(w, x, y) &= w + \delta W_{ne}(x) \\ &+s_1\kappa(\xi, V)\textstyle\int_{y'\in\mathcal{A}_e(x,y)} W_e(\phi_e(x, y, y'), x, y')v(y')dy' \\ &+s_1\kappa(\xi, V)\textstyle\int_{y'\in[0,1]\setminus\mathcal{A}_e(x,y)} \max\left\{W_e(\phi_e(x, y', y), x, y), W_e(w, x, y)\right\} v(y')dy'\end{aligned} \quad (10)$$

Proposition 1 implies that, conditional on having the same employer, a worker always prefers a higher wage. Therefore, the wage of a continuing match (x, y) with wage w is $\max\{\phi_e(x, y', y), w\}$.

In a match, the firm collects the match output and pays the wage and the payroll tax. Match outputs depend on the productivity levels of the worker and the firm involved in the match.[21] The value of a match (x, y) to the firm is defined as follows:

$$\begin{aligned}[r + \delta + s_1\kappa(\xi, V)V]J_f(w, x, y) &= f(x, y) - w - T(w) + \delta J_u(y) \\ &+s_1\kappa(\xi, V)J_u(y)\textstyle\int_{y'\in\mathcal{A}_e(x,y)} v(y')dy' \\ &+s_1\kappa(\xi, V)\textstyle\int_{y'\in[0,1]\setminus\mathcal{A}_e(x,y)} J_f(\max\left\{\phi_e(x, y', y), w\right\}, x, y)v(y')dy'\end{aligned} \quad (11)$$

Proposition 1 also implies that, for any given worker, a firm always prefers a lower wage. As we show in Appendix B.1, this requires that $T'(w) > 0$.

[20] 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.

[21] Note that there is no complementarity between workers within a firm, which is a common assumption made in the literature for tractability. As we explain in section 4, we exclude highly skilled individuals from our sample in the empirical analysis, and therefore the assumption of no complementarity is plausible.

3.6 Vacancy Creation

The present value of a vacant position to a firm is defined by

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

Following Lise and Robin (2017), we assume that each firm buys the advertising of vacancies from job placement agencies.[22] We assume that the marginal cost of posting v vacancies of type y takes the following form:

$$c'(v(y)) \quad = \quad c_0 v^{1/c_1} \tag{13}$$

with $c_0 > 0$ and $c_1 \in (0, 1]$. This is consistent with the typical assumption of convex costs and guarantees a non-degenerate distribution of vacancies.

Let $\mathcal{B}_u(y) = \{x : s(x) = 1 \text{ and } y \in \mathcal{A}_u(x)\}$ be the set of unemployed workers x with whom firm y can form a match. Similarly, let $\mathcal{B}_e(y) = \{(x, y') : s(x) = 1 \text{ and } y \in \mathcal{A}_e(x, y')\}$ be the set of matches from which firm y can successfully poach a worker. If $\mathcal{B}_u(y) = \emptyset$ and $\mathcal{B}_e(y) = \emptyset$, firm y has no chance of filling a job opening and would set $v(y) = 0$. Otherwise, the firm determines the number of vacancies by equating the marginal cost to the expected value of a job opening,

$$c'(v(y)) = \kappa(\xi, V) \int_{x \in \mathcal{B}_u(y)} J_f(\phi_u(x,y), x, y)] u(x) dx \\ + s_1 \kappa(\xi, V) \iint_{(x,y') \in \mathcal{B}_e(y)} J_f(\phi_e(x,y,y'), x, y)] h(x,y') dy' dx \tag{14}$$

where $\kappa(\xi, V) u(x)$ is the rate of contacting an unemployed worker of type x, and $s_1 \kappa(\xi, V) h(x, y')$ is the rate of contacting an employed worker x who is employed in firm y'. In equilibrium, $J_u(y) = 0$; any job opening that does not result in a match and any filled position that loses its employee cease to exist and have no continuation value.

3.7 Steady State Equilibrium

In a steady state equilibrium, the distributions $\{u(\cdot), h(\cdot, \cdot)\}$ are stationary. For workers who choose not to search in non-employment, $h(x, y) = 0$ and $u(x) = 0$; for the rest, the steady state levels of

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

$h(x, y)$ and $u(x)$ are determined by equating inflows with outflows such that

$$u(x) = \frac{\delta}{\delta + \kappa(\xi, V) \int_{y' \in \mathcal{A}_u(x)} v(y') dy'} \tag{15}$$

$$h(x, y) = \frac{v(y)\kappa(\xi, V) \left[u(x) + s_1 \int_{(x,y') \in \mathcal{B}_e(y)} h(x, y') dy'\right]}{\delta + s_1 \kappa(\xi, V) \int_{y' \in \mathcal{A}_e(x,y)} v(y') dy'} \tag{16}$$

where $\kappa(\xi, V) \int_{y' \in \mathcal{A}_u(x)} v(y') dy'$ is the the rate at which an unemployed worker x forms a match, $\kappa(\xi, V) \left[u(x) + s_1 \int_{(x,y') \in \mathcal{B}_e(y)} h(x, y') dy'\right]$ is the rate at which a recruiting firm forms a match with unemployed or employed worker x, and $\left[\delta + s_1 \kappa(\xi, V) \int_{y' \in \mathcal{A}_e(x,y)} v(y') dy'\right]$ is the overall separation rate of match (x, y).

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. 9) 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. 8 for all $x \in [0, 1]$ and $y \in [0, 1]$;
4. $v(y)$ satisfies Eq. 14;
5. $u(x)$ and $h(x, y)$ satisfy Eqs. 15 and 16 for all $x \in [0, 1]$ and $y \in [0, 1]$.

The wage of a match depends on the type of the match (x, y) as well as the worker x's outside option, which is either non-employment or employment at firm y' from whom the worker received her second best offer. The distribution of these outside options is fully determined in the steady state equilibrium. This implies that the wage distribution is also stationary. We relegate the details to Appendix C.

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.[23] In Appendix D, we describe the numerical solution algorithm.

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

3.8 Matching Thresholds and Policy Implications

Minimum wages and payroll taxes influence the labor market equilibrium in several ways. In this section, we show formally how these policies affect the viability of certain matches. We then discuss how they affect wages, the participation decision of non-employed workers, and the vacancy posting decision of firms.[24]

In Appendix B.2, we show that the set $\mathcal{A}_u(x)$, which describes viable matches for worker x, can be fully characterized by a threshold $\underline{y}(x)$ such that any firm $y \geq \underline{y}(x)$ can form a viable match with a worker x. The threshold is a combination of two constraints. The first constraint arises due 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 2. *For any $y \in \mathcal{A}_u(x)$, we have $y \geq y_{min}(x)$ where*

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

Proof. In equilibrium, $J_u(y) = 0$. By Definition 1, we have $J_f(\phi_u(x, y), x, y) \geq 0$ for any $y \in \mathcal{A}_u(x)$ in equilibrium. Then, Eq. 11 implies that $f(x, y) \geq w_{min} + T(w_{min}) \geq 0$. □

The second constraint is akin to the standard positive-surplus constraint. As specified by the bargaining problem in Eq. 3, we require that the match surplus *net* of taxes is positive. We use $y_u(x)$ to denote the lowest y satisfying the system of equations in Eq. 3.

The least productive firm with which worker x can form a viable match can be written in terms of these two constraints as, $\underline{y}(x) = \max\{y_{min}(x), y_u(x)\}$. In addition, the least productive active firm is given by

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

In addition to their direct effects on match surplus and viability, taxes and minimum wages also affect the value of non-employment, unemployed workers' outside option in wage bargaining. Specifically, if higher taxes and minimum wages reduce the returns to job search, then the value of unemployment is lower, which increases the size of the match surplus. Equilibrium effects further complicate these considerations. If changes in match viability affect the distributions of job seekers and vacancies, the rate at which job seekers and vacancies meet can be altered, inducing further behavioral changes in job search and vacancy posting.

[24] However, Appendix B.2 shows that different policies do not modify employed workers' preference to match with more productive firms.

In summary, higher minimum wages and payroll taxes influence job search and vacancy posting decisions in ambiguous ways and the effects can vary across individuals and firms. In particular, high-productivity individuals may be affected by low-wage payroll tax reductions even if they never occupy low-wage jobs; we refer to this phenomenon as a "spillover effect". Spillover effects can be understood in terms of hold-up and congestion externalities. Hold-up designates the problem that if firms do not internalize the full social value of a match due to bargaining, they post too few vacancies. Congestion externalities arise as workers do not internalize the fact that their search efforts lower the others' opportunity of a meeting. Shimer and Smith (2001) show that, in an labor market with heterogeneous agents, the congestion externality dominates the hold-up externality for low-productivity agents because there is a low social value of matching with them. A low-wage payroll-tax reduction policy that favors matching of low-productivity individuals and firms exacerbates the congestion externality.

4 Data

Our main source of data is the "*Déclaration Annuelles de Données Sociales*" (*DADS*), a French administrative data maintained by the French National Statistical Institute (*INSEE*). The *DADS* is based on mandatory employer declarations of the earnings of employees who contribute to the social security system. Data in the *DADS* are organized into several datasets with different sampling schemes and structures. We have access to three of them: (1) *panel DADS,* a linked employer-employee dataset covering job spells in specific sectors from 1967 onwards, including those in all private and some publicly owned firms. The sample consists of workers born in October of even-numbered years;[25] *(2) panel-tous-salariés,* which is similar to *panel DADS*, but covers job spells mainly in the public sector and starts only in 1993; and (3) *fichier Postes* (hereafter, POST), an exhaustive file containing all job posts in both public and private sectors starting in 1993 as well.

We combine *panel DADS* and *panel-tous-salariés* to obtain a dataset containing job spells in all sectors; this allows us to construct complete employment histories for individuals.[26] We refer to the resulting dataset as the panel data of the *DADS*. Since we only observe 1/24th of the working population in our panel data, it is difficult to use it to accurately estimate within-firm wage distributions, which play an important role in our estimation strategy. We thus use the exhaustive dataset POST to complement the panel data as firms can be linked across datasets.

The panel data and POST include information about the firm (identifier, sector, size) and each job spell (start and end date, earnings, occupation, part-time/full-time, contractual hours from 1993

[25] From 2002 onwards, the dataset also contains those born in October of non-even years.

[26] Exceptions include spells of self-employment, which we do not observe in *DADS.*

onwards). The data also report "net taxable yearly earnings" for each job. From this we compute employee and employer SSCs separately using the tax simulator TAXIPP.[27] To keep the model tractable, we do not take into account the fact that SSCs vary slightly across industries and regions, assuming instead that SSCs only depend on wages. For our estimation, we fit a linear spline to the relationship between simulated SSCs based on TAXIPP and net taxable earnings. This gives us our tax function $T(w)$. Net earnings and tax function are converted into 2010 euros.

We focus on reforms that took place in 1995. We estimate the model based on data from January 1993-August 1995, a period of relative labor market stability. We use a longer sample period 1991-2008 to identify worker and firm productivities (see section 5.2). Our sample contains men aged 30-55. This group has a fairly strong and uniform labor market attachment. In particular, participation decisions in this group are not strongly influenced by lifecycle events we do not model such as education, child care, or retirement. We exclude part-time workers for two reasons. First, SSCs for part-time workers vary significantly according to the exact number of hours worked, for which we have no reliable data during the years 1993-1994. Second, we have not modeled working hours and fear that the behavior of part-time workers may not be adequately captured by our model. In our sample, part-time only concerns around 1/8th of the workers - see Table G.1 - so the amount of data excluded remains limited.

