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JULIEN ALBERTINI, XAVIER FAIRISE

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Layoffs, Recalls and Experience Rating

Julien Albertini* Xavier Fairise†

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Abstract

In the U.S., between 30% and 50% of the unemployment spells end due to the recall of the workers to their last employer. The extensive use of rehiring may amplify labor market fluctuations and may have damaging consequence on the sustainability of the unemployment insurance (UI) system. In order to allocate the UI costs to firms with more volatile employment, the U.S. adopted an experience rating (ER) system. Under the ER system, firms are penalized for their past layoffs through a higher payroll tax in the future. In this paper we investigate the quantitative impact of the ER system on layoffs and recalls. We build a matching model in which heterogeneity in firms' layoffs history give rise to a distribution of tax rates among firms. We present a very detailed data set on firms distribution across tax rate in the U.S. from 1998 to 2016. The model matches a wide spectrum of moments of experience-rated firms distributions found in the data. Our simulations show that experience rating reduces job separations but also recalls in recessions. Unemployment would have been higher, especially in the trough of the Great Recession, in the absence of an experience rating tax.

Keywords: Search and matching, layoffs, recalls, experience rating, unemployment insurance.

JEL Classification: E23; E32; J63; J64; J65

*Gate, University of Lyon II. Corresponding author. Email address: `Julien.Albertini@univ-lyon2.fr`, University of Lyon, 93, chemin des Mouilles, 69131 Ecully, France

†Gains-TEPP, Le Mans University. `xavier.fairise@univ-lemans.fr` Le Mans Université, Avenue O. Messiaen, 72085 Le Mans Cedex 9, France

1 Introduction

In the U.S., between 30% and 50% of the unemployment spells end due to the *recall* of the workers by their last employer (Fujita & Moscarini (2016)). The recall possibility[1] makes firms more prone to use temporary layoffs in recessions as they expect to rehire their former workers in expansions without supporting hiring costs. The greater flexibility of temporary layoffs results in more volatile employment and frequent unemployment episodes which may have damaging consequences on the unemployment insurance (UI) budget. In order to reduce the profitability of temporary layoffs and to stabilize employment, the U.S. adopted an experience rating (ER) system as part of the UI financing. Under the ER system, each firm has a specific UI tax rate that depends on its layoff history. The UI cost of layoffs is charged to the firm from whom the workers separated through a higher tax rate in the future. This paper investigates through the lens of a search and matching model the extent to which the ER system stabilizes the labor market over the business cycle when firms have the ability to recall former employees.

Economic recessions in the U.S. are systematically marked by a sharp rise in unemployment and a sharp drop in hirings. Conversely, these variables typically come back after several years to their pre-crisis levels. The dramatic surge in unemployment that followed the Great Recession and its slow decline in the aftermath of the crisis is one illustrative example of the asymmetries in the labor market. Several papers stress the key role played by hirings in explaining the variations in unemployment (see Elsby et al. (2009) for the discussion). However, the reason why hirings vary over the business cycle is still a lively debate. Does it come from frictions and mismatches, job creations, the intensity of job search or recalls? Fujita & Moscarini (2016) unveil important characteristics on the cyclicality of hirings. They show that more than 40% of laid off employees return to their previous employer after a jobless spell[2]. The recalls rate[3] is highly volatile and strongly procyclical, suggesting an important contribution of recalls to unemployment variations.

The recall option gives firms an alternative to the costly and time-consuming standard hiring process and lowers the uncertainty surrounding the match quality. Even though the firm is not committed to re-initiate the match at a

[1] It should be emphasized that the possibility of recall is "quite naturally". A worker dismissed by an employer remains known by him. For instance, the dismissed worker's contact information are always known by the firm. In other words, the firm keeps the file of the old staff. So, it may be quite easy to recall some former employees if the firm wishes to do it.

[2] Recalls are also prevalent to a lesser extent in European countries and account by between 20% to 40% of all hires. See Winter-Ebmer (1998), Mavromaras & Rudolph (1998), Roed & Nordberg (2003), Jensen & Svarer (2003), Jansson (2002), Alba-Ramirez et al. (2007).

[3] The authors define the recall rate as the share of hirings that correspond to a recall, as opposed to a new jobs. Thorough the paper, we define the recall rate as the number of recalls divided by the number of unemployed.

future date, the possibility of recall creates an implicit attachment between the firm and the worker which may lower job search and involve more frequent unemployment episodes for the workers. When the UI finances temporary layoffs through unemployment benefits, it acts as a subsidy to firms' specific reserve pools of labor. In particular, firms with more volatile employment better benefit from the UI than firms with stable employment. The UI then introduces implicit subsidies among firms with different layoffs history.

ER has been designed to finance the UI in a way that it allocates the costs to firms with more variable employment. It contrasts with the *flat-tax system*[4] adopted in other countries where UI costs are equally shared among firms. The absence of individual incentives may lead to excessive match dissolutions. This effect is further amplified by aggregate fluctuations and countercyclical UI taxes. Indeed, in order to keep the UI budget afloat in flat-tax system, payroll taxes generally increases in recessions and decreases in expansions[5]. Burda & Weder (2016) shows that it raises the magnitude and the persistence of business cycle fluctuations. On the contrary, under the ER system the individual tax adjusts gradually. The smooth adjustment of the tax rate intends to stabilize employment without making firms dealing with heavy labor costs during recessions. Feldstein (1976) and Topel (1983) and several other studies[6] show that the way the UI is financed strongly impacts separation decisions and job search strategies. They underline the usefulness of this bonus-penalty system in reducing layoffs and unemployment but call for a complete ER[7]. Indeed, in the current UI financing, most employers are only partially liable for the benefits that their workers receive. Although the optimal design of the UI financing is an important issue, the focus of the paper remains positive. Our goal is to answer the following questions: how does ER impact the firms' layoff and recall strategies? To what extent does ER stabilize labor market fluctuations? What are the consequences of the implicit subsidies?

Despite the remarkable attention given to ER systems in previous studies the distinction between temporary and permanent layoffs is not considered. Furthermore, non-linearities and the delayed aspect of the tax are not clearly investigated. Last but not least, the heterogeneity in firms' layoff history are absent from previous studies while the core mechanism of ER lies in the ex-

[4]By flat-tax we mean that the tax rate is independent from the firms' experience with unemployment. However, it can differ for low-skilled workers, specific sectors, etc.

[5]See ECD Economic Outlook and Main Economic Indicators databases.

[6]See also Baily (1977), Brechling (1977), Marks (1984), Anderson & Meyer (1993), Anderson & Meyer (2000), Card & Levine (2000), Cahuc & Malherbet (2004).

[7]Complete (or perfect) ER means that firms are entirely liable for the UI benefits paid to laid off employees. The current systems of UI are partly experience-rated. Every dollar of UI benefit paid to a job loser is not entirely charged to the employer from whom the worker separated. The reasons are mainly due to firms closure which can not be charged UI benefits, the slow adjustment of the tax and the existence of statutory tax rates (minimum and maximum).

perience with unemployment and the reduction of implicit subsidies among firms. Measuring the impact of ER clearly requires an adequate modeling of heterogeneity in firms' layoffs history as well as a distinction between recalls and new matches. This study considers a detailed analysis of the ER system and investigates the quantitative impact on the labor market dynamic.

We build a matching model in the spirit of Mortensen & Pissarides (1994) where hirings and separations are endogenous. We make distinguish between permanent and temporary layoffs as in Fujita & Moscarini (2016). The latter resulted in a pool of attached workers that can eventually be recalled but have no date of return. The combination of individual productivity shocks and the ER system generates an endogenous distribution of firms that each have a different tax rate, depending on their layoffs history. We present a very detailed data set[8] on firms distribution across tax rate in the U.S. from 1998 to 2016. We show that our model reproduces fairly well the observed distortions in the distributions over the business cycle. In particular, the model matches the concentration of employment around low tax rates in normal times and the larger fraction of firms subject to high tax rates in recessions. The model also fits well with the strong asymmetries in the labor market. Unemployment and separations increase more during economic contractions than they decrease during expansions. Similarly, hirings fall more during economic downturns than they increase during upturns. Recalls significantly contributes to the non-linear behavior of total hirings.

The second original contribution of this paper is to evaluate the impact of ER on labor market outcomes. To this end, we compare the actual UI financing mode to a flat-tax system. We find that ER reduces job separations and recalls, thereby leading to a lower turnover rate. However, since ER reduces more separations than it reduces hirings, it lowers unemployment. ER affects firms' recall strategies through the expected rise in future tax rates. In particular, the hazard rates show that a firm with a low tax rate quickly recalls its former employees after a dismissal because it anticipates the increase in future UI costs. On the contrary, a firm with a high tax rate is less likely to rapidly use the recall option. As it approaches the maximum rate it expects no further increase in the tax. Simulations also predict that ER has stabilization virtues. In a counterfactual experiments we show that if the US had had a complete flat-tax system, the collapse of the labor market during the Great Recession would have been significantly stronger. In expansions, this scenario would have implied a modest fall in unemployment coming from the higher recall rate. ER then reduces both, the fluctuations and the asymmetries over the business cycle. Lastly, the simulations show that the implicit subsidies do affect the labor market but the average impact on unemployment is rather small.

[8] From DOLETA: Department of Labor, Employment & Training Administration. See appendix for details.

The rest of the paper is organized as follows. Section 2 is devoted to the presentation of the unemployment insurance financing mode. Section 3 presents the search and matching model. Section 4 addresses calibration issues and the model fit. Section 5 investigates policy experiments and Section 6 concludes. We provide a separate appendix describing the model, the calibration and the solution method.

2 The unemployment insurance financing

The States of the U.S. use different methods of experience rating. We will describe the most commonly used method (33 States) known as the *reserve-ratio* method. We mainly follow Brechling (1977), Topel (1983) and Anderson & Meyer (1993). Under the reserve ratio system, each individual firm i has its own account in the State UI fund. Every period, the firm account B_i is credited with the contributions collected and is debited with the benefits paid (by the UI) to the employer's laid off employees. This accounting process defines the next period reserve balance B_i'. Its law of motion writes:

$$B_i' = B_i + \underbrace{\tau_i \, n_i \, w_i^\tau}_{\substack{\text{Contributions} \\ \text{collected}}} - \underbrace{b \, u_i}_{\substack{\text{Benefits} \\ \text{paid}}} \tag{1}$$

Contributions collected correspond to the endogenous tax rate τ_i times the firms taxable wage base w_i^τ per employee times the number of employees in the firm n_i. w_i^τ is set by the UI in each State. It ranges from \$7000 to \$37000 per employee at annual rate. When the wage per employee is lower than the taxable wage base, the entire wage is subject to the tax rate. If the wage exceeds the taxable wage base, only a fraction of the wage is taxable. $b \, u_i$ stands for the benefits payment which are charged to the firm under regular unemployment compensation program. b is the level of unemployment benefits and u_i the pool of unemployed workers that results from the firm's layoff decisions. The account records the firm's experience with unemployment. Dividing the employer's reserve balance by its average taxable payroll gives the reserve ratio:

$$R_i = \frac{B_i}{n_i \, w_i^\tau} \tag{2}$$

The reserve ratio is used instead of the firm's reserve balance for comparison purpose since firms have different payrolls[9]. The reserve ratio is used to establish the tax assessed to an employer according to a specific tax schedule set by

[9]The legal reserve ratio is revised each year and is divided by the average taxable payroll over the past three years. To simplify we assume that the reserve ratio is based on the taxable payroll of the current period.

the UI in each state. Under the reserve ratio method, the tax schedule relates τ to R_i. For example, the Arizona UI tax schedule is plotted in Figure 1. The following approximation could be used to describe this relation:

$$\tau(R_i) = \min(\max(\eta_0 - \eta_1 R_i, \underline{\tau}), \overline{\tau}) \quad (3)$$

η_0, η_1 define the y-intercept of the tax schedule *i.e.* the value of the tax rate for which the reserve ratio is zero and the slope of the tax schedule respectively. $\underline{\tau}$ and $\overline{\tau}$ correspond to the minimum tax rate and the maximum tax rate respectively.