We exclude individuals who mainly work in executive positions or in the public sector.[28] Executive jobs account for a quarter of the jobs and include professors, engineers, business managers, and artists. In our model, the aggregate meeting technology $M(\xi, V)$ implies that all job seekers compete with one another in the job search process and all job providers compete with one another in the recruitment process. It is reasonable to assume that executive and public-sector jobs are filled via separate recruitment processes. Altogether, our sample restrictions limit the analysis to a relatively homogenous group of individuals that are likely to compete for similar jobs and to be affected by a more congested labor market.

The panel data of the *DADS* consists of employed workers; individuals who become non-employed or self-employed disappear from the data, creating "gap spells" which can be either unemployment, non-participation, or self-employment spells. We use additional data from the French labor force survey *Enquête Emploi* (*EE*) to predict individuals' status during these "gap spells". In the *EE*, we estimate the likelihood of unemployment in these spells based on variables that are observed both in the *DADS* and the *EE*. This includes the duration of the gap spell, the age of the individual, and the type of job (public or private sector, industry, and occupation) following the gap spell. Based

[27] 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.

[28] In order not to lose too many observation, we keep individuals who only have a few job spells in a part-time job, executive position or the public sector, see Appendix G.1.

on this estimation, we predict the probability that a gap spell in the *DADS* panel data corresponds to an unemployment spell. Appendix F.2 provides details on this imputation procedure.

In order to estimate non-employment incomes $b(x)$, we use rules regarding unemployment benefits and social welfare during our sample period. Legal entitlements depend on past earnings which we observe in *DADS*. We provide details of our procedure in Appendix E. Finally, we create a monthly panel based on *DADS* spell data. We explain all the steps we take in Appendix F.

5 Estimation Strategy and Results

5.1 Time frame and Simulated Method of Moments

Prior to the first major payroll tax reduction for low-wage earners implemented in 1995, the rules regarding SSCs and the minimum wage remained relatively stable (see Section 2). Therefore, we estimate our steady state equilibrium model based on the period between January 1993 and August 1995.[29]

Let θ denote the vector of structural parameters of the model, which contains bargaining power α, search cost q, relative search intensity of employed workers s_1, and parameters of worker and firm productivity distributions, production function, non-employment benefit function, meeting technology, and vacancy cost function. We estimate θ using the 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.[30] 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 $M \times 1$ vectors of moments computed from the actual data and the simulated data, and the weighting matrix Ω is a diagonal $M \times M$ matrix. The (m, m) entry of Ω is the bootstrap variance of the mth moment. The simulated data is a panel dataset containing $N = 100,000$ individuals over $T = 36$ months. For each individual, we simulate the profiles of labor force status, employer, and wage based on policy functions solved from the steady state equilibrium.[31]

[29] We choose this start date because 1993 is the first year for which the POST data used to rank firms is available (see Section 4).

[30] As we explain in Section 3.7, 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.

[31] See Appendix D for details on the numerical solution of the steady state equilibrium.

We discuss our choice of moments in Section 5.3. Certain moments used in estimation require prior ranking of workers and firms according to their productivities, x, and y. We thus first rank workers and firms. To construct the simulated moments, we produce a ranking using the same algorithm as the one used for ranking individuals and firms in the real data, disregarding our knowledge of the true ranks of simulated workers and firms.

5.2 Ranking Workers and Firms

Our model includes unobserved worker and firm productivities that are combined to generate the worker-firm match productivity according to a CES production function. We observe only wages, a function of the joint outcome of workers' and firms' productivities. Following (Hagedorn et al., 2017), we rank workers and firms according to their productivity as a first step in constructing moments for the SMM estimation which uses involves wage moments and labor force transition statistics based on these ranks.

5.2.1 Workers

To rank workers, we rely primarily on average lifetime net earnings and use lifetime minimum and maximum net wages to make adjustments.[32] These three measures are asymptotically increasing in workers' productivity. First, in our model, individuals are risk-neutral and make decisions with a view to maximizing their discounted lifetime net earnings from employment and non-employment transfers. Since both $f(x, y)$ and $b(x)$ increase in x, high-x workers can always pretend to be a low-x worker and achieve the same life-time earnings. Second, consider lifetime maximum wages. Since all labor force participants are able to form a viable match with the most productive firm, the maximum wage is reached with that firm for all workers and it is increasing in x because $\partial\bar{\phi}(x, y)/\partial x > 0$ (see Proposition 3). Finally, we show in Appendix G.2 that, under an additional assumption, the lifetime minimum wage is also monotone in x. As we find this result to hold in our simulation, we use the the lifetime minimum wage as another criterion for ranking.

We implement the ranking strategy in the panel data of the *DADS*, which contains nearly complete employment biographies of each individual in our sample. Ranking is based on data between 1991 and 2008. A longer timeframe reduces ranking errors as our ranking strategy is theoretically valid for infinitely-lived agents. Due to sampling and measurement errors, the three statistics may not be perfectly rank-correlated. We apply a simple rank-aggregation method such that the ranking is primarily based on lifetime earnings; the method assigns sample workers into $N_{xbin} = 8$ discrete

[32] Rather than taking residual earnings derived from a regression that controls for individual characteristics and experience, we choose to use actual net earnings in order to properly apply the tax schedule.

bins. Appendix G.1 provides further details of our ranking method and Appendix G.3 provides robustness checks.

Importantly, in constructing moments using the simulated data, instead of using true ranks x, we follow the same ranking procedure described above. We do so to make sure that biases in the computed moments due to ranking errors in the real data are also reproduced in the simulated data. In practice, we use 120 months of simulated data (after the steady state is reached) which corresponds to the average length of individuals' employment biography in our *DADS* sample.

5.2.2 Ranking Firms

In the model, the highest worker type with whom a firm can form a viable match increases with firm productivity. In addition, the maximal potential wage also monotonically increases in both worker and firm types (see Proposition 3). Thus, the highest wage a firm may ever offer increases with the firm type, and we use it to rank firms in the data.

In the panel data of *DADS*, we only observe 1/12 (1/24 after 2002) of the employees within each firm on average. It is thus impossible to construct reliable statistics of the within-firm wage distribution. In POST, however, we observe wages of all employees in each firm.[33]

We use the POST data from the period between 1993 to 2008 to rank firms, the same time-frame we use to rank workers.[34] To limit the effects of measurement errors and outliers, we use the 99th within-firm wage percentile as the ranking statistics and restrict our sample to firms that have an average firm size of at least 10 workers, where firm size is calculated as the number of unique male workers age 30-55 in non-executive, full-time, private sector jobs in a given month. We show in Appendix G.4 that about 30% of firms in POST can be ranked, accounting for over 80% of employment.[35] Firms satisfying our ranking criteria are assigned to a total of $N_{ybin} = 4$ discrete bins.

To rank firms in our simulated data, we simulate 10 years of data, as this corresponds to the average length of time for which we observe firms in the data. In addition, we replicate the sample selection on firm size in our simulated data. In addition, we fine-tune the simulation so that the share of employment accounted for by ranked firms matches that in the data.[36]

[33]We are not able to construct the poaching index, which is the fraction of hires that were poached from another firm, used by Bagger and Lentz (2019), in either dataset. This is because of the incomplete within-firm observations in the panel data of the *DADS* and the fact that we cannot track workers across years in POST.

[34]In the data, a firm is an establishment.

[35]In Appendix G.4, we also show that ranked firms in POST are not randomly selected; they have higher wages than other firms. We replicate this selection in simulation.

[36]For further details, see Appendix G.5.

5.3 Moments and Identification

In the following, we briefly discuss our choice of moments in SMM and how the vector of structural parameters, θ, is identified.

In the meeting technology (Eq. 1), the scale parameter m_0 determines the level of search frictions and disciplines the speed at which unemployed workers meet potential employers. A higher m_0 would shorten unemployment durations and result in a lower level of unemployment across all worker types. To pin down m_0, we target the unemployment rate, defined as the fraction of unemployed workers among labor force participants.

A higher search cost q discourages non-employed individuals from searching for a job. Since a non-employed individual who does not search is classified as a non-participant, the labor force participation rate can help identify q.

As data moments, we take the official unemployment and the labor force participation rates of French men aged 25-49 computed by *INSEE* because the *DADS* only contains employed workers. These rates are computed based on the French Labour Force Survey according to International Labour Organization's (ILO) definitions.

s_1 determines the intensity of on-the-job search relative to searching when unemployed. The parameter influences the transition rate from a job to another one relative to the transition rate from unemployment to employment and we therefore use this moment in estimation.[37] Moreover, a higher s_1 allows for faster transitions to more productive firms which will therefore employ a larger share of the workforce in equilibrium. Therefore, we use the employment share by the estimated firm bins as another moment to identify s_1.

In the vacancy cost function (Eq. 13), c_0 governs the aggregate measure of vacancies. To identify this parameter, we use the vacancy rate, defined as the number of vacancies divided by the sum of vacancies and jobs. We use the vacancy rate reported by the Employment Orientation Board (Conseil d'Orientation pour l'Emploi, 2013) for the non-public and non-agricultural sectors. This rate is calculated based on 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 outside of the concerned firm.

The convexity of the vacancy cost function is captured by c_1, which is difficult to identify. A greater c_1 reduces differences in vacancy posting across firms by discouraging more productive firms from posting more vacancies. However, it is difficult to distinguish the role of different vacancy costs

[37] 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, and the unemployment-to-employment transition rate as the fraction of unemployed workers that are not unemployed the next month.

across firms from the role of firms' productivity differentials in incentivizing vacancy creation. We have therefore prefer to set c_1 to 0.01, in line with Bagger and Lentz (2019).

Workers' bargaining power α 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 small α suggests that individuals start from a relatively low wage when coming out of unemployment. Wages rise as workers receive outside offers. The parameter α can therefore be identified from the comparison between starting wages out of unemployment and later wages. As moments in estimation, we use the median out-of-unemployment wages and the median of overall wages.

We assume that the match output is a constant elasticity of substitution (CES) function of the productivity levels:

$$f(x,y) = \begin{cases} f_0\left[\frac{1}{2}\mathfrak{h}(x)^{\gamma} + \frac{1}{2}\mathfrak{p}(y)^{\gamma}\right]^{1/\gamma} & \text{if } \gamma \neq 0 \\ f_0\mathfrak{h}(x)^{\frac{1}{2}}\mathfrak{p}(y)^{\frac{1}{2}} & \text{if } \gamma = 0 \end{cases} \tag{17}$$

with $f_0 > 0$ and $\gamma \leq 1$. f_0 is total factor productivity and $1/(1-\gamma)$ is the elasticity of substitution between worker and firm productivities. If $\gamma = 1$ worker and firm productivities are perfect substitutes. If $\gamma = -\infty$, the productivities are perfect complements. If $\gamma = 0$, the production function is Cobb-Douglas. The production function has the properties that $f_x(x,y) > 0$ and $f_y(x,y) > 0$ for all x and y.