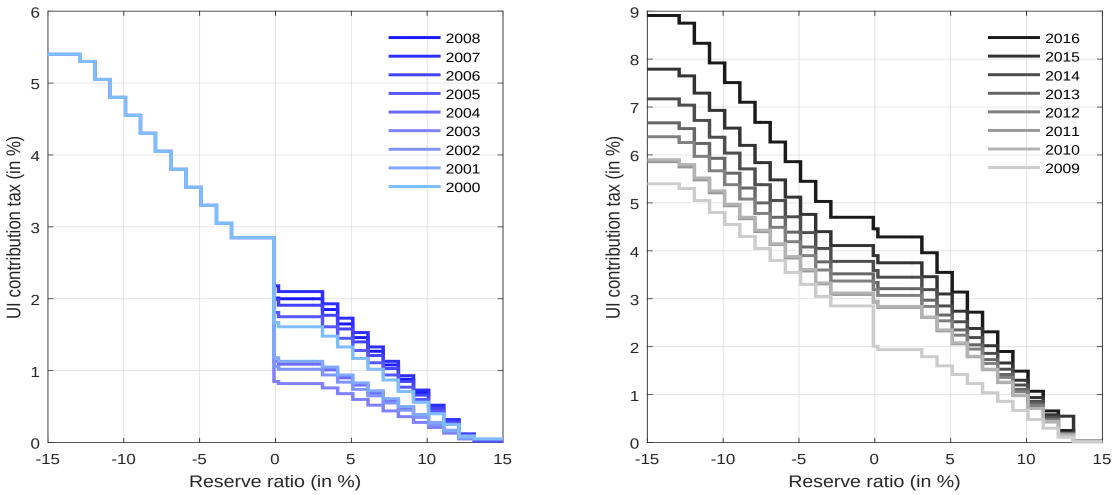

Figure 1: **Unemployment insurance payroll tax schedule.** *Arizona, 2000-2016, Source: Arizona Department of Economic Security.*

The tax schedule calls for several comments. Our objectives is to capture in a rigorous manner the key aspect of the UI financing.

- τ increases in step as R decreases. When the sum of past contributions exceed the amount of unemployment benefits paid to the former employees, the reserve ratio is positive, implying a lower contribution rate in subsequent years and *vice-versa*. The slope of the tax schedule governs the degree at which the firm supports the cost it imposes on the UI. A steeper slope makes the firm more responsible for its dismissal decisions as the tax rate adjusts faster.

- If the reserve ratio strongly decreases, the tax may hit the maximum rate. More layoffs do not results in a higher tax rate. Similarly, at the minimum rate (which can be greater than zero), an increase in hires does not result in a lower contribution rate.

- The tax schedule may change every year. It shifts up following an economic downturn and becomes lighter in normal time. The changes reflect the willingness of the State UI to keep its solvency. The shifting behavior of the tax schedule contrasts with ER mechanism since it affects every firms, no matter their experience with unemployment. It is worth noting that the slope become steeper due to the stronger rise in the maximum rate than that of the minimum rate. In other words, the speed at which the tax rate adjusts to the layoff history is higher during recessions than during expansions. Changes in the tax schedule mainly occurs in deep recessions like in 2008. In good times or tranquil times the tax schedule remains barely unchanged.
- Firm without layoff history (new firms) pay the *new employer rate*. It remains mildly constant over the business cycle but varies between states. In most of the States, its value is the one implied by a zero-reserve ratio.
- The taxable wage base (the basis on which the tax rate is assessed) varies between states and increases with inflation but does not vary so much with the business cycle. The taxable wage base can not exceed the wage rate. On average between 20% and 40% of the total wages are taxable.

3 The model

We build a model based on Mortensen & Pissarides (1994) and Fujita & Moscarini (2016) in which hirings and separations are endogenous. Hiring takes place through the matching process or through the recall process. Wages are the outcome of a bilateral Nash bargaining process between the firm and the worker. Firms are heterogenous in their layoff history. Due to ER the different employment trajectories create an heterogeneity in the tax rate. The model of the UI approximates the *Reserve-ratio method* described previously.

3.1 Economic disturbances

Agents are risk neutral. The discount rate is given by $r > 0$. An homogeneous consumption good, traded on a competitive market, is produced by firms. A firm-worker pair uses one unit of labor and produces a flow of output $p\varepsilon$. p stands for the aggregate component of productivity and is common to all firms. ε denotes the idiosyncratic component of productivity. The two components evolve according to a Markov chain. The aggregate productivity shock occurs with arrival rate λ_p in which case a new value p' is drawn from the c.d.f. $P(p'|p)$. Similarly, λ_ε is the Poisson rate at which new idiosyncratic productivity shocks occur. The new individual productivity ε' is drawn as follows. With a probability δ, the new productivity is $\varepsilon' = 0$. This is an absorbing state so that the pair will definitely separate. With a probability $1 - \delta$, a new productivity ε' is drawn form the c.d.f. $G(\varepsilon'|\varepsilon)$.

We borrow from Fujita & Moscarini (2016) the modeling of the recall option. A firm and a worker (a pair or a match) can agree to suspend the production. This decision is taken if the match no longer generates a positive joint surplus. This may occur following an aggregate or an idiosyncratic shock (provided that the individual productivity remains strictly positive). After this decision, the relationship continues to exist and the match may be reactivated (in the event of a favorable evolution of productivity through an evolution of p or ε). The unemployed worker is "attached" to the firm as long as its idiosyncratic productivity is higher than zero. We assume the idiosyncratic productivity of a mothballed match ε continues to evolve as for an active match. The arrival rate is λ_ε. When a new idiosyncratic productivity is drawn, $\varepsilon' = 0$ appears with a probability δ. In that case, the match is forever destroyed (permanent layoff) and the unemployed worker is no longer attached to its former employee. Finally, with a probability $1 - \delta$, ε' is drawn from[10] $G(\varepsilon'|\varepsilon)$. It should be stressed that when a match is mothballed, the *attached* unemployed worker holds the possibility to search for a new job. If he uses his option and finds a new job, the firm loses its recall option. All firms belonging to an inactive match may search for an alternative match partner. However, in equilibrium they all have an interest to exclusively opt for the recall[11].

3.2 A proxy for the UI experience rating

The experience rating system described by the equations (1)-(3) will be adapted[12] to the case of a firm-worker pair alternating production and non-production periods. We denote by $\ell = \{1, 2, ..., L\}$ the firm-worker type associated to an employment history or, equivalently, a value of the reserve ratio. The basic idea is to link the tax rate to the type ℓ and to determine the evolution of types that produce similar variations of the tax rate than that of the original reserve ratio method. The higher the firm-worker type, the lower the tax rate. If no separation occurs the firm-worker pair of type ℓ becomes of type $\ell' = \ell + 1 \leq L$ with probability $\psi_n(p)$. As long as the employment relationship goes on, the reserve ratio increases due to the contributions collected. Recall that the firm has only one job which is either filled ($n_i = 1$, $u_i = 0$) or unfilled ($n_i = 0$, $u_i = 1$). Then, the reserve ratio either increases or decreases. $\psi_n(p)$ governs the pace at which the firm-worker pair switches type

[10] Fujita & Moscarini (2016) notice that the idiosyncratic productivity of an inactive match could be drawn from a conditional distribution different from $G(\varepsilon'|\varepsilon)$. For the sake of simplicity, and following Fujita & Moscarini (2016), we suppose the two distributions are the same.

[11] We show this issue in the supplementary appendix.

[12] For tractability reasons. In particular the model remains block recursive and the grid defining the proxy for the reserve ratio does not have to be extremely fine to match the data.

and benefits from payroll tax reductions. We describe later how we define the functional forms of the tax rate and the transition rates. When the firm-worker pair has reached the type L, it does not change type as long as no separation occurs, the minimum tax rate being reached.

An active firm-worker pair of type ℓ may be dissolved or mothballed. In case of a temporary layoff (the match is mothballed), it results in a type-ℓ inactive firm-worker pair. The worker is unemployed but remains attached to the firm. We can then refer to a type-ℓ vacancy-unemployed worker pair. An inactive pair follows the reverse path. From type $\ell = L$ to type $\ell = 2$, inactive firm-worker pairs of type ℓ become of type $\ell - 1$ at rate $\psi_u(p)$. $\psi_u(p)$ governs the speed at which a suspended job switches type and supports a higher payroll tax in case of a recall. When an inactive pair reaches the type $\ell = 1$, the maximum tax rate would be applied in case of recall and the pair keeps this type as long as the pair remains inactive. What can happen to a type-ℓ inactive pair? In case of a favorable evolution of productivity, the pair may be reactivated, the firm being able to recall its former employee as long as the latter does not find a new job. In case of a recall, the inactive firm-worker pair previously of type ℓ restarts an employment relationship of type ℓ. If the worker finds a new job, a new firm-worker pair of type M is formed. This type-M job characterizes new matches for which the "new employer rate" applies. Indeed, new employers do not have an employment history and their reserve ratio can not be calculated. They are assessed a particular tax rate which is usually the one implied by a zero reserve ratio.Transitions between types are depicted in Figure 2. The law of motion of ℓ can be summarized as follows:

$$\ell' = \begin{cases} \min(\ell+1, L) & \text{with probability } \psi_n(\ell) \quad \text{in active jobs} \\ \max(\ell-1, 1) & \text{with probability } \psi_u(\ell) \quad \text{in suspended jobs} \\ \ell & \text{otherwise} \end{cases}$$

The key variables of our approximation of the ER system are $\tau(p,\ell)$, $\psi_u(p)$ and $\psi_n(p)$. There is a micro or firm specific aspect of ER expressed by the dependence of $\tau(p,\ell)$ to the type ℓ of the pair[13]. It should be stressed that shifts in the tax schedule as a whole may occur over time. Those shifts are not simply translations. The slope of the tax schedule varies over the business cycle and leads to slower (expansion) or faster (recession) adjustments of the tax rate. This macroeconomic indexation of the tax schedule is captured by the dependence of the tax rate $\tau(p,\ell)$ and the transition rates $\psi_u(p)$ and $\psi_n(p)$ to the aggregate productivity p. Throughout the paper, we well refer to the *macro indexation* of the tax schedule.

[13]Our model naturally encompasses the statutory tax rates due to the bounds on employment types *i.e.* $\max(\ell, 1)$ for the maximum rate and $\min(\ell, L)$ for the minimum rate.

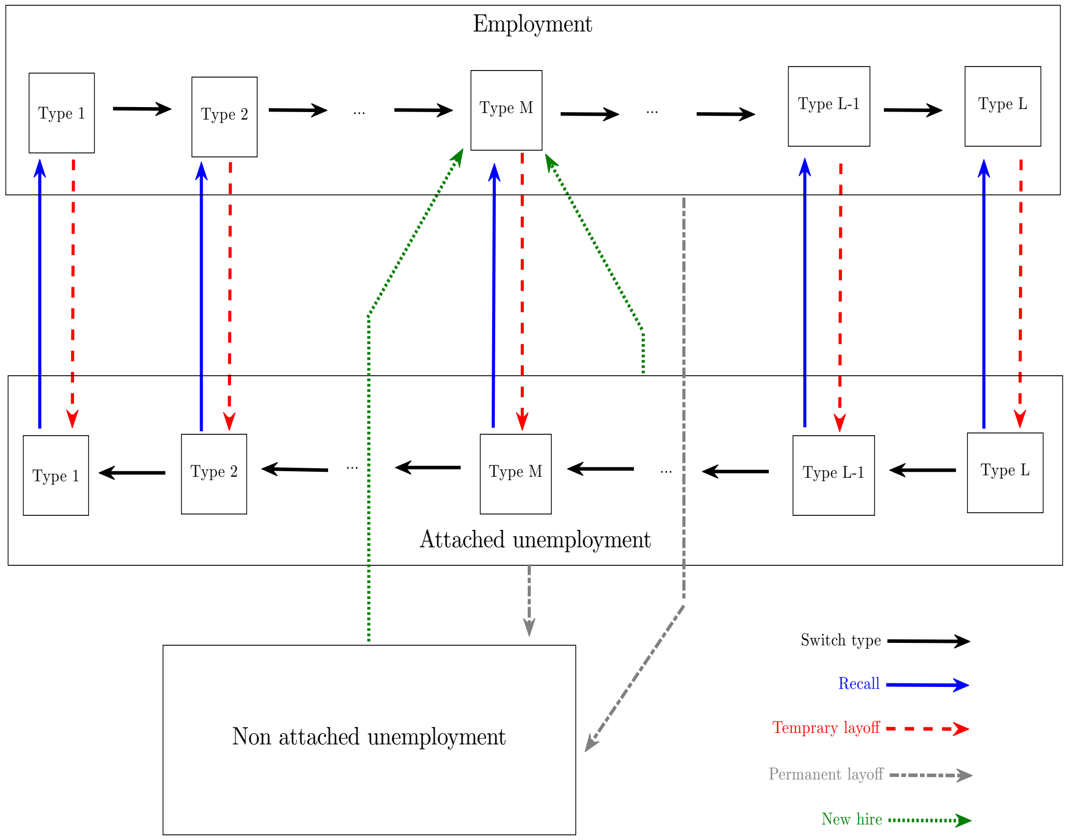

Figure 2: **Labor market transitions.** *New hires (green dotted line) from attached unemployment concern every type of unemployed workers. Similarly, permanent layoffs from employment (gray dashed line) concern every type of employed workers. Attached unemployed workers become unattached unemployed workers at the same rate than that of employed workers i.e.* δ.

Regarding the transition rate, we distinguish between active jobs and suspended jobs. The reason is that UI contributions per employee in active jobs are lower than the benefits paid per unemployed worker in a suspended job. The reserve ratio then decreases faster when the job is vacant than it increases when the job is active. In other words, if the pair is inactive and if it lasts, the payroll tax to be applied in case of recall will "quickly" be higher. This mechanism shall provide incentives to the firm to minimize the duration of inactivity spells and helps to balance the firm's UI account.

Finally, new matches, which naturally have no layoff history, start with a rate $\tau(p, M)$, whatever the previous type of the worker. In the short-run the UI benefits may outweigh contribution collected. For simplicity we assume that a lump-sum tax balanced the UI budget.

3.3 Matching technology and match acceptance

The search process and recruiting activities are costly and time-consuming for firms and workers. Every unemployed workers (attached and non attached) are engaged in the search process. Firms search for a worker to fill a vacancy, incurring a cost $c_v > 0$. Denote by $u \geq 0$ the number of unemployed workers and $v \geq 0$ the mass of vacancies. The number of matches, m, is given by the following Cobb-Douglas matching function:

$$m = \mu u^{\alpha} v^{1-\alpha} \leq \min(u, v) \tag{4}$$

The labor force is assumed to be constant over time and normalized at 1. The matching function (4) is increasing and concave in its two arguments. A vacancy is filled with probability $q = m/v$ and an unemployed worker finds a job with probability $\phi = m/u$. It should be stressed that these two probabilities only depend on the aggregate productivity: $\phi(p)$ and $q(p)$.

We denote by $J(p, \varepsilon, \ell)$, $V(p, \varepsilon, \ell)$, $W(p, \varepsilon, \ell)$ and $U(p, \varepsilon, \ell)$ the value of a filled job for the firm, the value of a vacant job for the firm, the value of an employed worker and the value of an unemployed worker respectively. A value depends on three variables: (i) the aggregate productivity p, (ii) the idiosyncratic productivity ε, and (iii) the type ℓ determining the payroll tax level. A firm-worker pair is active if[14]:

$$W(p, \varepsilon, \ell) \geq U(p, \varepsilon, \ell) \quad \text{and} \quad J(p, \varepsilon, \ell) \geq V(p, \varepsilon, \ell)$$

Both the firm and the worker accept the match, or accept to continue production if the above condition is satisfied. In the case of an inactive pair, the firm may recall its former employee as long as the latter does not find a new job. The recall occurs if the above condition is satisfied again (following a favorable evolution of the aggregate or idiosyncratic productivity). A match that is characterized by the following conditions $W(p, \varepsilon, \ell) < U(p, \varepsilon, \ell)$ (and $J(p, \varepsilon, \ell) < V(p, \varepsilon, \ell)$) is inactive.

An unemployed worker belonging to an inactive pair has a recall option $U(p, \varepsilon, \ell)$ but also searches for a new job. Then, if a new match occurs, a new individual productivity ε' is drawn from $F(\varepsilon')$ that is independent from today's productivity. However, given its current productivity ε and the new one ε', the unemployed worker decides whether he accepts or turns down the offer. We have the following acceptance conditions:

$$\begin{array}{ll} \text{Worker:} & W(p, \varepsilon', M) \geq U(p, \varepsilon', M) \text{ and } W(p, \varepsilon', M) \geq U(p, \varepsilon, \ell) \\ \text{Firm:} & J(p, \varepsilon', M) \geq V(p, \varepsilon', M) \end{array}$$

[14]Due to the Nash sharing rule, if one of the two bargainers accepts the match, the other also accepts the match.

The probability that a new match is acceptable writes:

$$a(p,\varepsilon,\ell) = \int \mathbb{1}\{W(p,\varepsilon',M) \geq \max(U(p,\varepsilon',M), U(p,\varepsilon,\ell))\} dF(\varepsilon') \qquad (5)$$

The expected gain of searching a job, conditional on having a contact with a vacant job, of a worker who has a recall option is:

$$\begin{aligned} \Omega(p,\varepsilon,\ell) &= \int \mathbb{1}\{W(p,\varepsilon',M) \geq U(p,\varepsilon',M)\}[\max(W(p,\varepsilon',M), U(p,\varepsilon,\ell)) \\ &- U(p,\varepsilon,\ell)] dF(\varepsilon') \qquad (6) \end{aligned}$$

3.4 Bellman equations

The expected value for a firm with a filled job is given by the following Bellman equation:

$$\begin{aligned} rJ(p,\varepsilon,\ell) &= p\varepsilon - w(p,\varepsilon,\ell) - \tau(p,\ell) w^{\tau}(p,\varepsilon,\ell) \\ &+ \mathbb{1}\{\ell < L\}\psi_n(p)\big[\max(J(p,\varepsilon,\ell'), V(p,\varepsilon,\ell')) - J(p,\varepsilon,\ell)\big] \\ &+ \lambda_p \int [\max(J(p',\varepsilon,\ell), V(p',\varepsilon,\ell)) - J(p,\varepsilon,\ell)] dP(p'|p) \qquad (7) \\ &+ \lambda_\varepsilon \Big\{ \delta[\max(J(p,0,M), V(p,0,M)) - J(p,\varepsilon,\ell)] \\ &+ (1-\delta) \int [\max(J(p,\varepsilon',\ell), V(p,\varepsilon',\ell)) - J(p,\varepsilon,\ell)] dG(\varepsilon'|\varepsilon) \Big\} \end{aligned}$$

with $w(p,\varepsilon,\ell)$ being the wage and $w^{\tau}(p,\varepsilon,\ell)$ the taxable wage base. The first term is the present value and corresponds to instantaneous profit *i.e.* the worker productivity $p\varepsilon$ minus wage and UI costs. The expected value gives rise to three possibilities. First, the job switches type at rate $\psi_n(p)$, the new type being $\ell' = \ell + 1$ if $\ell < L$. Second, with rate λ_p the job is hit by an aggregate productivity shock, leading a temporary separation if the new value of the firm is lower than the value of a vacancy. Third, with arrival rate λ_ε the job is hit by an idiosyncratic productivity shock. The job is permanently destroyed with an exogenous probability δ. If the job is not permanently destroyed, a new individual productivity is drawn from G with probability $1-\delta$, involving a separation if the job value falls below the one of a vacant job.

The value of a firm with a vacant job is somewhat more cumbersome due to the recall option. It writes as follows:

$$
\begin{aligned}
rV(p,\varepsilon,\ell) &= \mathbb{1}\{\ell > 1\}\psi_u(p)\big[\max(J(p,\varepsilon,\ell'),V(p,\varepsilon,\ell')) - V(p,\varepsilon,\ell)\big] \\
&+ \lambda_p \int [\max(J(p',\varepsilon,\ell),V(p',\varepsilon,\ell)) - V(p,\varepsilon,\ell)]dP(p'|p) \\
&+ \lambda_\varepsilon \Big\{ \delta[\max(J(p,0,M),V(p,0,M)) - V(p,\varepsilon,\ell)] \\
&+ (1-\delta)\int [\max(J(p,\varepsilon',\ell),V(p,\varepsilon',\ell)) - V(p,\varepsilon,\ell)]dG(\varepsilon'|\varepsilon) \Big\} \\
&+ \mathbb{1}\{\phi(p)\Omega(p,\varepsilon,\ell) \geq 0\}a(p,\varepsilon,\ell)\phi(p)(V(p,0,M) - V(p,\varepsilon,\ell))
\end{aligned} \tag{8}
$$

The first term on the right-hand side of Equation (8) involves that the vacant job switches type at rate $\psi_u(p)$ and becomes type $\ell' = \ell - 1$ if $\ell > 1$. In that case, the firm recalls its former employee if the value of a filled job exceeds the value of the vacant job. When the vacant job is hit by an aggregate productivity shock, the firm may decide to recall its former employee. Similarly, if the job is hit by an idiosyncratic productivity and is not destroyed permanently, a recall may occur depending on whether the surplus from a filled job is larger than that of a vacant job. The last term on the right-hand side of Equation (8) shows that the loss of the recall option occurs when the unemployed worker finds a job at rate $\phi(p)$ and accepts it at rate $a(p,\varepsilon,\ell)$ given the gains of an unemployed worker searching for a job $\Omega(p,\varepsilon,\ell)$. In that case the value of a vacant job becomes $V(p,0,M)$ (determination later).

The value of an employed worker is defined as follows:

$$
\begin{aligned}
rW(p,\varepsilon,\ell) &= w(p,\varepsilon,\ell) + \mathbb{1}\{\ell < L\}\psi_n(p)\big[\max(W(p,\varepsilon,\ell'),U(p,\varepsilon,\ell')) - W(p,\varepsilon,\ell)\big] \\
&+ \lambda_p \int [\max(W(p',\varepsilon,\ell)),U(p',\varepsilon,\ell))) - W(p,\varepsilon,\ell))]dP(p'|p) \\
&+ \lambda_\varepsilon \Big\{ \delta[\max(W(p,0,M),U(p,0,M)) - W(p,\varepsilon,\ell)] \\
&+ (1-\delta)\int [\max(W(p,\varepsilon',\ell),U(p,\varepsilon',\ell)) - W(p,\varepsilon,\ell)]dG(\varepsilon'|\varepsilon) \Big\}
\end{aligned} \tag{9}
$$

As for the value of the firm, the expected value gives rise to similar possibilities. The job switches type at rate $\psi_n(p)$. With rate λ_p the job is hit by an aggregate productivity shock, leading either to a separation or to job continuation. With rate λ_ε the employment relationship ceases permanently at rate δ or temporarily if the new individual productivity drives the employed value function below the one of an unemployed worker $U(p,\varepsilon',\ell)$. Unemployed worker value function writes:

$$
\begin{aligned}
rU(p,\varepsilon,\ell) &= b+h+\mathbb{1}\{\ell>1\}\psi_u(p)\big[\max(W(p,\varepsilon,\ell'),U(p,\varepsilon,\ell'))-U(p,\varepsilon,\ell)\big] \\
&+ \lambda_p\int[\max(W(p',\varepsilon,\ell),U(p',\varepsilon,\ell))-U(p,\varepsilon,\ell)]dP(p'|p) \\
&+ \lambda_\varepsilon\Big\{\delta[\max(W(p,0,M),U(p,0,M))-U(p,\varepsilon,\ell)] \\
&+ (1-\delta)\int[\max(W(p,\varepsilon',\ell),U(p,\varepsilon',\ell))-U(p,\varepsilon,\ell)]dH(\varepsilon'|\varepsilon)\Big\} \\
&+ \max(0,\phi(p)\Omega(p,\varepsilon,\ell))
\end{aligned}
\tag{10}
$$

where b stands for unemployment benefits and h for home production. The recall occurs either if the switching of the worker's type, the idiosyncratic shock or the the aggregate shock are such that the worker is better off in employment than in unemployment. Finally the unemployed worker is searching for a job if the expected gains $\phi(p)\Omega(p,\varepsilon,\ell)$ is positive.