Worker and firm productivity levels $\mathfrak{h}(x)$ and $\mathfrak{p}(y)$ follow log-Normal distributions. More precisely, we have $\mathfrak{h}(x) = \exp\left[\Phi_x^{-1}(x)\right]$ and $\mathfrak{p}(y) = \exp\left[\Phi_y^{-1}(y)\right]$ with support $[0,1]$. Φ_x is the cumulative distribution function of the Normal distribution $N(\tilde{\mu_x}, \tilde{\sigma}_x)$. The mean and standard deviation of the worker productivity are thus $\mu_x = \exp(\tilde{\mu}_x + \tilde{\sigma}_x/2)$ and $\sigma_x = \sqrt{[\exp(\tilde{\sigma}_x) - 1]\exp(2\tilde{\mu}_x + \tilde{\sigma}_x^2)}$. Similarly, Φ_y is the cumulative distribution function of the Normal distribution $N(\tilde{\mu_y}, \tilde{\sigma}_y)$, and the mean and standard deviation are $\mu_y = \exp(\tilde{\mu}_y + \tilde{\sigma}_y/2)$ and $\sigma_y = \sqrt{[\exp(\tilde{\sigma}_y) - 1]\exp(2\tilde{\mu}_y + \tilde{\sigma}_y^2)}$. Note that not all firms on the support $[0,1]$ are active. To ensure that we have a bounded problem, we impose an exogenous upper bound $p_h = 4$ on firm productivity. Given Φ_y, the upper bound on firm type is $y_h = \Phi_y(\ln(p_h))$. In addition, there is also an endogenous lower bound on the firm distribution. As a result of the bounds, σ_y may be greater than the standard deviation of the observed firm productivity distribution.

To identify dispersions in worker and firm productivity levels, we target median wages by the estimated worker and firm bins respectively. In addition, we also use statistics of the unconditional wage distribution as moments, including wage deciles and the share of workers with jobs paying within specific wage intervals that are relevant in the SSC and tax schedules paid within policy-relevant wage intervals (i.e., w_{min} to $1.3w_{min}$, $1.3w_{min}$ to $1.6w_{min}$, $1.6w_{min}$ to $2.5w_{min}$, and more than $2.5w_{min}$.). Because worker and firm productivities are only observed jointly, we normalize the means of worker and firm productivity distributions such that $\mu_x = 1$ and $\mu_y = 1$ and estimate the scale factor for joint production f_0.

The scale factor f_0 in the CES production function can be identified from the average wage level. The parameter γ governs the degree to which individuals and firms are complementary in production. In our model, this parameter influences the shape of the "reservation firm type" function $\underline{y}(\cdot)$, the set of firms with which workers of different ranks will match. It therefore influences how job finding rates vary across workers of different ranks. To identify γ, we use job finding rates by the estimated worker bins.

The non-employment benefit function $b(x)$ is hard to identify separately from the distribution of workers' and firms' productivities with only data on employment outcomes. This is why we rely on actual regulations regarding unemployment benefits and social minima to recover $b(x)$. However, unemployment benefits depend on past wages, something that would make our model non-Markovian in the sense that wages earned at some point can influence more than one future transition. To avoid this additional complexity, we model a non-employment benefit function dependent on x rather than past wages. To do so, we parameterize $b(x)$ 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 unemployment benefit in each worker bin.[38]

5.4 Estimation Results

In the SMM estimation, we simulate 100,000 individuals whose types are drawn from the discretized worker productivity distribution with 100 grid points. We simulate 2,000 firms drawn from a discretized firm productivity distribution with 50 grid points. The computation of simulated moments is based on 36 months of simulated data, consistent with our moment computation using the *DADS* data. We consider a discrete time version of our model by aggregating to the monthly level.

The exogenous separation rate δ can be calibrated independently of the simulated data based on the frequency of transitions from employment to unemployment observed in the DADS data. Before carrying out the SMM estimation, we calibrate the separation rate δ to 0.00855 per month, which implies an annual separation rate of 0.098.[39]

[38] Note that our data does not include individuals who have never been in the labor force, thus our computation of the simulated moments of the benefit levels are also based solely on those in the labor force.

[39] The separation rate 0.00855 is the monthly employment-to-unemployment transition rate computed using the monthly DADS data. Specifically, the transition rate is computed as the fraction of employed workers who become

Table 1 shows parameter estimates and Figure 2 shows the estimated production function. We discuss the interpretation of the parameters in turn.

The estimate of the parameter γ indicates that workers and firms are complementary in production to a degree slightly greater than a Cobb-Douglas specification. The output of a median worker in terms of her productivity at a median active firm in terms of its productivity is 2633 euros per month. While the upper bound of the firm productivity distribution is fixed at $p_h = 4$, the endogenous lower bound is $p_l = 2.85$. Given the estimated σ_y, the standard deviation of the productivity of active firms is 0.33, which is smaller than the estimated standard deviation of worker productivity, $\sigma_x = 0.42$. If matched with the median active firm, a worker at the 90th percentile of the productivity distribution produces 1.49 times the output of a worker with median productivity, while the median worker produces 1.51 times the output of the worker at the 10th percentile of the productivity distribution. Conversely, the influence of the firm productivity distribution can be shown. Matched with a median worker, the firm at the 90th percentile of productivity distribution of active firms produces 1.07 times the output of the median firm, while the median firm produces 1.06 times the output as the firm at the 10th percentile of the same distribution.

The linear specification of the benefit function $b(x)$ (Eq. 18) provides a close match to the data, so we do not need to include terms of higher orders. The parameter estimates of b_0 and b_1 indicate that while all non-employed workers receive a basic level of transfer of 590.5 euros per month, the transfer increases with worker productivity at a moderate rate.

The job search parameters m_0 and s_1 imply that, on average, an unemployed worker meets a vacancy every 9.0 months, an employed worker meets a vacancy every 14.7 months, and a vacancy meets a worker every month.[40]

The estimated search cost q is 13.2 euros per month, which is only 1.4% of the minimum wage. Since non-employed individuals receive the same non-employment income regardless of job search decision, q fully captures the cost of engaging in job search. In equilibrium, individuals choose to search when the expected returns to search for unemployed workers exceed search costs q (see Eq. 9). The small estimated value of search cost is driven by the fact that returns to search for unemployed workers are low while the labor force participation rate is relatively high. This is largely due to the high non-employment benefit levels that unemployed workers receive.

The vacancy cost parameter c_1 implies that the cost of posting one additional vacancy for the least productive firm is 3.15 euros per month, while the cost for the most productive firm is 1472 euros per month.

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unemployed in the following month conditional on becoming either employed or unemployed. Employment include all jobs that can be observed in the DADS data. As we explain in Section 5 and Appendix F.2, unemployment is imputed .

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

Table 1: Parameter Estimates.

Parameter		Value	S.E.[i.]
Production function:	γ	-0.12	0.0006
$F(x,y) = f_0(\frac{1}{2}\mathfrak{h}(x)^\gamma + \frac{1}{2}\mathfrak{p}(y)^\gamma)^{1/\gamma}$	f_0	1626.27	0.41
Dispersion parameter of the worker productivity distribution	σ_x	0.424	0.0002
Dispersion parameter of the firm productivity distribution	σ_y	2.49	0.71
Non-employment benefit:	b_0	590.5	5.61
$B(x) = b_0 + b_1\mathfrak{h}(x)$	b_1	654.9	11.60
Intensity of on-the-job search relative to unemployment search	s_1	0.593	0.017
Meeting technology: $M(\xi, V) = m_0\sqrt{\xi V}$	m_0	0.914	0.051
Cost of unemployment search:	q	13.2	3.86
Vacancy cost: $c(v) = (c_0 v)^{100}$	c_0	1980.7	118.67
Worker's share of surplus	α	0.729	0.026

i. Standard errors are estimated by bootstrap with 30 iterations.

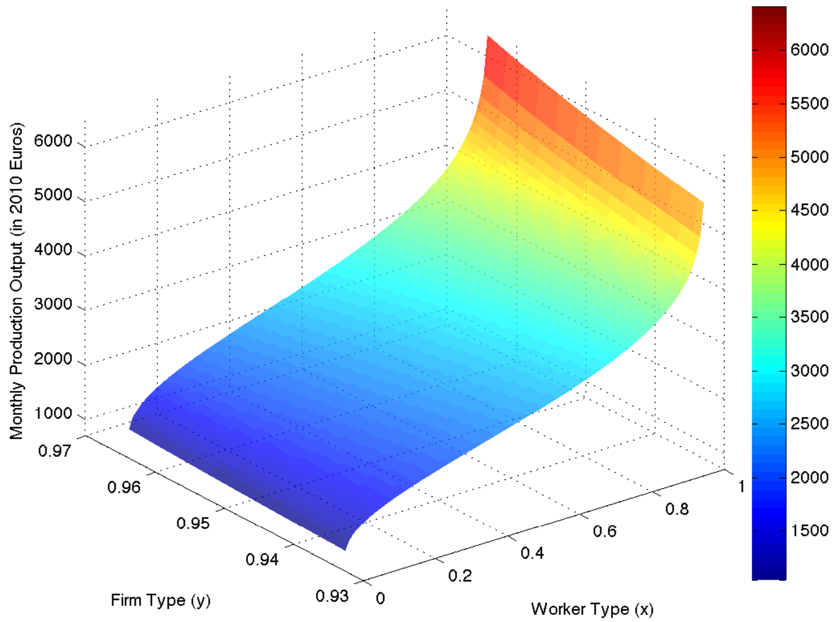
Finally, our estimated workers' bargaining power α is 0.729. The estimate is higher than that in Cahuc et al. (2006), who also use French data over a similar period. Since dispersion in wages is the main source of identification for bargaining power in both Cahuc et al. (2006) and this paper, the discrepancy in the estimated value is in part due to the fact that we explicitly model taxation and thus are able to simulate wage measures corresponding to the data targets.

5.5 Model Fit

Table 2 shows the fit of 48 targeted moments. Overall our model is able to fit the moments well. We replicate the hump-shape pattern in the job finding rate: it is lower among the lowest and the highest ranked workers and higher for those in the middle.

Our model also closely matches the unconditional wage distributions and wage dispersion across worker bins. We under-predict the wage dispersion across firms ranks (see median wages by firm bin). However, our simulation reveals that the firm ranking is substantially less accurate than the worker ranking. The correlation between our simulated workers' rank b_x and true type x is 0.983. 77% of the simulated workers are correctly ranked, 23% are ranked higher or lower by one bin, and virtually no workers are mis-ranked by more than one bin. In contrast, among the simulated firms that we are able to rank, the correlation between our simulated firm's rank b_y and true type y is

Figure 2: Estimated production function. Parameter values are shown in Table 1.



0.390.[41] This modest correlation invites us to caution when considering moments based on firms' ranking.

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

6 Distributional Effects of Payroll Tax Reductions For Low-Wage Jobs

6.1 Simulating Payroll Tax Changes Between 1995 and 1997

In this section, we simulate the effects of the payroll tax reduction that occurred between 1995 and 1997 (see Figure 1). Note that during the same period there was a small increase in the marginal rate of SSC such that jobs that pay more than $1.3w_{min}$ paid more SSC in the 1995-1997 period while those below $1.3w_{min}$ paid less. We also include this feature in our simulation.

[41] 33.6% of the firms are correctly ranked, while 44.6% are ranked higher or lower by one bin.

Table 2: Model fit. $\chi_{i,t}$ denotes the employment status of worker i in period t such that $\chi_{i,t} = j$ if the worker is employed in firm of index j, $\chi_{i,t} = 0$ if the worker is not employed and searches for employment, and $\chi_{i,t} = -1$ if the worker is not employed and does not search. Workers and firms productivity ranks are given in discrete bins, denoted by $\iota_x(i)$ and $\iota_y(j)$ respectively. We use $N_{xbin} = 8$ bins for workers and $N_{ybin} = 4$ bins for firms

Moment	Data	Simulation	Moment	Data	Simulation
Job finding rate of workers in bin $\iota_x(i)$					
relative to that of workers in the top bin:					
$\frac{Pr(\chi_{i,t}>0 \mid \chi_{i,t-1}=0 \text{ and } \iota_x(i)=\iota_x)}{Pr(\chi_{i,t}>0 \mid \chi_{i,t-1}=0 \text{ and } \iota_x(i)=8)}$			*Median wage by firm bin:* $\text{median}(w_{i,t} \mid \iota_y(\chi_{i,t}) = \iota_y)$		
$\iota_x = 1$	0.472	0.518	$\iota_y = 1$	1358	1497
$\iota_x = 2$	0.870	1.004	$\iota_y = 2$	1527	1557
$\iota_x = 3$	1.048	1.089	$\iota_y = 3$	1717	1589
$\iota_x = 4$	1.200	1.127	$\iota_y = 4$	1861	1621
$\iota_x = 5$	1.201	1.143	*Median out-of-unemployment wage*		
$\iota_x = 6$	1.209	1.142	$\text{median}(w_{i,t} \mid \chi_{i,t-1} = 0)$	1492	1491
$\iota_x = 7$	1.196	1.129	*Median non-employment benefit by worker bin:*		
Wage percentiles:			$\text{median}(b_{i,t} \mid \iota_x(i) = \iota_x)$		
$w(p10)$	1131	1090	$\iota_x = 1$	811	833
$w(p20)$	1280	1226	$\iota_x = 2$	941	961
$w(p30)$	1401	1340	$\iota_x = 3$	1017	1044
$w(p40)$	1518	1460	$\iota_x = 4$	1090	1143
$w(p50)$	1638	1575	$\iota_x = 5$	1196	1243
$w(p60)$	1769	1716	$\iota_x = 6$	1338	1388
$w(p70)$	1929	1885	$\iota_x = 7$	1540	1594
$w(p80)$	2155	2107	$\iota_x = 8$	2181	2095
$w(p90)$	2502	2438	*Labor force participation rate*		
Wage distribution relative to w_{min}			$LFPR$	0.947	0.95
$Pr(w \leq 1.05 w_{min})$	0.040	0.033	*Unemployment rate*		
$Pr(1.05 w_{min} < w \leq 1.3 w_{min})$	0.093	0.148	UR	0.077	0.085
$Pr(1.3 w_{min} < w \leq 1.6 w_{min})$	0.217	0.166	*Job-to-job transition rate relative to*		
			unemployment-to-job transition rate		
$Pr(1.6 w_{min} < w \leq 2.5 w_{min})$	0.494	0.499	JJ/UE	0.091	0.105
Median wage by worker bin: $\text{median}(w_{i,t} \mid \iota_x(i) = \iota_x)$			*Vacancy rate (vacancies over vacant and filled jobs)*		
$\iota_x = 1$	998	1014	VR	0.011	0.011
$\iota_x = 2$	1176	1191	*Employment share by firm bin:* $Emp(\iota_y)/Emp$		
$\iota_x = 3$	1293	1335	$\iota_y = 1$	0.140	0.127
$\iota_x = 4$	1418	1477	$\iota_y = 2$	0.256	0.240
$\iota_x = 5$	1562	1638	$\iota_y = 3$	0.331	0.325
$\iota_x = 6$	1731	1837	$\iota_y = 4$	0.272	0.308
$\iota_x = 7$	1978	2107			
$\iota_x = 8$	2496	2620			

We simulate data from our model under the two tax schedules prevailing before and after the SSC reductions occurred while fixing the parameters at the estimated values obtained by SMM applied to the pre-reform period. In simulation, we assume that the government keeps a balanced budget: tax revenues are first used to finance non-employment benefit payments, and the remaining revenue is redistributed to the entire population as a lump-sum transfer or tax, which we denote by D_t.[42] More precisely,

$$D_t = \frac{1}{N}\left[\sum_{i:\chi_{i,t}>0} T(w_{i,t}) - \sum_{i:\chi_{i,t}\leq 0} b(x_{i,t})\right] \tag{19}$$

where N is the number of simulated individuals. $\chi_{i,t} > 0$ if the worker i is employed in period t and $\chi_{i,t} \leq 0$ if the worker is non-employed. Since individuals in our model are risk-neutral, D_t does not influence equilibrium outcomes. The consumption of individual i in period t is

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

6.2 Simulation results

The simulated results are shown in Table 3. The top panel of Table 3a shows the aggregate effects of the payroll tax changes. Overall, there is a 2.5% increase in employment and a 1.2% increase in aggregate production. These effects are in line with Crépon and Desplatz (2003) and Chéron et al. (2008). The increase in employment and the increase in the tax rate for high-wage jobs result in higher tax revenue and lower non-employment benefit payments, which in turn lead to a 3.9% increase in the lump-sum transfer. On average, individuals are better-off with consumption rising by 1.2%.

As we explain in Section 3.8, a low-wage payroll tax reduction has potential spillover effects on high-productivity individuals. To understand how spillover effects contribute to the results, we start by examining changes in search intensity and vacancy. There is a 2.1% increase in labor force participation, driven exclusively by low-productivity individuals. This increases the total search intensity and has a dampening effect on workers' meeting rate. Meanwhile, there is a 4.8% increase in the overall number of vacancies and the meeting rate for workers increases by 1.5%. However, Table 3b shows that the increase in vacancies is entirely driven by low-productivity firms. High productivity workers that cannot form viable matches with these firms do not benefit from the increased vacancies; instead, their chances of becoming employed worsen due to the increased participation of low-productivity workers.

[42] Because of the weak link between an individual's SSCs and the benefits he or she can claim (see Section 2), it is not unreasonable to assume a lump-sum redistribution of the SSCs.

To further examine the spillover effects, we look at individuals by productivity quartiles in Table 3c. The increase in employment is driven entirely by the least productive quartile (Q1), and comes despite a slight drop in employment of the most productive quartile (Q4).

There are two potential explanations for the drop in employment in Q4. The first is that the individuals are more selective in forming matches. However, our simulation indicate the opposite. As shown in Columns (4) and (5) of Table 3c, after the reform, employed workers in Q4 form matches with less productive firms. This can also be seen from the fact that there is little change in average job productivity among Q4. The second explanation for the decrease in employment in Q4 is that these individuals have a harder time meeting a vacancy posted by a firm with which they can form a viable match as a result of the changes in aggregate search intensity and vacancy distribution.

The drop in employment of the most productive individuals has strong negative implications for aggregate production; this is made worse by the fact that workers and firms are found to be complementary in production. Individuals in Q4 accounts for a 0.2% drop in aggregate production, which brings the overall effect on aggregate production to 1.2% rather than 1.4%. In summary, the distributional results indicate that even a relatively moderate low-wage tax reduction policy can lead to quantitatively important spillover effects. Therefore, policy evaluations and designs should account for the effects on those who are not directly targeted.

Finally, the tax changes are redistributive toward the disadvantaged as the least productive individuals experience the highest consumption growth.

6.3 Validation

As a validation exercise, we look at the distributional effects of the 1995 tax-reform using the *DADS* data in Appendix H. We compare the employment effect of individuals in different productivity ranks, and the results are largely consistent with our simulation results. In particular, individuals whom we rank to be the least productive experience the highest employment growth. In addition, we also compare the distribution of employment across firms in different productivity ranks. The results indicate an increase in the share of employment among less productive firms, which is consistent with our simulation results.

7 Optimal Coverage of Payroll Tax Reductions

In order to achieve a given employment target, different designs of the payroll tax reductions are possible. These design involve a potential efficiency-equity trade-off. On the one hand, a policy

Table 3: Simulated effects of tax changes between the baseline period and 1997. The baseline period is January 1993 to August 1995.

(a) Aggregate effects (percentage changes from the baseline).

Employment	2.55%
Job productivity	-1.35%
Aggregate production	1.16%
Lump-sum transfer	3.85%
Consumption	1.15%
LF participation	2.11%
Vacancies	4.82%
Meeting rate	1.45%

(b) Effects on the distribution of vacancies. Firm quartiles represent the quartiles of firm productivity among active firms under the 1997 tax schedule, with Q1 being the least productive. Columns show the distribution of vacancies.

Firm Quartiles	(1) Baseline	(2) 1997	(3) Change from Baseline
Q1	0.196	0.233	18.9%
Q2	0.248	0.237	-4.4%
Q3	0.251	0.239	-4.8%
Q4	0.305	0.291	-4.6%

(c) Distributional effects. Worker quartiles represent the quartiles of worker productivity, with Q1 being the least productive. "Emp." refers to employment, "Job Prod." refers to average job productivity, and "Agg. Prod." refers to aggregate production output. The values in Columns (1)-(3) are percentage changes from the baseline for the worker quartile. In Column (4), the value refers to the percentage change in the overall production output that is accounted for by the worker quartile. Columns (5)-(6) show the productivity of the least productive firm among employed workers in each quartile.

	(1)	(2)	(3)	(4)	Min. Firm Prod. $\mathfrak{h}(\underline{y})$	
Worker Quartiles	Emp.	Job Prod.	Agg. Prod.	Consumption	(5) Baseline	(6) 1997
Q1	13.58%	-2.47%	1.43%	2.92%	2.95	2.79
Q2	-0.09%	-0.10%	-0.04%	1.47%	2.86	2.84
Q3	-0.07%	-0.10%	-0.05%	0.75%	2.86	2.84
Q4	-0.59%	0.06%	-0.20%	0.16%	2.90	2.88

that offers a generous tax reduction for a narrow range of minimally-paid jobs is likely to be more effective in reducing consumption inequality between low and high productivity individuals. On the other hand, such a reduction is likely to induce large negative spillover effects, lowering average productivity and possibly aggregate production. To understand the implications of increasing the coverage of French payroll tax reductions since the late 1990s, we simulate alternative policy programs with varying coverage and generosity using our estimated model.[43]

7.1 Framework

To simplify our analysis, we restrict our attention to tax reduction programs in which tax reduction is largest for minimum wage jobs, decreases linearly with the wage, and is phased out at the upper bound of the coverage threshold. This framework encompasses many major payroll-tax reduction programs implemented in France in recent decades. We refer to the tax reduction as a payroll subsidy and assume the following functional form:

$$\text{Subsidy}(w) \quad = \quad \begin{cases} (subb \times w_{min} - w)suba & \text{if } w \leq subb \times w_{min} \\ 0 & \text{otherwise} \end{cases} \tag{20}$$

where $suba$ is the generosity parameter and $subb$ is the coverage parameter. Given a subsidy characterized by $(suba, subb)$, the effective tax schedule becomes

$$T(w; suba, subb) = \max\{0, T(w) - \text{Subsidy}(w)\} \tag{21}$$

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

To evaluate alternative tax reduction programs, we consider a social welfare criterion that takes into account both the aggregate level of consumption, which measures efficiency in our model, and inequality in consumption. We choose a criterion function that accounts for the distribution of consumption since reducing inequality is an important goal for policy makers. [44] Based on a

[43]Reducing the minimum wage is another way for policy makers to manipulate the employment rate, but it is politically unattractive. We expect minimum wage reductions to incentivize greater labor market participation by low-productivity workers and firms, thereby generating similar negative spillover effects on more productive workers. A comparison between payroll tax reductions and minimum wage reductions is an interesting question for future research.