3.5 Job creation condition

When $\varepsilon=0$, in absence of a recall option, Equation (8) becomes:

$$
rV(p,0,\ell) = q(p)\int[\mathbb{1}\{J(p,\varepsilon',\ell)\geq V(p,\varepsilon',\ell)\}(J(p,\varepsilon',\ell)-V(p,0,M))dF(\varepsilon')-c_v
$$

The free entry condition ensures that $V(p,0,\ell)=0$. It implies:

$$
q(p)\int\mathbb{1}\{J(p,\varepsilon',\ell)\geq V(p,\varepsilon',\ell)\}J(p,\varepsilon',\ell)dF(\varepsilon',\ell)=c_v \tag{11}
$$

This condition shows that the expected gain from hiring a new worker is equal to the average cost of search (which is the marginal cost of a vacancy times the average duration of a vacancy $c_v/q(p)$).

3.6 Wage negotiation

Wages are determined through an individual Nash bargaining process between each worker and the employer who share the total surplus of the match. The outcome of the bargaining process is given by the solution of the following maximization problem:

$$
\max_{w(p,\varepsilon,\ell)} \; (J(p,\varepsilon,\ell)-V(p,\varepsilon,\ell))^{1-\beta}(W(p,\varepsilon,\ell)-U(p,\varepsilon,\ell))^{\beta} \tag{12}
$$

The optimality condition of the above problem is given by:

$$\beta(J(p,\varepsilon,\ell) - V(p,\varepsilon,\ell)) = -(1-\beta)\frac{\partial J(p,\varepsilon,\ell)}{\partial w(p,\varepsilon,\ell)}(W(p,\varepsilon,\ell) - U(p,\varepsilon,\ell)) \quad (13)$$

where $\beta \in [0,1]$ and $1-\beta$ denote the firms' and workers' bargaining powers respectively[15]. The taxable wage base may differ from the wage. Let $\bar{w}$ be the threshold above which the wage is not subject to the tax rate. Formally it writes:

$$w^{\tau}(p,\varepsilon,\ell) = \min(w(p,\varepsilon,\ell),\bar{w}) \quad (14)$$

which involves the following derivative for the Nash Bargaining rule:

$$\frac{\partial J(p,\varepsilon,\ell)}{\partial w(p,\varepsilon,\ell)} = \begin{cases} -1 & \text{if } w(p,\varepsilon,\ell) > \bar{w} \\ -(1+\tau(p,\ell)) & \text{otherwise} \end{cases} \quad (15)$$

4 Quantitative analysis

4.1 Calibration strategy

The model is calibrated at weekly frequencies. We set the steady state interest rate r to 0.1%, which more or less corresponds to a 5% annual rate. The other parameters are chosen as follows.

Productivity. The aggregate shock p and the individual shock ε both evolve according to an order-one autoregressive process with parameters ρ_p, σ_p, ρ_ε and σ_ε. The steady state level of p and ε is one. To solve and simulate the model, the two stochastic processes are discretized using Rouwenhorst method. For each shock, the discretization method provides a transition matrix and a grid points[16]. We choose 21 points for the aggregate shock and 49 grid points for the individual shock. The values of λ_p, λ_ε, ρ_p and ρ_ε are taken from Fujita & Moscarini (2016). We set $\lambda_\varepsilon = 3/13$ in such a way that idiosyncratic shocks arrive on average every month while aggregate shocks arrive every quarter, which corresponds to $\lambda_p = 1/13$. One also has $\rho_p = 0.97$ and $\rho_\varepsilon = 0.97$. The standard deviation of the aggregate shock is set in such a way that the simulated unemployment rate lies in the range of its empirical counterpart, that is between 4.5% and 12%. We obtain $\sigma_p = 0.02$. The determination of the value of σ_ε is explained later. In case of a new match, the individual productivity ε' is drawn from $F(\varepsilon')$ which does not depend on the past productivity. We suppose ε' is drawn from a uniform distribution for simplicity.

[15]Due to the complexity of the wage structure, we report the calculation in the separate appendix.

[16]The matrix coefficients depend on the autoregressive coefficient while the grid points depend on the standard deviation and the autoregressive coefficient.

Labor market, stocks and flows. Because the paper focuses on the UI, our strategy to calibrate the rest of the parameters is somewhat different than that of Fujita & Moscarini (2016). In particular we target the following first-order moments: (1) the unemployment rate, (2) the separation rate, (3) the recall rate and (4) the job finding rate (new jobs). The steady state u is 5.5% on average over the last three decades. The total separation rate is 3.2% on a monthly basis according to JOLTS. It includes quits, layoffs and discharges. Fujita & Moscarini (2016) find that the EU separation rate is 1.4% per month using SIPP. Fujita & Moscarini (2016) calculate that the total job finding rate is around 27%, 14% for new matches and 13% for recalls. To hit the mark of the target, we use four parameters: the efficiency of the matching function μ, the exogenous job destruction rate δ, the standard deviation of the individual shock σ_ε and the cost of posting a vacancy c_v. The average unemployment rate is 4.5%, slightly lower than its empirical counterpart. The simulated separation rate almost reaches the targeted value 1.5%. The recall rate and the probability to find a new job are both slightly higher than the ones found in the data. We obtain $\mu = 0.06$, $\delta = 0.0008$, $\sigma_\varepsilon = 0.035$ and $c_v = 0.5$. Long-run levels are presented in Table 2. Finally, we impose $\alpha = 0.5$ and $\beta = 1 - \alpha$ as it is standard in the literature. The calibrated parameters are presented in Table 1.

Variables	Symbol	Value	Source
Real interest rate	r	0.001	5% annual rate
Arrival rate of aggregate shock	λ_p	1/13	1 shock every quarter
Autocorr. coefficient	ρ_p	0.97	Target productivity persistence
Std. of p_t	σ_p	0.02	Target productivity volatility
Arrival rate of aggregate shock	λ_ε	3/13	Fujita & Moscarini (2016)
Autocorr. coefficient	ρ_ε	0.94	Target separation rate persistence
Std. of ε_t	σ_ε	0.035	Target mean separation rate
Vacancy posting costs	c_v	0.5	Target recall rate
Unemployment benefits	b	0.07	Target Replacement rate 36% (OECD)
Home production	h	0.44	Deduced to balance wage equation
Matching elasticity	α	0.5	Pissarides & Petrongolo (2001)
Exogenous Separation rate	δ	0.0008	Target separation rate
Worker bargaining power	β	0.50	Hosios condition satisfied

Table 1: **Calibrated parameters**

Variables	Data	Model
Unemployment rate	5.5	4.5
Separation rate	1.4	1.5
Recall rate	12.8	18.9
Job finding rate	14.8	16.6
Total JF prob.	27.7	35.5

Table 2: **UNCONDITIONAL MEANS.**

4.2 UI experience rating

4.2.1 Data

In order to calibrate the UI, we use data from DOLETA[17] on firms' distribution per level of tax. This aggregate data set provides the distribution of (*i*) employers, (*ii*) taxable payrolls, (*iii*) total payrolls, and (*iv*) total contributions as a function of the tax rate. For instance it shows how many employers have a tax rate between 0 and 0.1%, between 0.1% and 0.2%, etc. The distributions are available for almost each State of the U.S. and since almost two decades on a yearly basis. Additionally, DOLETA publishes four observations that are useful for the UI calibration: (*v*) the ratio of taxable wages to total wages, (*vi*) the new employer tax rate, (*vii*) the minimum tax rate and (*viii*) the maximum tax rate. Figure 3 shows the distributions (*i*) to (*iv*). On average, most of employment and wages are concentrated around low tax rates *i.e.* less than 2%. All distributions are asymmetric with positive skewness. The contributions of firms with a high tax rate to the financing of the UI is shown to be marginal compared to firms with a low tax rate. A very few number of firms support a tax rates above 10%.

The distributions of the variables (*v*) to (*viii*) show that the ratio of taxable to total wages may be very heterogenous among States but most of the States have a ratio between 20% and 40%. The mode of the distribution of the new employer rates is 2.7% but many States adopt a lower tax rate. The observed minimum tax rates are mostly around zero. However, several States who experienced difficulties during the Great Recession have raised the minimum rate up to 2%. As for the minimum rate, the distribution of the maximum rate across States and over time is positively skewed. The average value is around 7%.

[17]See appendix B.2 for details.

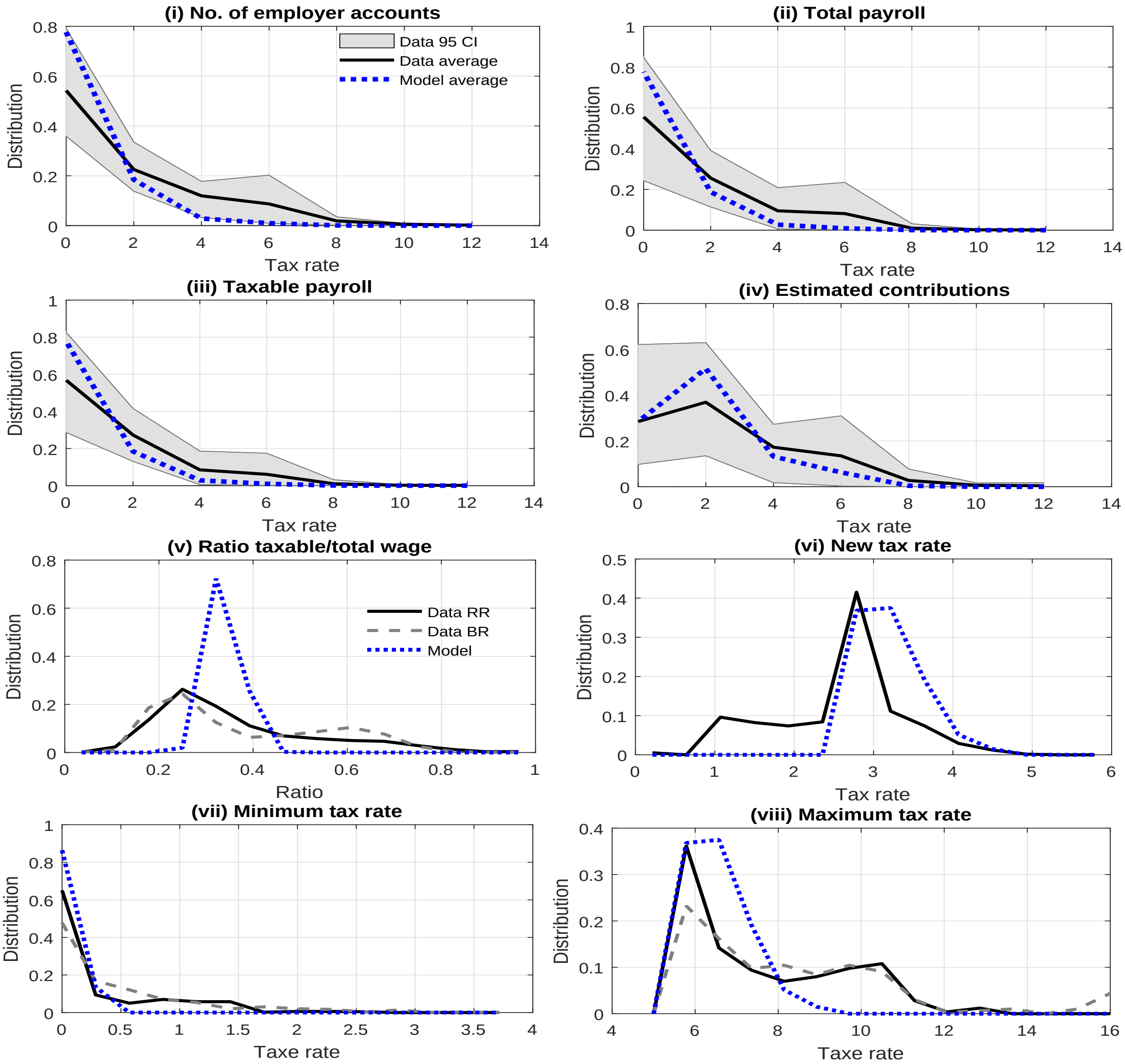

Figure 3: **Distributions.** *The distributions in the model are computed by simulating the model over 11000 weeks horizons, replicated 10 times and average the time series. We discard the first 1000 observations. RR: Reserve Ratio method, BR: Benefit Ratio method.*