[44]Since individuals in our model are risk-neutral, a utilitarian welfare criterion does not penalize inequality in consumption. Alternatively, one can assume that individuals are risk-averse and the social planner is utilitarian. However, note that, unlike Bagger and Lentz (2019), individuals in our model do not make job search decisions at the intensive margin. Thus, risk aversion does not affect job search behavior of labor market participants and does not impact the degree of labor market sorting that arises due to differences in job-to-job transition rates across heterogeneous workers.

sample of N individuals over T periods, the social welfare level $\mathcal{W}$ is computed as follows:

$$\mathcal{W} = \frac{1}{TN} \sum_{t=1}^{T} \sum_{i=1}^{N} welfare(c_{i,t}) \tag{22}$$

where $welfare(c_{i,t})$ is the individual welfare weight placed on worker i in period t if her consumption is $c_{i,t}$. We assume a constant-relative-risk-aversion formulation for $welfare(\cdot)$:

$$welfare(c_{i,t}) = \begin{cases} \frac{c_{i,t}^{1-\rho}}{1-\rho} & \text{if } \rho \neq 1 \text{ and } \rho > 0 \\ \log c_{i,t} & \text{if } \rho = 1 \end{cases} \tag{23}$$

7.2 Results

In Figure 3, we show the simulated effects of payroll tax reduction programs that differ in *subb*, the coverage of the subsidy. The generosity parameter *suba* is adjusted such that the employment level is always 5% higher after the tax reduction.[45]

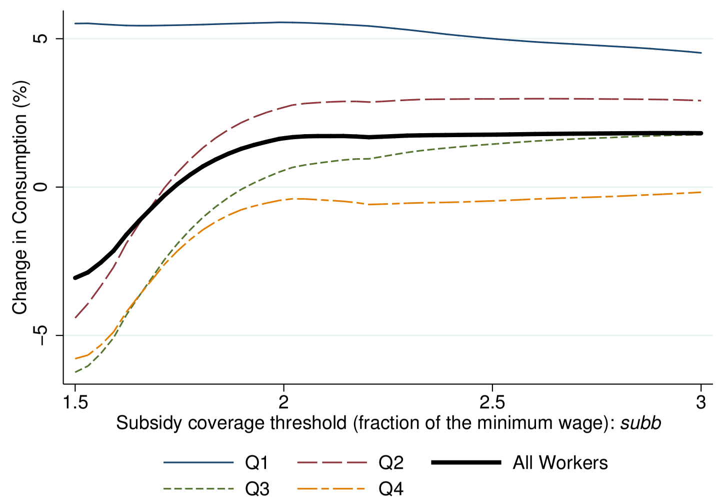
Figure 3a plots the percentage change in consumption against subsidy coverage. Individuals in the least productive quartile (Q1) are better-off under all subsidies with a consumption increase of around 5%; they are slightly more better-off under a narrower subsidy than a broader one. This is because these individuals benefit from larger reduction on average in this latter case. By contrast, individuals in the most productive quartile (Q4) are significantly worse off under subsidies with $subb < 2$; as the coverage broadens, the negative effects almost entirely dissipates. Subsidies with narrow coverages more strongly favor low-productivity workers and firms, distorting the job search and vacancy posting decisions and causing negative spillover effects on more productive individuals. Figure 3b shows that subsidies with a narrower coverage have more divergent employment effects, with positive effects on low-productivity workers and negative effects on high-productivity ones.

Although the negative employment effects on the most productive workers seem moderate compared to the positive employment effects on the least productive workers, they are disproportionally costly for aggregate production. Figure 3c shows the contributions by each quartile of worker to the overall change in aggregate production. With a subsidy that covers jobs of less than 1.5 times the minimum wage, the bottom quartile of workers accounts for a 3% increase in aggregate production, while the top quartile accounts for a 2% decrease in aggregate production. As the subsidy coverage broadens, the gap between the top and bottom workers shrinks.

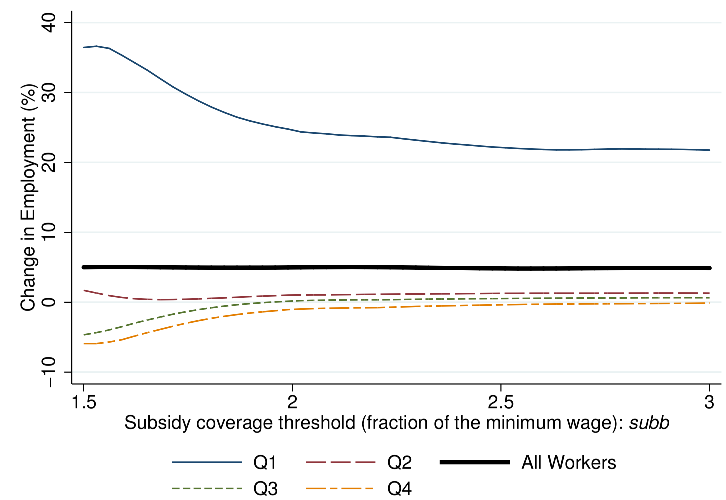
[45] Narrowly focused tax reduction programs with $subb < 1.5$ are not able to achieve the 5% employment increase even if the subsidy is highly generous.

Figure 3: Equilibrium effects of expanding tax reduction coverage.

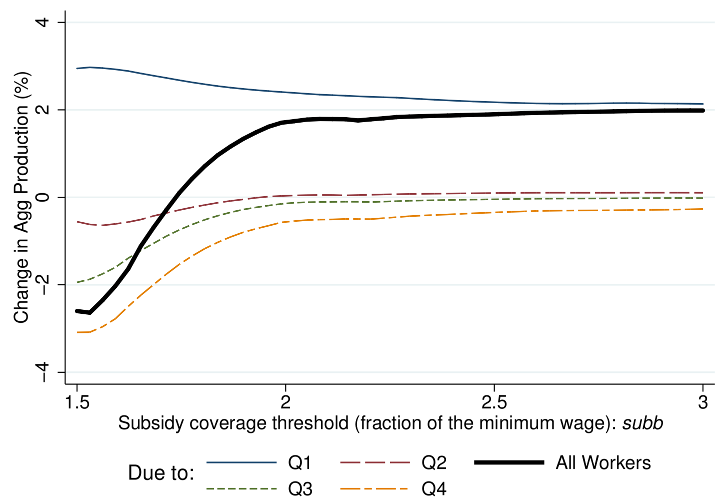
(a) Consumption



(b) Employment



(c) Production Output



Notes: All tax reduction programs raise baseline employment by 5%. The subsidy coverage threshold parameter subb is a multiple of the minimum wage (see Eq. 20). Subsidy generosity suba varies such that the subsidy program raises baseline employment by the corresponding percentage. The thick solid line shows aggregate effects and the lines "Q1-Q4" correspond to quartiles of worker productivity, with Q1 being the least productive. The graph has been smoothed using a third degree polynomial. Changes in consumption, employment, and aggregate output are the difference between the counterfactual and the baseline environments.

The results shown above clearly indicate an efficiency-equity trade-off: a narrower subsidy coverage results in a smaller consumption gap between the most and the least productive workers, but it costs employment from the most productive workers, resulting in significant reductions in aggregate production and consumption. This trade-off gives rise to an optimal level of subsidy coverage that balances efficiency and equity. We use the welfare criterion in Eq. 22 with $\rho = 4$ to evaluate alternative subsidies.[46]

Figure 4 shows the social welfare gains under subsidy programs that raise the baseline employment by 2%, 3%, and 5%. To increase employment by 5%, the optimal tax reduction program is one with a relatively broad coverage: jobs that pay up to 2.1 times the minimum wage should benefit from the tax reduction. To reach the same level of employment increase, a narrower program leads to worse welfare outcomes compared to a tax reduction program with a more moderate employment goal. Overall, a higher employment goal requires a broader coverage.

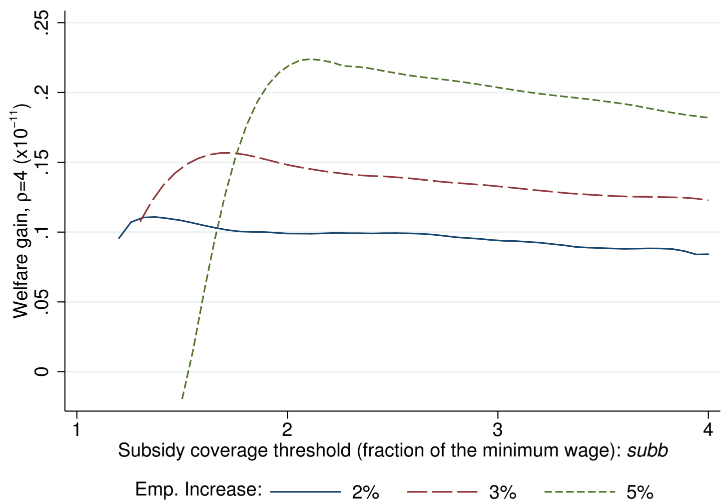
Chéron et al. (2008) conduct a similar exercise regarding the subsidy coverage. However, instead of considering fixed employment goals, they study alternative subsidies that have the same ex-ante fiscal cost, the same upfront sum of subsidies before equilibrium labor market reactions are taken into account. They conclude that the optimal coverage threshold is 1.36 times the minimum wage, which results in an employment rise of around 2%. Their result is not inconsistent with our findings.

Note that having a fixed ex-ante fiscal cost does not imply that the equilibrium budget cost is unchanged. Based on our simulations, ex-post (equilibrium) fiscal budget effects can be quite different from the ex-ante budget effect. In Figure 5, we show both the equilibrium and ex-ante simulated fiscal costs of our alternative subsidy programs, where the fiscal cost is measured as decreases in D from the baseline. Because the policies we consider have positive employment effects, the equilibrium fiscal costs are lower than the ex-ante cost. In particular, the optimal program, which entails a coverage threshold of around 2.1 times the minimum wage, incurs practically no additional fiscal cost in equilibrium.[47] Moreover, subsidy programs that raise employment level by 5% are more costly ex-ante than in equilibrium. Thus, focusing on programs with the same ex-ante costs biases policy recommendations against subsidy programs that are more effective in increasing employment.

[46] Alternative specifications of $\rho = 1$ and 2 give similar results regarding the optimal subsidy coverage.

[47] The fact that the optimal payroll tax reduction program incurs little additional fiscal cost is also potentially important for policy makers because payroll tax reductions are not accompanied by reductions of benefit levels in social security programs.

Figure 4: Simulated welfare gain under alternative subsidies. The welfare criterion is shown in Eq. 22 with $\rho = 4$. The subsidy coverage threshold parameter $subb$ is a multiple of the minimum wage (see Eq. 20). Subsidy generosity $suba$ varies such that the subsidy program raises baseline employment by the corresponding percentage.



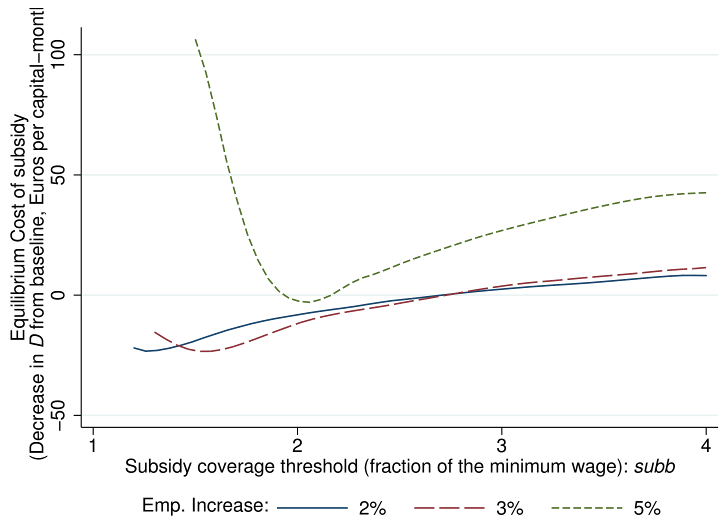
8 Conclusion

In this paper, we examine payroll tax reductions for low-wage jobs using an equilibrium search-and-matching model with individuals and firms that are heterogeneous in their respective productivity levels. We use the model to account for the effects of these tax reductions on those who directly benefit from them and the potentially negative spillover effects on more productive individuals. We focus on labor markets that are constrained by a minimum labor cost resulting from the combination of a minimum wage and payroll taxes.

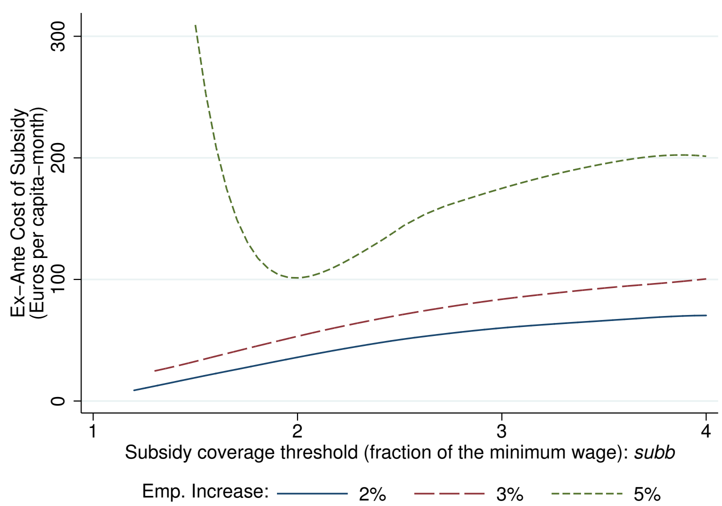
In our model, low-productivity individuals and firms are constrained by the minimum labor cost because the after-tax match surpluses are not always sufficient to cover the labor costs. Reducing taxes for low-wage jobs expands matching opportunities for low-productivity individuals and firms, inducing higher labor force participation and more job creation from them. Spillover effects arise for two reasons. First, changes in aggregate search intensity and number of vacancies affect the rate at which all individuals meet a potential employer. Second, changes in the productivity distribution across vacancies affect the conditional probability of forming a viable match with the firm that the worker meets. Increased search intensity and vacancy creation from low-productivity individuals and firms negatively affect the employment of high-productivity workers, which in turn reduces average job productivity and the overall efficiency of the labor market equilibrium. Our model estimated on French data shows that the consequences of the congestion of the market can be quantitatively important, especially when the tax reductions are strongly targeted towards the lowest wage earners

Figure 5: Fiscal Costs of Subsidies. Measured as the decrease in tax revenue redistribution $(D_{baseline} - D)$. The subsidy coverage threshold parameter *subb* is a multiple of the minimum wage (see Eq. 20). Subsidy generosity *suba* varies such that the subsidy program raises baseline employment by the corresponding percentage.

(a) Equilibrium costs



(b) Ex-ante costs



(i.e. close to the minimum wage). We recommend against such strong targeting.

Let us conclude with three final comments and suggestions for future research. The first comment is related to the role of capital. It is sometimes argued that reductions targeted to low wages is a way to subsidize low-skill workers that are substitute to information and communication technology (ICT) capital, as they sometimes perform tasks that may be automated. Hence, such reductions may discourage firms from investing in ICT capital, which can have negative consequences for other workers whose marginal productivity increases in ICT capital and the country's global competitiveness. The simplest way to study these alleged concerns would be to estimate an aggregate production function in capital and low- and high-skill labors. While this simple approach may directly capture the potential under-investment in capital due to tax reductions, it would, however, neglect the possible reallocation of workers across jobs with different levels of capital investments. It would also neglect labor market frictions that prevent workers and firms from matching instantly.

Our richer and more realistic model of the labor market allows us to study the role of frictions and reallocations. Importantly, it is also suited for the study of complementarities between labor and capital. Indeed, firm productivity in our model has no direct real counterparts and nothing prevents us from interpreting it as firms' capital intensity. There are at least two good reasons to do so. First, we estimate the extent to which worker productivity is complementary to firm productivity in the production process. The estimate of production complementarity naturally captures how the marginal product of labor depends on firms' capital investment. Second, in our estimated model, vacancy creation costs increase with firm productivity in equilibrium. If firm productivity is interpreted as capital intensity, we can interpret the vacancy creation costs as the opportunity cost of capital, which increases with capital intensity.

Our main result - that payroll tax reductions lead to a decrease in the average firm productivity among available vacancies which hurts high-skill workers - is fully consistent with the trade-off between capital investment and hiring low-skill workers. The difference is that in our settings, investment decisions are modeled as vacancy creation decisions, which are made at a disaggregated level by firms whose productivity is exogenously given. In equilibrium in our model, there are more vacancies by less capital-intensity firms if low-wage jobs are subsidized through payroll tax reductions.

Our second comment concerns the comparison of the two main policy tools used to limit labor costs while protecting net wages. The first approach is to remove or reduce the minimum wage while offering a tax credit directly to low-wage workers. This approach is typically 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 incidence is uncertain, so that 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). In contrast, some central Europe countries such as France take the second approach, namely setting a high minimum wage while limiting reducing payroll taxes in order to reduce labor costs. Such a policy mix does not allow precise targeting of working-poor individuals but it has the strong advantage of perfectly controlling both the minimum net wage and the minimum labor cost.

Our model builds a general tool to study the combined effect of the minimum wage and payroll taxes. While we have focused here more specifically on the effects of payroll tax reductions, one may also use our model to compare the two types of policies described above. Understanding better the advantages and disadvantages of the two policy approaches appears an important exercise for policy design.

Finally, as in most equilibrium studies, our analyses have focused exclusively on the steady state equilibrium and placed no weight on periods when the economy is in transition. Studying the speed at which employment responds to a subsidy and the potential short-run welfare costs to individuals in a frictional labor market is another interesting avenue for future research.[48]

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[48]Simulating the short-run dynamics precisely is difficult because our model is intractable off the steady state equilibrium. Based on our approximations of the transitional path, we find that subsidy programs only achieve 50-65% of the equilibrium employment growth in the first year after implementation. Moreover, the nominal incidence matters in the short-run, and payroll tax reductions can make workers strictly worse-off in the short run than tax credits given to workers.

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A Nash Bargaining

Consider the wage bargaining problem between a non-employed worker and a firm. Using notations defined in Section 3, under Nash bargaining, the wage is

$$\phi_u^{Nash}(x,y) = \arg\max_w [W_e(w,x,y) - W_{ne}(x)]^{\alpha_{Nash}} [J_f(w,x,y) - J_u(y)]^{(1-\alpha_{Nash})} \tag{24}$$

The first order condition is

$$W_e(w,x,y) - W_{ne}(x) = \frac{\alpha_{Nash}}{1-\alpha_{Nash}} [J_f(w,x,y) - J_u(y)] \frac{\partial W_e(w,x,y)/\partial w}{-\partial J_f(w,x,y)/\partial w} \tag{25}$$

Without taxes, utility is perfectly transferable between the worker and the firm, so that $\frac{\partial W_e/\partial w}{-\partial J_f/\partial w} = 1$. In this case, the wage under Nash bargaining coincides with the wage under proportional bargaining, that is $\phi_u^{Nash}(x,y) = \phi_u(x,y)$ whenever $\alpha_{Nash} = \alpha$.[49] With taxes, however, this is no longer the case if the marginal tax rate is different from zero.

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

Using the equilibrium characterization of the set $\mathcal{A}_e$, partial derivatives $\partial W_e/\partial w$ and $\partial J_f/\partial w$ can, respectively, be written as

$$[r+\delta+s_1\kappa V]\frac{\partial W_e(w,x,y)}{\partial w}=1 \tag{26}$$
$$+s_1\kappa\frac{\partial\left[\int_{y_0(w,x,y)}^{y}W_e(\phi_e(x,y,y'),x,y)v(y')dy'\right]}{\partial w}$$
$$+s_1\kappa\frac{\partial\left[\int_{y_l}^{y_0(w,x,y)}W_e(w,x,y)v(y')dy'\right]}{\partial w}$$

and

$$(r+\delta+s_1\kappa V)\frac{\partial J_f(w,x,y)}{\partial w}=-1-\frac{dT(w)}{d}$$
$$+s_1\kappa\frac{\partial\left[\int_{y_0(w,x,y)}^{y}J_f(\phi_e(x,y,y'),x,y)v(y')dy'\right]}{\partial w} \tag{27}$$
$$+s_1\kappa\frac{\partial\left[\int_{y_l}^{y_0(w,x,y)}J_f(w,x,y)v(y')dy'\right]}{\partial w} \tag{28}$$

where $y_0(w,x,y)$ is the threshold firm type such that $J_f(\bar{\phi}(x,y'),x,y')\geq J_f(w,x,y)$ for all $y'\geq y_0(w,x,y)$. Applying the Leibniz integral rule and noting that $\phi_e\left(x,y,y_0(w,x,y)\right)=w$, we get

$$\frac{\partial W_e(w,x,y)}{\partial w}=\frac{1}{r+\delta+s_1\kappa\int_{y_0(w,x,y)}^{y_h}v(y')dy'} \tag{29}$$

and

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

Substitute the partial derivations in Eq. 25, we have

$$\frac{W_e(w,x,y)-W_u(x)}{J_f(w,x,y)-J_u(y)}=\frac{\alpha}{[1-\alpha]}\frac{1}{\left[1+\frac{dT(w)}{dw}\right]} \tag{31}$$

which states that the match surplus is split according to the 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 $\frac{dT(w)}{dw}$, 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 that we describe in Section 3.

Furthermore, by assumption, $dT(w)/dw\geq 0$, thus $\frac{1}{\left[1+\frac{dT(w)}{dw}\right]}\leq 1$. Given x and y, the Nash wage

ϕ_u^{Nash} must be smaller than the proportionally bargained wage ϕ_u. This implies that, all else equal, the estimated bargaining power under proportional bargaining must be smaller than that under Nash bargaining. The intuition is that, with Nash bargaining, the worker needs to compensate the firm knowing that increasing wage leads to increasing tax burden. In proportional bargaining, the two parties remain ignorant about how the tax burden comes about.

B Theoretical Appendix for Equilibrium Results

B.1 Monotonicity of Value Functions and Uniqueness of Bargaining Solutions

In this Appendix, we show that the bargaining problems set out in Eqs. 3 and 7 have unique solutions. This is the case because the value functions W_e and J_f are, respectively, monotonically increasing and decreasing in wage.

First, consider the employment value function W_e characterized in Eq. 10. Since the flow return function is equal to wage w, the value function W_e is increasing in wage by the contraction mapping theorem. Moreover, we have $\lim_{w\to-\infty} W_e(w,x,y) = -\infty$ and $\lim_{w\to\infty} W_e(w,x,y) = \infty$. The monotonicity of W_e in wage implies that employed workers prefer higher wages with the same employer. Thus, the renegotiated wage of an ongoing match (x,y) is $\max\{w, \phi_e(x,y',y)\}$ where w is the current wage and y' is the poaching firm that underbids firm y.

Next, consider the value function for filled positions, J_f, characterized in Eq. 11. The derivative of the flow return with respect to wage is $-[1+T'(w)]$, which is strictly negative because of the assumption that $T'(x) \in (0,1)$. Therefore, by the contraction mapping theorem, J_f is decreasing in wage, with $\lim_{w\to-\infty} J_f(w,x,y) = +\infty$ and $\lim_{w\to\infty} J_f(w,x,y) = -\infty$.