4.2.2 Calibration of the UI

Our objective is to reproduce the eight distributions presented above[18]. In the model, the UI is characterized by (1) the tax schedule $\tau(p,\ell)$, (2) the transition rates $\psi_n(p)$ and $\psi_u(p)$, (3) the taxable wage base $\bar{w}$ and (4) the new employer

[18]We could also target the distortions in the distributions over time. For the sake of simplicity, we focus on average values in order to calibrate the UI parameters. We investigate latter how the model performs over the business cycle.

type M. To set (1) and (2) we consider a similar version of the tax schedule than that of Equation (3):

$$\tau(p,\ell) \quad = \quad \eta_0(p) - \eta_1(p)\,\ell \tag{16}$$

where η_0 stands for the y-intercept and η_1 the slope of the tax schedule. Both are state-dependant due to the shifts in the tax schedule. In line with the observed stability of the tax schedule in good times (see Figure 1) we assume that $\tau(p,\ell)$ does not change with p when $p \geq \tilde{p}$[19]. Furthermore, to minimize the number calibrated parameters we only set $\eta_0(p)$ and $\eta_1(p)$ at ($p = \tilde{p}$) and in the worst state ($p = \underline{p}$). Intermediate values *i.e.* $p \in]\underline{p}, 1[$ are assumed to be equidistant between the less and the more cumbersome tax schedule. Using a linear transformation[20], one can express the entire tax schedule as a function of four parameters: the minimum and the maximum tax rate when $p = \tilde{p}$ and when $p = \underline{p}$. The values are determined to fit the observed distributions (panel vii and viii). The implied distributions of the minimum and the maximum tax rates are very similar in shape than that of the data. Panel a of Figure 4 displays the tax schedule in the model. We obtain a minimum rate that ranges from 0.1% to 0.6%, depending on the aggregate productivity. The maximum rate ranges from 5.4% to 10%, which encompasses most of observed values. The shifts in the tax schedule are larger in low-type jobs than in high-type jobs, consistent with the heavier penalty for firms with negative reserve ratio.

We proceed in the same manner for the transition probabilities $\psi_n(p)$ and $\psi_u(p)$. We impose a constant value in good times. We set $\psi_n(p)$ and $\psi_u(p)$ when $p = \tilde{p}$ and in the worst state ($p = \underline{p}$) and assume that intermediate values range equidistantly in between the bounds. Again, they are four parameters that must be determined. Our strategy is to pin down the 4-tuples that best fit the distributions (*i*) to (*iv*). We use a minimization routine to bring the model's average distributions to their empirical counterparts. The simulated distributions are broadly consistent with the data. The model reproduces the concentration of employment and wages at low tax rates. It also matches the positive skewness in all distributions but predicts a slightly thinner tail than in the data. Panel b of Figure 4 displays the resulting transition probabilities. First, ψ_u is several times higher than ψ_n. This result is consistent with the fact that the reserve ratio decreases more rapidly when the job is suspended than it increases when the job is active. Indeed, the UI benefits paid to a job loser are larger than the contributions paid by the firm to the UI. Second, when the aggregate productivity falls, descending transitions are faster while ascending transitions are slower. The former aspect is consistent with the steeper slope of the tax schedule in recessions. The latter aspect arises from the persistent

[19] The aggregate productivity p have the following support $\{\underline{p}, ..., \tilde{p}, ..., \overline{p}\}$. At the steady state $p = 1$. $\tilde{p}$ can be above or below 1.

[20] See supplementary appendix for calculus.

effects of high tax rates. When the tax rate reaches high levels, it takes several years for the firms to benefit from a decline in the tax rate.

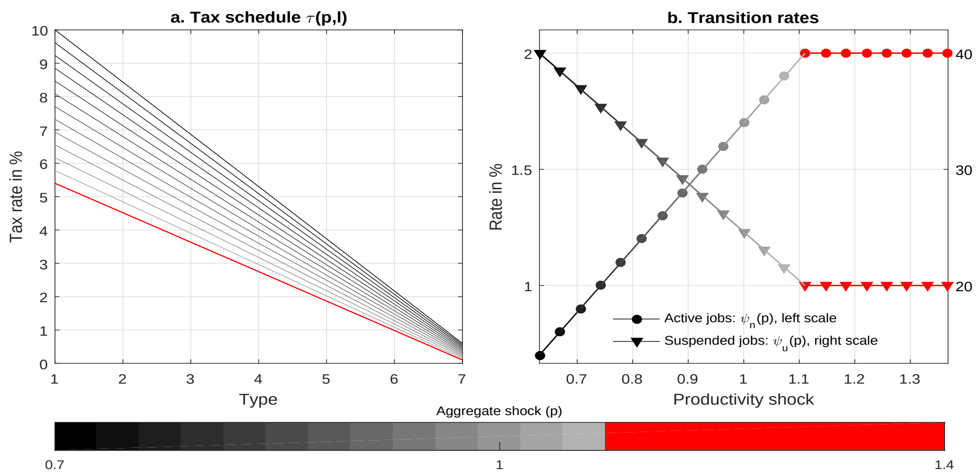

Figure 4: **MODEL TAX SCHEDULE.**

We set $\bar{w}$ in order to match the average ratio of the taxable payroll over total payroll. The distribution of the model's ratio does not imply so much variations as it is the case in the data but the mean is accurately reproduced. Last but not least, the average new employer rate is around 2.7% in the data. To match the average new employer tax rate we consider that the new employer type M is equal to type-4, the middle type according to the range considered.

4.3 Recall and unemployment

4.3.1 Contribution of recalls

What is the respective contribution of temporary and permanent layoffs to total compensated unemployment? Using the Continuous Wage and Benefit History (CWBH) system and telephone interviews in Missouri and Pennsylvania between 1979 and 1980, Katz & Meyer (1990) investigate how many unemployment spells are accounted for by ex post temporary layoffs (resulting in recalls). They show that 57% of the unemployment spells end in recall but those spells account for by 32% of the weeks of unemployment of UI recipients. Using SIPP data over the period 1993-2013, Fujita & Moscarini (2016) find a recall share of hires equal to 46.4%. Temporary layoffs occur more frequently but are short-lived compared to permanent layoffs. In Katz & Meyer (1990), the average duration of the former is 8.4 weeks and the latter is 17.0 weeks.

We simulate individual trajectories and obtain results in line with the aforementioned authors. From Table 3, recalls account for 50% of unemployment spell but only 43% of the weeks of unemployment. The average mean duration of ex post temporary layoffs is around 10 weeks while it is 17 weeks for permanent layoffs (new job). These results highlight the important contribution of temporary layoffs in explaining unemployment. Albeit temporary layoffs are short-lived, the frequency at which they occur involves significant costs on the UI.

	Recall	New job
% of unemployment spell	49.9	50.1
% of week unemployment	42.8	57.2
Mean duration (weeks)	10.5	17.2

Table 3: **RECALLS AND UNEMPLOYMENT SPELL.**

4.3.2 Hazard rates

In order to investigate the distinctive properties between recalls and new matches we compute the hazard rates *i.e.* the fraction of unemployed workers who exit unemployment as a function of their unemployment duration. Fujita & Moscarini (2016) estimate the hazard rates using SIPP data from 1996 to 2008 and distinguish between recalls and new jobs[21]. They found a rapid decrease of the recall hazard rate when the unemployment duration increases. In other words, the longer the unemployment spell, the less likely the unemployed is to be recalled. It falls from around 20% after one month to around 7% after 6 months. On the contrary, the new jobs hazard rate remains relatively stable over the first 6 months of unemployment. Its value lies between 10% and 15%, depending on the sub-sample considered. The observed total hazard rate falls from around 35% after one month to 20% after 6 months.

As shown in Figure 5 the model matches the different hazard rates fairly well. It reproduces the flat shape of the new hires hazard rate (panel b) and the declining profile of the recall hazard rate (panel c). However, by averaging firms with different tax rates, the latter hides important heterogeneities. A striking aspect of ER is that the recall hazard rate strongly depends on the tax rate (Panel d). High-type firms (low tax rate) are more likely to recall short-terms unemployed workers while the opposite is true for low-type firms (high tax rate).

[21]Figure 1 in their paper. We define the recall hazard rate as to the probability - conditional on an unemployment spell - that an unemployed worker is recalled. Then, the declining profile of the hazard rate involves that the longer the unemployment spell the lower the probability of being recalled. The new job hazard rate corresponds to the probability - conditional on an unemployment spell - that an unemployed worker finds a new job.

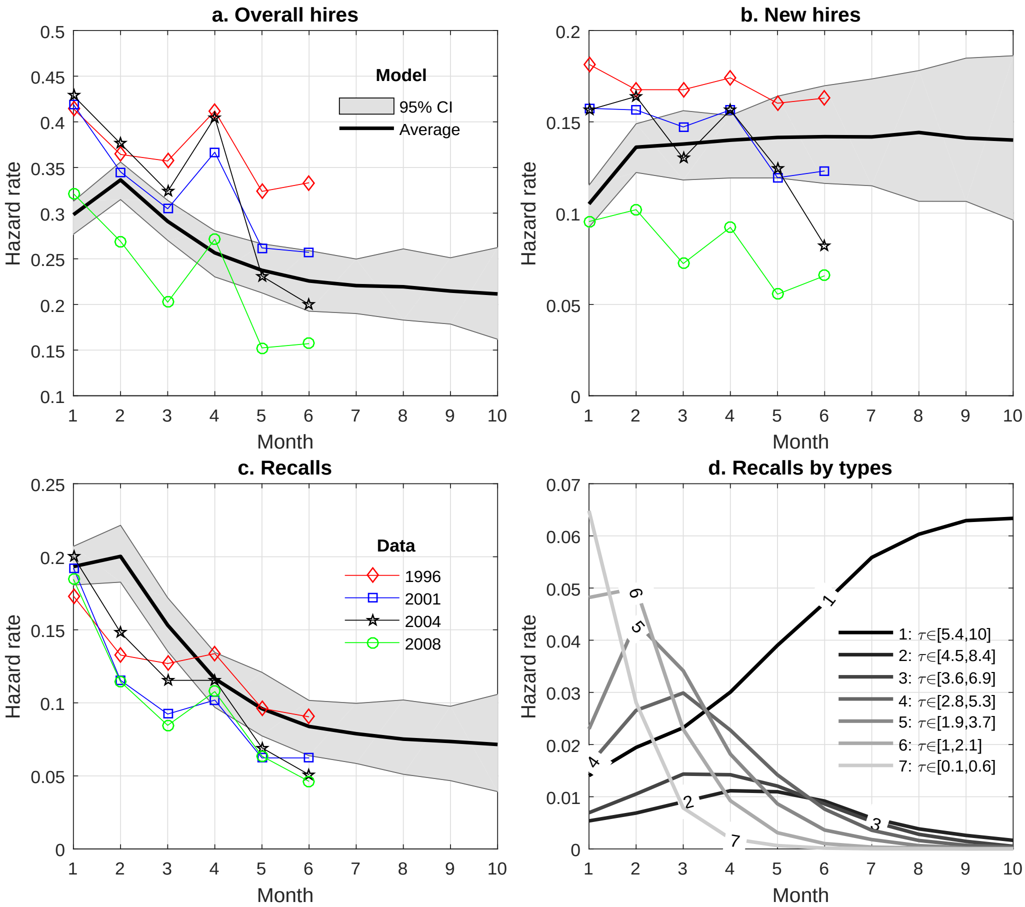

Figure 5: **HAZARD RATES.** *The rates are obtained by simulating the model with 1000 agents over* 10^5 *weeks. For each individual trajectory we extract the unemployment spells. We then compute the number of agents exiting unemployment after n months and divide this amount by the number of agents that have an unemployment duration of n months or more. Shaded areas correspond to 95% confident interval. Data from Fujita & Moscarini (2016).*

This important result comes from two contrasting forces. On one hand, ER reduces the profitability of recalls and discourages the employer from rehiring its former employee. On the other hand, ER penalizes firms who wait several periods before proceeding to the recall. If the laid-off worker does not find a new job, he receives UI benefits. Those benefits are charged to the original firm through a higher payroll tax in the future. The longer the firm waits, the higher its UI-bill and the higher will the tax rate be. Then, ER may urge the firm to trigger the recall to turn off *the spigot of taxes*. The overall impact crucially depends on how far is the firm's tax rate from the maximum rate. The closer the tax from the maximum rate, the lower the incentive for the firm to recall its former employee immediately. Firms heavily taxed have interests to wait for improvements in economic activity as they anticipate that the tax rate can not increase furthermore. Said differently, the extra cost of waiting one additional period before using the recall tends to zero as firms approach the maximum rate. On the contrary, the expected rise in the tax rate is high for firms with low tax rate. ER then affects recall strategies.