The surplus-sharing conditions in the bargaining problems in Eqs. 3 and 7 can, respectively, be rewritten as

$$W_e(w,x,y) - W_{ne}(x) = \frac{\alpha}{1-\alpha}[J_f(w,x,y) - J_u(y)] \quad (32)$$

$$W_e(w,x,y) - W_e(\bar{\phi}(x,y'),x,y') = \frac{\alpha}{1-\alpha}[J_f(w,x,y) - J_u(y)] \quad (33)$$

The left hand side of the two equations are increasing in wage, approaching $-\infty$ when w approaches $-\infty$ and approaching ∞ when w approaches ∞. The right hand side of the two equations are decreasing in wage, approaching ∞ when w approaches $-\infty$ and approaching $-\infty$ when w approaches ∞. Therefore, there exist unique solutions to Eqs. 32 and 33, implying that solutions to the bargaining problems in Eqs. 3 and 7 must also be unique.

B.2 Job-to-Job Transitions

In this Appendix, we show that employed workers prefer firms with higher productivity levels and transition to these firms when they have the opportunity to do so. In this sense, minimum wages and payroll taxes do not change the direction of job mobility, despite affecting other aspects of the equilibrium outcome, including viability of certain matches and distributions of job seekers, vacancies, and wages.

In an auction for an employed worker x, the firm that offers a higher $W_e(\bar{\phi}(x,y),x,y)$ succeeds; workers prefer more productive firms if and only if $W_e(\bar{\phi}(x,y),x,y)$ increases in y. In the next Proposition, we show that the maximum potential wage $\bar{\phi}$ is increasing in worker and firm productivities.

Proposition 3. *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 the definition of $\bar{\phi}(x,y)$ in Eq. 5 and Proposition 1, it must be the case that $J_f(\bar{\phi}(x,y),x,y)=J_u(y)$. Because of the free-entry condition, $J_f(\bar{\phi}(x,y),x,y)=0$. Therefore, it must be the case that

$$\bar{\phi}(x,y)+T(\bar{\phi}(x,y))=f(x,y) \tag{34}$$

Taking the derivative of Eq. 34 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 are able to offer higher wages conditional on the worker type. Together with the fact that W_e increases in wage, 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 $w=\bar{\phi}(x,y)$. At the maximum potential wage, the only events that can change the flow return for an employed worker are exogenous separations and voluntary job-to-job transitions. Replacing w with $\bar{\phi}(x,y)$, we can rewrite the value function in Eq. 10 as

$$\begin{aligned}&[r+\delta+s_1\kappa(\xi,V)V]W_e(\bar{\phi}(x,y),x,y)=\bar{\phi}(x,y)+\delta W_{ne}(x)\\&+s_1\kappa(\xi,V)\int_0^1\max\left\{W_e(\bar{\phi}(x,y),x,y),W_e(\phi_e(x,y,y'),x,y')\right\}v(y')dy'\end{aligned} \tag{35}$$

By the contraction mapping theorem, the value function $W_e(\bar{\phi}(x,y),x,y)$ must also be increasing in the third argument because $\bar{\phi}(x,y)$ is increasing in y.

It follows that the total derivative of $W_e(\bar{\phi}(x,y),x,y)$ with respect to y is increasing. 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. This implies that matches between an employed worker and an outbidding firms are always viable and employed workers make job-to-job transitions only toward more productive firms. We can then conveniently express the set $\mathcal{A}_e$ as

$$\mathcal{A}_e(x,y) \quad = \quad \left\{y' \in [0,1] : y' > y\right\} \tag{36}$$

Moreover, we can fully characterize the set $\mathcal{A}_u(x)$, which contains firm types that can form viable matches with worker x, with a threshold $\underline{y}(x) \in [0,1]$ such that

$$\mathcal{A}_u(x) \quad = \quad \left\{y \in [0,1] : y > \underline{y}(x)\right\}. \tag{37}$$

C Steady State Wage Distribution

Since wages depend on the combination of worker and firm productivities in the current match (x,y) and the worker's outside option y', the equilibrium wage distribution is stationary as long as the distribution of (x,y,y') is stationary. Let $G(y'|x,y)$ represent the fraction of type (x,y) matches such that the worker's outside option is of type y' or lower. Let $y' = -1$ denote the case that the worker's outside option is non-employment. Equating inflow into and outflow from $G(y'|x,y)h(x,y)$ gives us

$$G(y'|x,y)h(x,y) = \frac{v(y)\kappa(\xi,V)\left[u(x) + s_1 \int_{(x,y'')\in\mathcal{B}_e(y),y''\leq y'} h(x,y'')dy''\right]}{\delta + s_1\kappa(\xi,V)\int_{y''\in\mathcal{A}_r(\tilde{\phi}(x,y,y'),x,y)} v(y'')dy''} \tag{38}$$

Let $\tilde{\phi}(x,y,y')$ be the wage of match (x,y) when y' is the worker's outside option such that

$$\tilde{\phi}(x,y,y') = \begin{cases} \phi_u(x,y) & \text{if } y' = -1 \\ \phi_e(x,y,y') & \text{if } y' \in [0,1] \end{cases},$$

and let $\mathcal{A}_r(w,x,y) \subseteq [0,1]$ be the set of firms that can either poach worker x from firm y or trigger a wage renegotiation between x and y, such that

$$\mathcal{A}_r(w,x,y) = \left\{y' \in [0,1] \,|W_e(\bar{\phi}(x,y'),x,y') > W_e(w,x,y)\right\}$$

In the denominator of the right hand side of the Eq. 38, $s_1\kappa(\xi,V)\int_{y''\in\mathcal{A}_r(\tilde{\phi}(x,y,y'),x,y)} v(y'')dy''$ is the rate at which worker x transitions to a different firm or renegotiates her wage beyond

$\tilde{\phi}(x, y, y')$. Therefore, the denominator is the rate of outflow from $G(y'|x, y)h(x, y)$. In the numerator $s_1\kappa(\xi, V) \int_{(x,y'') \in \mathcal{B}_e(y), y'' \leq y'} h(x, y'')dy''$ is the rate at which firm y poaches workers of type x who are in matches with firm $y'' \leq y'$. The numerator is thus the inflow into $G(y'|x, y)h(x, y)$.

D Numerical Solution of Steady State Equilibrium

The steady state equilibrium can be characterized with the knowledge of the value functions W_e, W_{ne}, J_f and distributions u, v, h. As we explain in Section 3, solving for the steady state equilibrium requires knowledge of the value functions of workers and firms because the net match surplus varies in the way the surplus is shared. Below, we describe the iterative algorithm that solves for the fixed point numerically. With inputs W_e, W_{ne}, J_f, $h(\cdot, \cdot)$, and $u(\cdot)$, each iteration proceeds as follows:

1. Given W_e, W_n, J_f, we solve for the set of viable matches, Ω, such that

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

2. Solve for $\phi_u(x, y)$ for all $(x, y) \in \Omega$ in the following equation

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

   Compute $\bar{\phi}(x, y)$ such that $J_f(\bar{\phi}(x, y), x, y) = 0$. Solve for $\phi_e(x, y', y)$ for all (x, y', y) such that $(x, y) \in \Omega$ and $(x, y') \in \Omega$ in the following equation.

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

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

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

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

4. Update aggregate search intensity: $\xi = \int \left[s(x)u(x) + \int h(x, y)dy \right] dx$.

5. Update $v(\cdot)$ using Eq. 14 with $\mathcal{B}_u(y) = \{x : (x, y) \in \Omega\}$ and $\mathcal{B}_e(y) = \{(x, y') : mobility(x, y, y') = 1\}$. Define $mobility(x, y', y) = 1$ 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 $(x, y') \in \Omega$.

6. Update κ.

7. Update value functions W_u, W_e, J_f using Eq. 9, 10, and 11.

8. Update the unemployment distribution $u(\cdot)$ using Eq. 15 and the match distribution $h(\cdot, \cdot)$ using Eq. 16.

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 Computing Non-Employment Benefits

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

1. compute $\tilde{b}_0(\tilde{w}) = \max\left\{\tilde{f} + \tilde{s}_0\tilde{w}, \tilde{s}_1\tilde{w}\right\}$;

2. compute $\tilde{b}_1(\tilde{w}) = \max\left\{\tilde{b}_0(\tilde{w}), \tilde{m}\right\}$;

3. if $\tilde{b}_1(\tilde{w}) = \tilde{m}$, the simulated benefit $\tilde{b} = \tilde{m}$. Otherwise, $\tilde{b} = \min\left\{\tilde{b}_0(\tilde{w}), \tilde{s}_2\tilde{w}\right\}$.

The parameters $\tilde{f}$, $\tilde{m}$, $\tilde{s}_0$, $\tilde{s}_1$, and $\tilde{s}_2$ are policy parameters. $\tilde{f}$ and $\tilde{m}$ are time-varying, whose values are shown in Table 4. The values of $\tilde{s}_0$, $\tilde{s}_1$, and $\tilde{s}_2$ are fixed in the entire sample period from 1991 to 2008, with $\tilde{s}_0 = 40.4\%$, $\tilde{s}_1 = 57.4\%$, and $\tilde{s}_2 = 75\%$.

F Panel Data from the *DADS*

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

Table 4: Values of the policy parameters $\tilde{f}$ and $\tilde{m}$ for simulating non-employment benefits. Values are nominal. Values prior to 2001 have been converted from French francs (FF) to Euros (€) using the conversion rule of 1€=6.55957FF.

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

F.1 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 dataset.

F.1.1 Correcting Missing Spell-Dates.

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

F.1.2 Correcting Overlapping Spells.

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

F.1.3 Correcting Whole-Year Gaps.

We notice that in years 1994, 2003, and 2005 a large number of 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 occurs 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 the whole-year gaps in the three years are corrected.

F.1.4 Transforming Spell Data to Monthly Data

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

F.2 Imputing Labor Force Status in Employment History

We use the *Enquête Emploi* (hereafter, *EE*), French labor force survey, to impute the status of an individual in a gap spell in the *DADS*. Within the *EE*, we label all spells that are not covered by the *DADS* panel as "non-working", with the indicator *nw*. This includes unemployment, but also self-employment and non-participation. The aim is to identify the probability of unemployment conditional on non-employment 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 ages 30-55 and dropping individuals who have never been employed prior to or following an *nw* spell. The latter restriction is related to the data structure in the *DADS* panel, in which a gap spell can only be observed if it is sandwiched between two employment spells. We also drop *nw* spells that last for more than 3 years.

We then estimate the likelihood of unemployment in *EE*. We use information on the individual's age, the duration of the *nw* spell, the social-professional status, industry, and sector (private or public) of the employment spell following the *nw* spell. We denote 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 non-working 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.

G Implementing the Ranking Strategy

G.1 Ranking Individuals

The three statistics that we use to rank individuals are average life-time earnings and life-time maximum and minimum wages. In order to compute the three statistics in our data, we apply two additional sample selection criteria. First, we exclude individuals whose sample duration is less than 5 years, where the sample duration is calculated as the difference between the start date of the first employment spell and the end date of the last employment spell.[50] Second, we exclude individuals whose employment biography features less than 50% of the sample duration in Sample Jobs or unemployment. We define a Sample Job as a private-sector, full-time, and non-executive job. Our final sample contains 416,221 men aged 30-55 between 1991-2008.[51]

Given our sample selection criteria, individuals who are being ranked may differ in their average age within the sample. Since we rely on actual wages instead of wage residuals in computing the individual-level statistics, comparing individuals of at different points in the lifecycle may raise concerns. We argue that this is not a serious problem. The main reason for right-censoring an individual's lifespan in the sample is that our data stops in 2008, so that individuals for whom we observe a lower average age are the youngest cohorts. Similarly, left-censoring of an individual's sample lifespan is concentrated among the oldest cohorts. In estimating our model, we fit moments computed for the years 1993-1995, which lie between the bounds of the sample window for ranking. The computation of moments is therefore not heavily influenced by the youngest or the oldest cohorts.

[50]The 5-year minimum is a compromise between sample size and the length of an individual's sample duration.
[51]Our data is only available from 1991.

Table 5: Descriptive Statistics. "Data" refers to the merged *DADS* panels restricted to men age 30-55 between 1991-2008. "Sample" refers to our final sample after cleaning and restricting the panel. Sample duration is calculated as the difference between the start date of the first employment spell and the end date of the last employment spell. A sample job is one that is full-time, private-sector, and non-executive. Daily wage is the daily net wage.

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

Table 5 compares the raw data from *DADS* to our final sample. As expected, individuals' employment biographies in the final sample are longer and they are more likely to hold Sample Jobs. Since we exclude individuals who mainly work as executives, the average wage is lower in our sample.

In computing individual workers' ranking statistics, we include all labor incomes including those from overlapping jobs and non-sample jobs. All income measures are net of taxes. The lifetime minimum and maximum wage are calculated for annualized wages divided by 12. Since part-time jobs are included in these statistics, the lifetime minimum monthly wage may fall below the legal minimum wage.

Due to sampling and measurement errors, the three statistics may not be perfectly rank-correlated. For this reason, we apply a simple method to assign workers into N_{xbin} bins. The method involves iterative bisections. At the end of each iteration $n_{xiter} = 1, ..., N_{xiter}$, workers are assigned to $N_{xbin} = 2^{n_{xiter}}$ ranked bins based on the three statistics. We use the lifetime net earnings as the primary statistic because it is measured with the least noise. There may be disagreements among the three statistics when one statistic places a worker in the upper half of his current bin and another places a worker in the bottom half. In these cases, the location of the worker is determined by the primary statistic, unless the other two statistics simultaneously show a strong indication for the alternative. We choose $N_{xiter} = 3$, resulting in $N_{xbin} = 8$ worker bins. Table 7 shows that the average values of all three statistics increase in the discrete worker bin b_x.

Table 6: Ranking statistics of workers by discrete worker bins (b_x) based on the panel data of the *DADS* from 1991 to 2008, restricted to men aged 30-55 who are primarily employed in non-executive, full-time, private sector jobs. All statistics are on a monthly basis measured in 2010 euros. "Lifetime income" refers tothe average life-time income based on net wages and non-employment benefits. "Lifetime min. wage" and "Lifetime max. wage" refer to the lowest and the highest net wage from employment that an individual obtains over the sample period.

(a) Distributions of worker ranking statistics.

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

(b) Spearman rank correlations between worker ranking statistics.

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

* all correlations are significant at the 1% level.

Table 7: Ranking statistics of workers by discrete worker bins (b_x) based on the panel data of the *DADS* from 1991 to 2008, restricted to men age 30-55 who are primarily employed in non-executive, full-time, private sector jobs. All statistics are on a monthly basis measured in 2010 euros. "Lifetime income" refers tothe average life-time income based on net wages and non-employment benefits. "Lifetime min. wage" and "Lifetime max. wage" refer to the lowest and the highest net wage from employment that an individual obtains over the sample period. Individuals are assigned to bins based on the three statistics, with higher incomes assigned to bins with a larger numerical value.

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

G.2 Lifetime Minimum Wages As a Ranking Criterion

Assume that $\phi_u(x, y)$ is increasing in both x and y, which is the case for most parametric specifications. $\phi_u(x, \underline{y}(x))$ is the lowest wage that a worker x can ever attain if she lived infinitely. If $\underline{y}(x)$ were constant or increasing in x, $\phi_u(x, \underline{y}(x))$ must be increasing in x by assumption. However, $\underline{y}(x)$ may be decreasing in x because of the minimum wage constraint - low-x workers cannot match with low-x firms because these pairs cannot produce sufficient output that exceeds the minimum labor cost. Nevertheless, we know that the wage is exactly equal to the minimum wage in matches where the minimum wage constraint is binding. In summary, $\phi_u(x, \underline{y}(x))$, the asymptotical value of lifetime minimum wage, is weakly increasing in worker productivity.

G.3 Robustness of the estimated worker ranks

Since the end of 1995, a series of payroll tax reductions for low-wage workers were implemented. One may fear that these reductions may affect our empirical ranking of individuals as we use data from 1991-2008. Although the tax reductions do not change the order of individual net incomes within each year, they may affect the ranking of individuals by life-time income. In particular, similar individuals may be ranked differently because they spend different fractions of their life-time in the post-reform era.

As a robustness check, we estimate "pre-reform" individual ranks based only on *DADS* data from periods between 1991 and 1995. This severely reduces the number of individuals to 272 because of our sample restrictions, including the requirements that individuals must be between age 30 and 55 and present in our sample for at least 5 years.

The "pre-reform" individual ranks are closely correlated with the baseline ranking using data between 1991 and 2008, with a Spearman's rank correlation coefficient of 0.82. More importantly, the difference between the two estimated ranks is not correlated with the fraction of time an individual is observed in the pre-reform era - the coefficient is only -0.08 and is insignificant. This confirms the robustness of our method in estimating individual ranks from *DADS* data between 1991 and 2008.

G.4 Ranking firms

We compute firm size from the POST dataset by counting the total number of employee-days divided by the total number of days a firm is in the sample. In the computation, we only consider wages in sample jobs that are filled by individuals who are male and aged 30-55. Table 8 shows the firm size distribution and the average sample duration for firms of different sizes. On average, larger firms

Table 8: Firm size distribution, firm duration in sample and employment share. The statistics are computed from the POST dataset of the *DADS*. Firm size is computed by counting the total number of employee-days divided by the total number of days a firm is in the sample. We restrict our sample to jobs that are non-executive, full-time, in the private sector, and are filled by individuals who are male, age 30-55.

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

Table 9: Firm statistics for ranked and unranked firms computed from the POST dataset, and restricted to non-executive, full-time, private-sector jobs that are filled by men of age 30-55. "Highest firm wage" of a firm is the 99th monthly wage percentile ever reported by the firm; "Mean firm wage" of a firm is the average monthly wage ever reported by the firm; and "Firm size" is the total number of employee-days divided by the total number of days a firm is observed in POST. Wages are monthly gross wage measured in 2010 Euros.

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

have longer sample durations. In our estimation procedure, we only rank firms with a firm size of at least 10. For these firms, the average sample duration is over 10 years. Moreover, although only 29% of firms satisfy our criterion, they account for 88% of total employment.

Table 9 compares firm wages and firm sizes between ranked (larger) and unranked (smaller) firms. According to our model, firm size monotonically increases in firm productivity. The set of ranked firms is thus not randomly selected, but rather represents more productive firms.

G.5 Simulating Firms

As we explain in Section G.4, we are only able to rank relatively large firms in the POST data and these firms pay higher wages on average. In simulating data from our model, we need to replicate the selection on firm size in ranking firms and match the fraction of firms that can be ranked. To do so, we set the number of simulated firms such that the simulated firm size distribution matches that in the POST data.

Based on the estimated parameter values, of the 2000 simulated firms, 31.25% are ranked. These firms account for 81.9% of total employment. In comparison, 29% of firms in POST are ranked, accounting for 88% of total employment.

H Validation Exercise

According to our model, the 1995 tax-reduction increases employment among less productive individuals and slightly decreases employment among the most productive individuals (Table 3 in Section 6). The distributional effects are largely consistent with what we find in the data from the *DADS*.

We compute the employment rate based on the *DADS* panel data during the baseline period (January 1993 to August 1995) and the post-reform period (January to December 1995). The sample contains men between ages 30 and 55 who are primarily employed in full-time, private sector, and non-executive positions. Using the estimated worker productivity ranks, we divide individuals into 4 quartiles. Note that, since we rank individuals using data from 1991 to 2008, each individual in the panel data has one unique ranking. The employment rate is the proportion of the population employed with any employer; this includes any type of job except self-employment.

We show the employment rates in Table 10. There is a clear pattern that the least productivity quartile (Q1) experiences the highest employment growth after the 1995 tax reduction, which is consistent with the findings in Table 3.

However, the magnitude of the changes in employment is not identical to our simulation findings for several reasons. First, our simulation exercise compares two steady states, while in the data we merely observe the short-run employment effects within a year after the tax reductions. The full extent of the tax reform may take time to be fully realized. Second, the simulation results we report in Table 3 are based on the true individual productivities, while the results in Table 10 are based on the estimated productivity ranks. The errors in ranking individuals may lead to differences in the two tables. Third, in the simulation exercise, we are able to control for the aggregate economic environment and identify the effect of the tax reductions. In the actual data, the employment effects may be additionally driven by other factors such as changes in the aggregate productivity or other institutions. In particular, from 1995 to 1996, there is a 2% increase in the minimum wage. This may contribute to the fact that the employment growth among individuals from Q1 is not as strong as that predicted from the model.

Table 10: Employment rate by worker productivity rank quartiles based on data from the *DADS*. Worker productivity ranks are computed using data from 1991-2008. The sample is restricted to men age 30-55 who are primarily employed in non-executive, full-time, private sector jobs. Employment rate is the fraction of individuals in each quartile who are employed.

	Employment rate			
Worker productivity rank quartiles	Baseline (1993-1995)	Post-Reform (1996)	Change from Baseline	Simulated Change from Baseline*
Q1	0.6365	0.6533	2.63%	13.58%
Q2	0.8284	0.8465	2.18%	-0.09%
Q3	0.8889	0.8973	0.94%	-0.07%
Q4	0.9121	0.9140	0.21%	-0.59%

* The values for the simulated change in employment rate from baseline are taken from Table 3c, which are based on the quartiles of simulated workers' true productivity levels.

Our model also shows that the 1995 tax reductions lead to an increase in vacancies among low-productivity firms (Figure 3b in Section 6). While it is difficult to find micro-data on vacancies, we provide some evidence on the distribution of employment across firms. Table 11 shows changes in the employment distribution over quartiles of the estimated firm productivity ranks.[52] After the 1995-tax reduction, a larger fraction of employment comes from less productive firms. This is consistent with our simulation findings regarding the shift of vacancies toward less productive firms.

[52] There is one unique ranking per firm in the DADS. Note that small firms for whom we do not have sufficient observations are not ranked. See Table 8.

Table 11: Employment distribution over firm productivity ranks based on data from the *DADS*. The sample is restricted to men aged 30-55 who are primarily employed in non-executive, full-time, private sector jobs. "Employment distribution" is the distribution of employed workers in the four quartile of firms.

	Employment Distribution			
Quartiles in terms of firm rank in DADS	Baseline (1993-1995)	Post-Reform (1996)	Change from Baseline	Simulated Change from Baseline*
Q1	0.1360	0.1372	0.89%	27.5%
Q2	0.2504	0.2595	3.63%	1.7%
Q3	0.3418	0.3409	-0.26%	3.7%
Q4	0.2718	0.2624	-3.46%	-1.2%

* The values for the simulated change in employment rate from baseline are based on the quartiles of simulated firms' true productivity levels.