4.4 Cyclical properties of the model

We now investigate how the model behaves over the business cycle. The first column of Figure 6 displays the impulse response functions to a negative and (minus) positive shock. The policy rules are depicted in the second column. The model involves strong non-linearities. Basically, unemployment increases more during recession than it decreases during expansion. Indeed, starting from an initial rate of 4.5%, unemployment reaches 10% when the adverse supply shock hits the economy and it barely falls by 0.5 percentage point when the shock is positive (panel a). This results echoes to Hairault et al. (2010) who explain the asymmetric behavior of unemployment through non-linearities in the job finding rate. The total job finding rate declines more after an adverse shock than it increases after a positive shock. However, the job finding rate does not explain all asymmetries in the model. The separation rate (panel c) falls smoothly after a positive shock but increases sharply after a negative shock albeit its jump is short-lived. The recall rate (panel d) falls more upon the recessionary shock than it increases after a positive shock, thereby contributing to the non-linear behavior of unemployment. Even though the separation rate remains a few period above its long-run value after a recessionary shock, it does not offset the large decline in hirings, thereby causing unemployment to persist at high levels.

The policy rules of unemployment and the separation rate are strongly convex. The policy rule for the recall rate is highly concave, meaning that the recall rate falls more in recessions than it increases in expansions. The inflection point is at the steady state meaning that even small shocks generate an asymmetric response. Finally, the shape of the new job finding rate is slightly concave, thereby magnifying the non-linearities in total hirings.

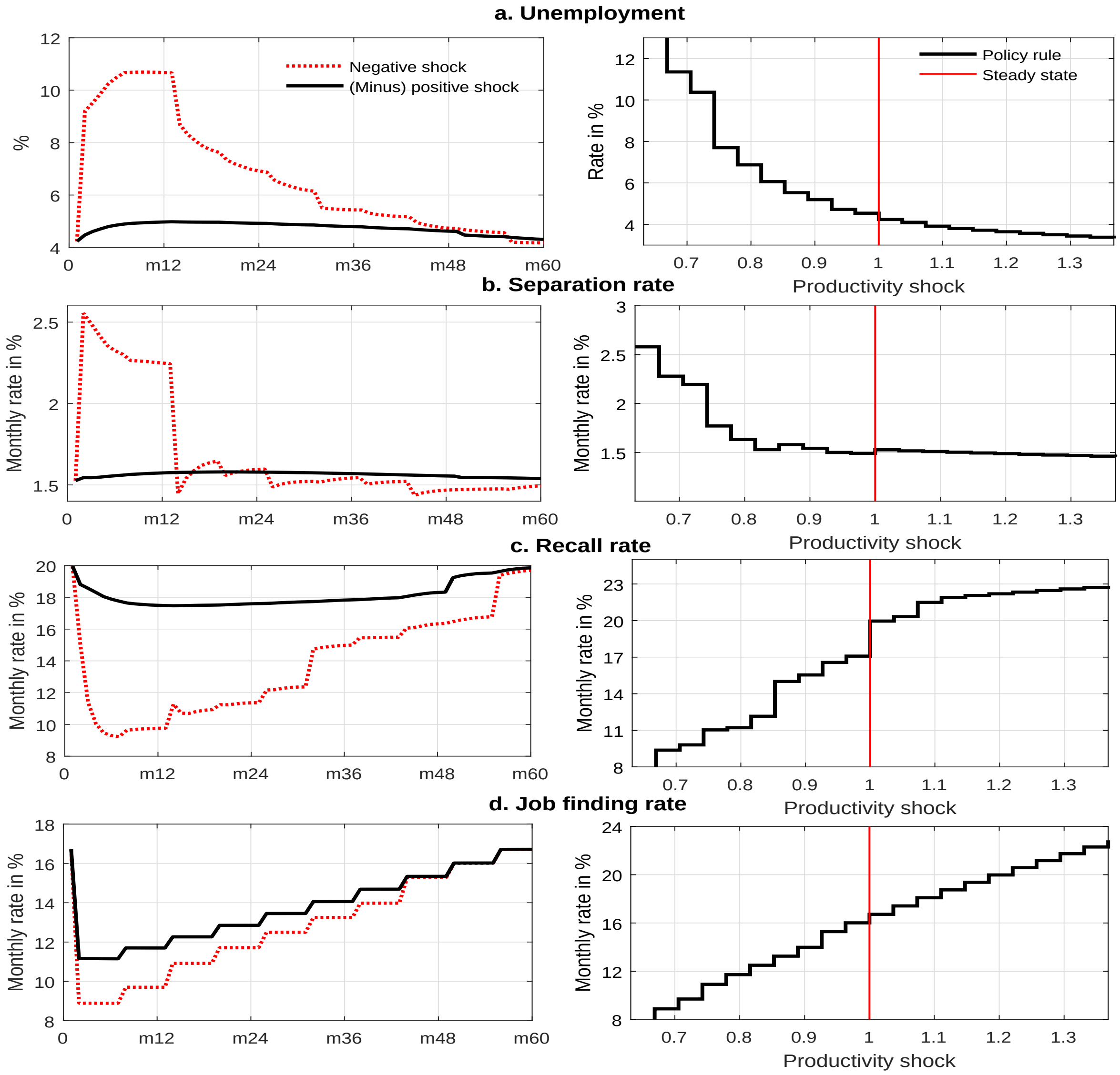

Figure 6: **Impulse response function and policy rules.** *The positive and the negative shock have the same magnitude. The path of the shock adjusts according to the transition matrix $P(p'|p)$ given the arrival rate of aggregate shock λ_ε.*

5 Policy experiments

How does ER impact the transmission of aggregate shocks to the labor market? To what extent do implicit subsidies affect the labor market? To answer these questions we first analyze the policy rules and hazard rates under an alternative tax schedule. We make a counterfactual experiment in which we calculate what would have been the path of the labor market during the Great Recession in the absence of ER. Lastly, we increase the burden of UI taxes to evaluate how more ER affect the labor market.

5.1 Alternative tax schedules

We compare the benchmark case (labeled [s0]) to two alternative scenarios:

s1 : We remove the shifts of the tax schedule corresponding to the macro indexation. This case is label **ER only**[22]

s2 : The payroll tax rate is only contingent to macroeconomic conditions. This case is labeled **Flat-tax**

In scenario [s1], neither the tax rate nor the switching probabilities depend on the macroeconomic conditions (p). We assume that the reference aggregate shock is $p = 1$ (the steady state). There are no shifts in the tax schedule. The tax only moves along one of the tax schedule. In scenario [s2], we assume that the tax rate only moves according to the aggregate economic conditions. The two alternative scenarios allow to disentangle the respective impact of the individual incentives of the ER and the adjustment of the tax rate according to the macroeconomic conditions. In order to discipline our experiments we assume that the simulations of [s1] and [s2] involve the same average UI budget deficit (see appendix C.1).

5.1.1 The impact of ER on the labor market

Figure 7 shows that scenario [s1] has no impact on the labor market in expansions. On the contrary, the recall rate and the separation rate are both higher in recessions. As the two effects cancel out, the impact on unemployment is nil. This suggests that the macro indexation of the UI lowers the labor market turnover in recessions. As shown by the hazard rates from Figure 8, the exit rates from unemployment are almost unaffected.

When the ER is turned off (scenario [s2]) the separation rate policy rule becomes more asymmetric. It increases furthermore in downturns but remains very flat in upturns. While hirings though the matching process remain similar to the benchmark case, the recall rate is higher over the whole range of the aggregate shock. With more separations and more recalls, the impact on unemployment is *a priori* ambiguous. However, the model predicts a stronger impact on separations (taking into account the total amount) which shifts up the unemployment curve. Said differently, unemployment would have been higher on average in a flat-tax system. The flatter shape of the recall rate under the scenario [s2] suggests that ER leads to a stronger decline in the exit rate from unemployment during recessionary periods.

[22]It should be noted that this case is not a complete experience rating case. Due to statutory tax rate and permanent separation, the ER remains incomplete.

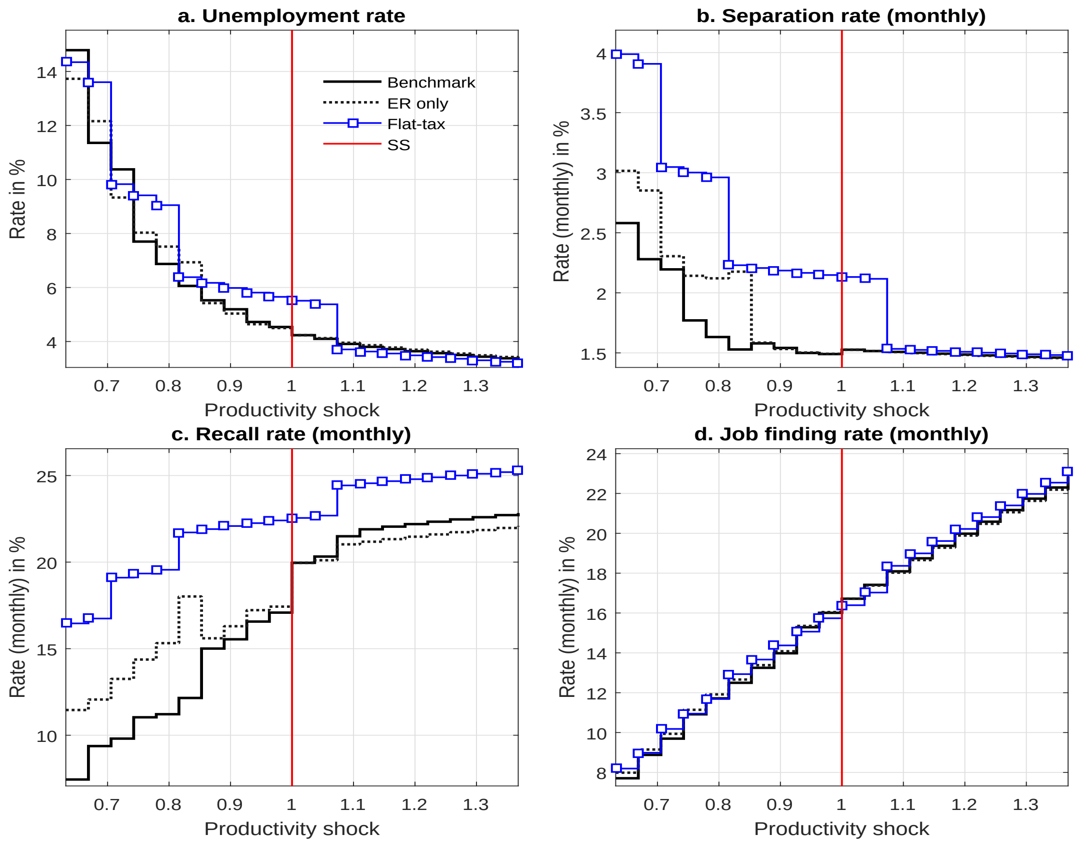

Figure 7: **Policy rules - alternatives scenarios** *SS stands for stochastic steady state.*

As shown by the hazard rates, the exit rate to a recall (panel c) increases by around two percentage points for workers that are unemployed for 5 months or more. For short-term unemployed (less than 5 weeks), the impact is almost nil. The intuition is similar than that from Figure 5. Mid-term and long-term unemployed workers are more likely to be recalled if the firms do not expect their UI bill to increase with the unemployment spell. Some of these workers were too costly to be recalled due to ER. By muting the ER down, the recall of the long-term unemployed becomes profitable. The impact is almost nil on short-term unemployed because the tax penalty is not as high as for the long-term unemployed.

To summarize, the experiments show that the ER aspect of the UI may have a sizable impact on the labor market, thus highlighting the impact of the individualized taxation. ER reduces separations but also the exit rate from unemployment through its effect on recalls. The ER has stabilization virtues despite leading to a more asymmetric recall rate over the business cycle. Since its effect on separations are stronger than its effects on recalls, it dampens rises in unemployment during recessions. The model predicts a slightly lower unemployment in expansions under scenario [s2].

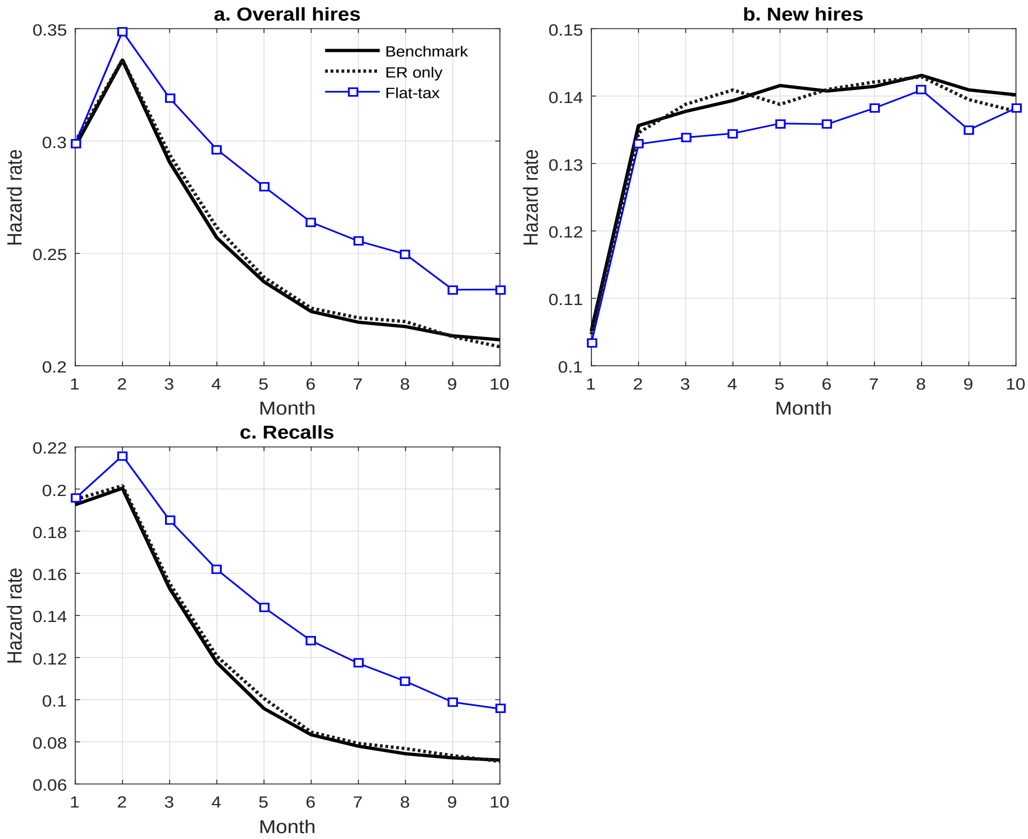

Figure 8: HAZARD RATES. *The rates are obtained by simulating the model with 1000 agents over* 10^5 *weeks. For each individual trajectory we extract the unemployment spells. We then compute the number of agents exiting unemployment after n months and divide this amount by the number of agents that have an unemployment duration of n months or more. See appendix for details of the calculation.*

5.2 Counterfactual analysis

We now switch to a more applied exercise by focusing on the historical time series. In particular, we wonder what would have been the path of the labor market in the absence of ER. The methodology is as follows:

- We solve for the path of the aggregate shock that makes the simulated series of the unemployment rate from the model as close as possible to its empirical counterpart.
- Given the path of the productivity shock, we simulate the path of the endogenous variables under the alternative scenario.

- We compare the *counterfactual* series under the alternative scenarios.

5.2.1 Model fit

The paths of the productivity obtained by simulations[23] is depicted in panel a of Figure 9 for the period 1980 Q1-2015 Q4.

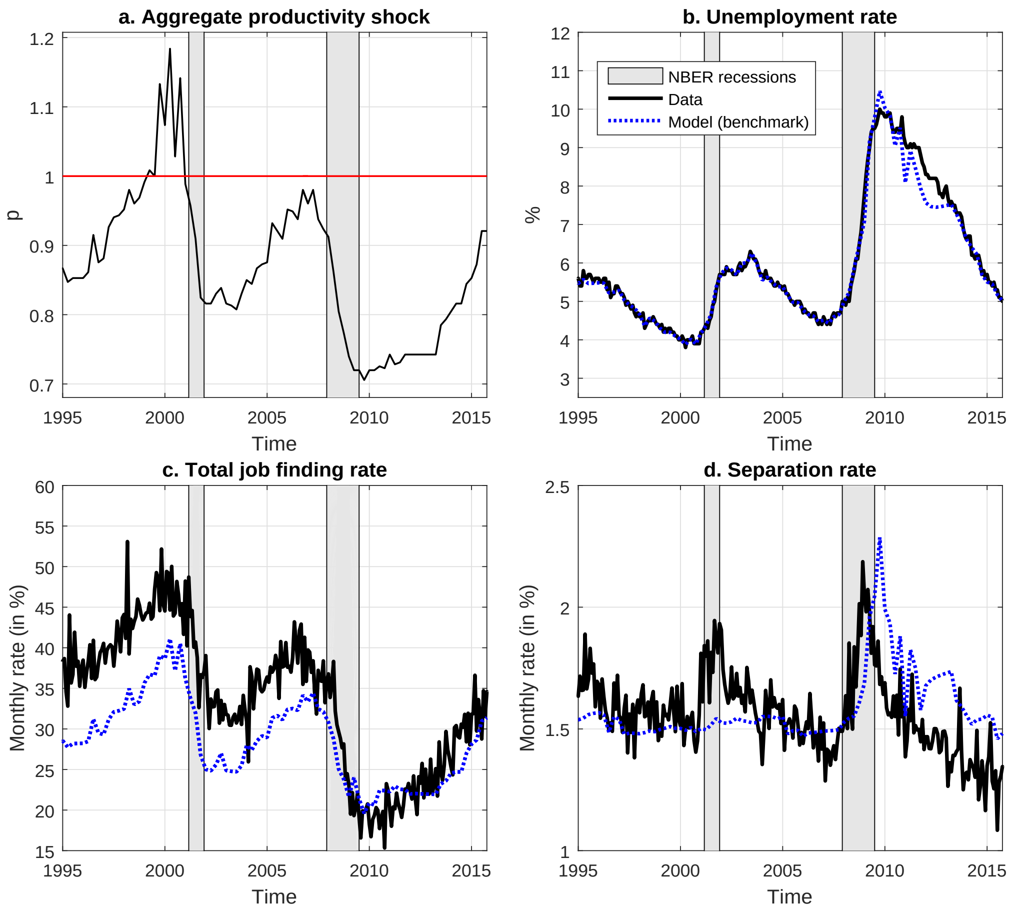

Figure 9: **MODEL VS DATA: AGGREGATE SERIES.**

The low unemployment rate (panel b) prior to the 2001 recession calls for a high level of productivity. Following the rebound in the middle of the 00's, the productivity underwent a brutal decrease during the Great Recession and slowly comes back to its pre-crisis level. Panels c to d show the simulated paths

[23]The objective of the paper is not to determine which shock drives business cycle fluctuations. In line with Fujita & Moscarini (2016), we simply consider one aggregate shock and check if the model generates enough volatility in its key variables. Our simulations aim at capturing several aspect of the labor market fluctuations and evaluating the role of the ER system, not identifying the origin of business cycle fluctuations.

for the total job finding rate and the separation rate[24]. The latter is a proxy for the average tax rate when expressed as a function of total wage. Despite the remarkable simplicity of the model, the fit is surprisingly good since we only use one shock to reproduce the historical unemployment rate, the rest of the macroeconomic series being simulated. The synchronization of the job finding rate with its empirical counterpart is matched reasonably well. The simulated separation rate behaves similarly to the one observed in the data although the 2001 recession is not detected.

Figure 10 shows the evolution of the distribution of employment, taxable wages, total wages and UI contributions as a function of the tax rate. As for the average values, all the distributions from the data are negatively skewed. Most of employers are subject to a low tax rate and represent the core of the UI financing. The model performs extremely well at matching the constant shape of the distribution at the end of the nineties and the beginning of 00's. In the aftermath of the 2008 Great Recession, employment losses entail an increase in the payroll taxes. The mode of the distributions shifts to the right, meaning that employment and wages are subject to an increase in the tax rate. Until 2016, the distributions flatten due to the delayed effect of ER. The model reproduces the distortions of the distributions fairly well even though these moments were not targeted in the calibration.

5.2.2 Alternative scenarios

We now consider scenarios [s1] and [s2] (see Figure 11). In line with previous results, scenario [s1] has little effects on the labor market dynamic. It slightly delayed the increase in the separation rate and narrows the decline in the recall rate during the Great Recession. A flat tax system (scenario [s2]) would have raised unemployment by 3 percentage points in the through of the recession compared to what it actually was. The separation rate mainly explains the additional rise in unemployment. It would have increased earlier and stronger. In addition it would have persisted to high levels for four additional years. The recall rate would have not declined as much as in the benchmark and remained higher over the whole sample. However, the stronger impact of ER on the separation rate would have resulted in a sharper increase in unemployment. In the expansionary phase of the cycle, unemployment would have been modestly higher without ER. We argue that the absence of ER foster unemployment fluctuations. Due to the strong asymmetries in the dynamic of unemployment, we conclude that ER reduces average unemployment by dampening the economic downturns.

[24] They are obtain with the same procedure as in Shimer (2005).

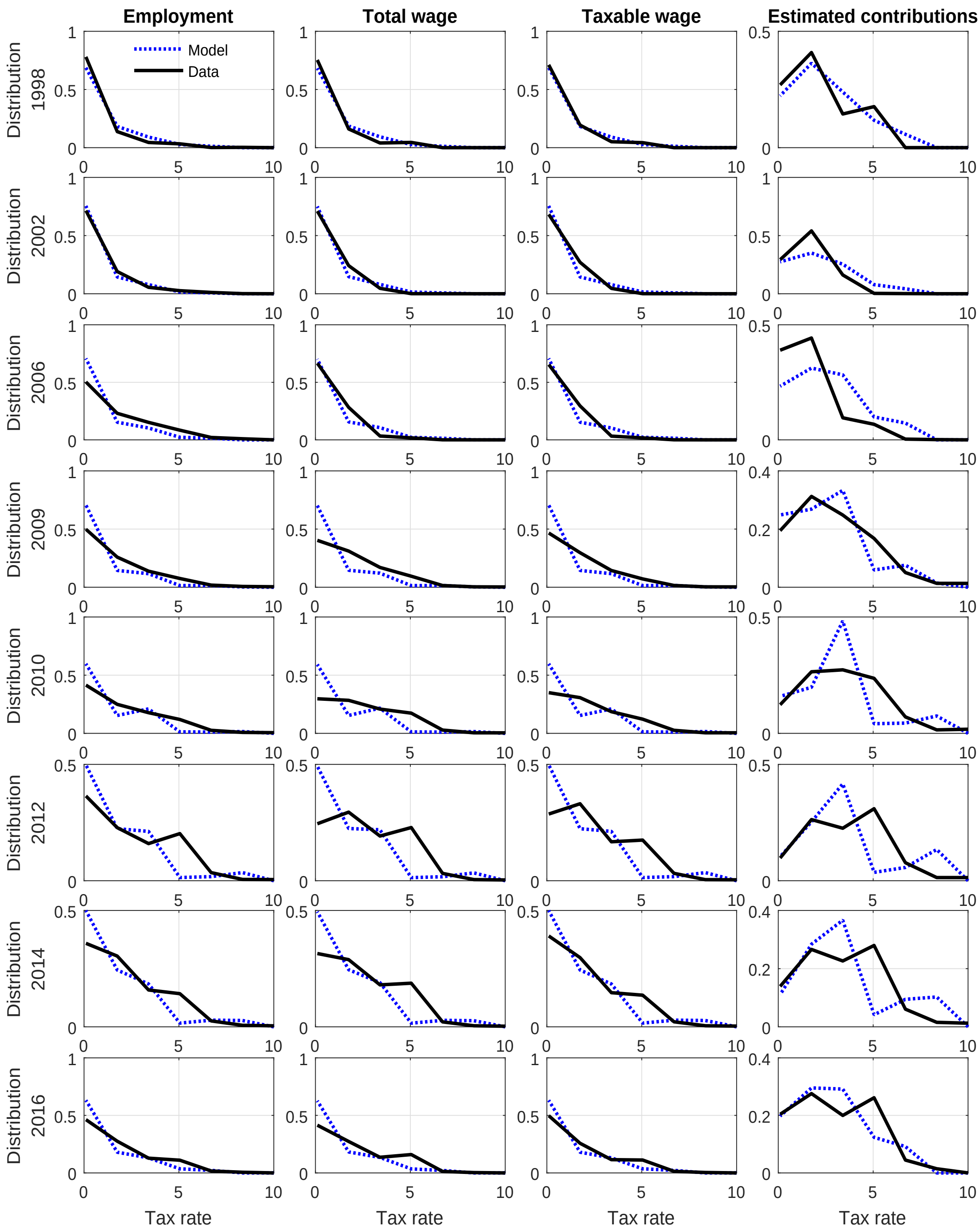

Figure 10: **Model vs data: distributions.** *The model's distributions are averaged over 52 weeks for comparison purpose. See appendix for calculations.*

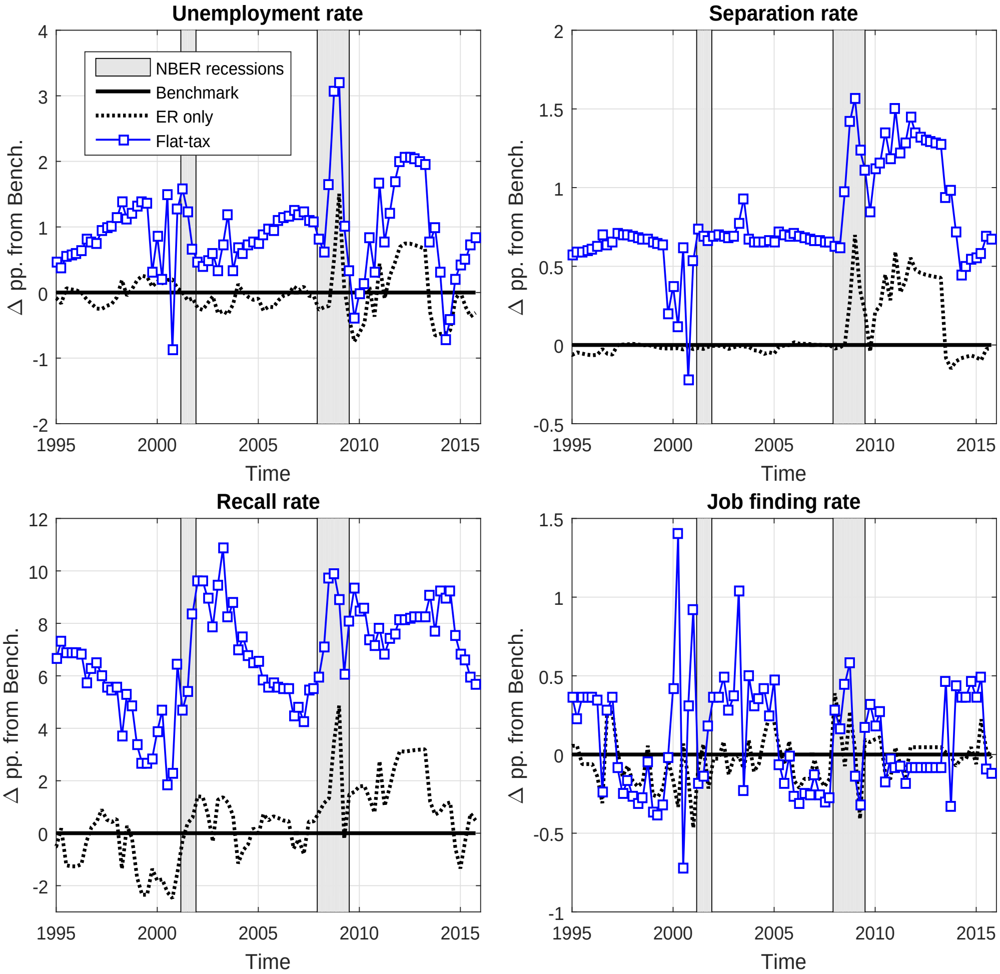

Figure 11: **COUNTERFACTUAL ANALYSIS.** Value are expressed in deviation in percentage points from the benchmark.

5.3 Implicit subsidies

Due to incomplete ER, some firms pay less to the UI than the cost of their dismissal decisions and *vice-versa*. How important are implicit subsidies among firms? How much do statutory rates explain the existence of implicit subsidies? We follow DOLETA in the report "Significant measures of state UI tax systems report" available since 2005 in order to define implicit subsidies. Mainly, it corresponds to the difference between what the firms cost to the UI and what they already paid. We distinguish two cases:

BCeCC: Benefits charged to employers in excess of the contributions collected from those employers.

CCeBC: Contributions collected from employers in excess of benefits charged to those Employers .

We use the above definitions to measure how much UI contributions are in excess of benefits charged and how much benefits charged to firms are in excess of their UI contributions[25]. Figure 13 shows the evolution of BCeCC and CCeBC. Both are displayed in proportion of employers (solid black line) and in percentage of total benefits paid (blue dashed line). By doing so, we can determine how many firms generate implicit subsidies and how large are those subsidies.

BCeCC increase in recessions and reduce in expansions while CCeBC adjust in the opposite direction. During the Great Recession unemployment increased sharply. The slow adjustment of the tax rates and the existence of the maximum rate have prevented the UI to allocate the costs to firms with more layoffs. As a consequence, the proportion of employers with BCeCC became larger. When expressed in percentage of total benefits paid, the evolution of BCeCC is similar, meaning that the larger number of firms explains the result. In the aftermath of the Great Recession, the decline in unemployment and the rise in UI taxes contribute to the increase in the CCeBC.

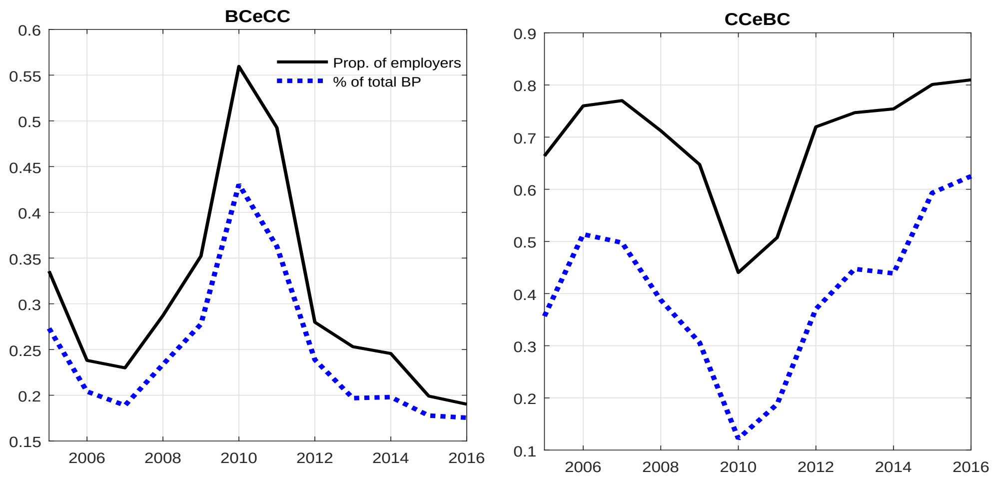

Figure 12: **Implicit subsidies in the data.** *Reserve ratio method. Period: 2005-2015. BC: benefits charged. Reading: in 2010, about 55% of employers have benefits charged in excess of contribution collected. Benefits charged in excess of contribution collected represent 43% of total benefits paid.*

[25]We assume that all benefits paid to laid off employees are charged to the firm. Then, benefits paid (BP) and benefits charged (BC) are here assumed to be equivalent. It is worth noting that previous evaluations of the degree of ER are based on the benefits paid to UI claimants not charged to the employers. The main reason is that those employers are gone out of the business (inactive accounts), social charges, solvency charges, etc. Here, our goal is to evaluate the difference between total costs and total contributions. See appendix C.2 for calculation.

In the model, we decompose the BCeCC and CCeBC into three tax categories: (i) firms at the minimum rate (ii) firms at the maximum rate and (iii) firms that have a tax rate above the minimum rate but below the maximum rate. This decomposition allows us to evaluate what are the consequences of the statutory rates on the implicit subsidies. Table 4 displays the simulated values of BCeCC and CCeBC. Albeit the values implied by the model are slightly higher than in the data, they remain broadly consistent. Not surprisingly, the BCeCC come mainly from firms at the maximum rate. CCeBC mainly come from firms for which the tax rate lies between the two statutory rates.

Tax rate	$\overline{BCeCC}$	$\overline{CCeBC}$
Total Data	0.25	0.40
Total Model	0.29	0.44
Min tax rate $\underline{\tau}$	0.00	0.07
ER tax rate $\tau \in \ ]\underline{\tau}, \overline{\tau}[$	0.09	0.29
Max tax rate $\overline{\tau}$	0.20	0.08

Table 4: **Implicit subsidies by tax rate.** *Values are relative to total benefits paid. The data are averaged from Figure 13.*

We now change the BCeCC and the CCeBC by varying the taxable wage base $\bar{w}$ from 0 to +60%. This parameter changes the firm's liability to its UI costs in a very simple manner. By impacting the burden of UI tax, it directly affects the level of the implicit subsidies[26].

Figure 13 displays the result of this experiment. For the sake of clarity, the abscissa is expressed as the ratio of taxable wages to total wages instead of $\bar{w}$[27]. When the taxable wage base is equal to zero, there is no ER. All benefits paid are in excess of UI contributions and there are no contributions in excess of benefits charged. Average unemployment is 0.5% percentage point higher compared to the benchmark (panel a). The higher separation rate explains this result even though the model involves a larger recall rate (panel b and c). The decrease in the BCeCC in panel e entailed by the rise in the taxable wage base comes with an increase in the CCeBC (panel f). The separation rate, the recall rate and the probability to find a new job fall. The decline in the separation rate becomes weaker as the basis on which the tax is levied increases. Conversely the recall rate falls almost linearly with the taxable wage base and the job finding rate starts declining significantly for higher value of $\bar{w}$. Unemployment decreases until the taxable to total wage ratio reaches 27%

[26]An alternative experiment could be the increase of the maximum tax rate and/or the decrease of the minimum rate. In the supplementary appendix we show that these simulations involve the same results than that of the taxable wage base.

[27]The abscissa is then endogenous.

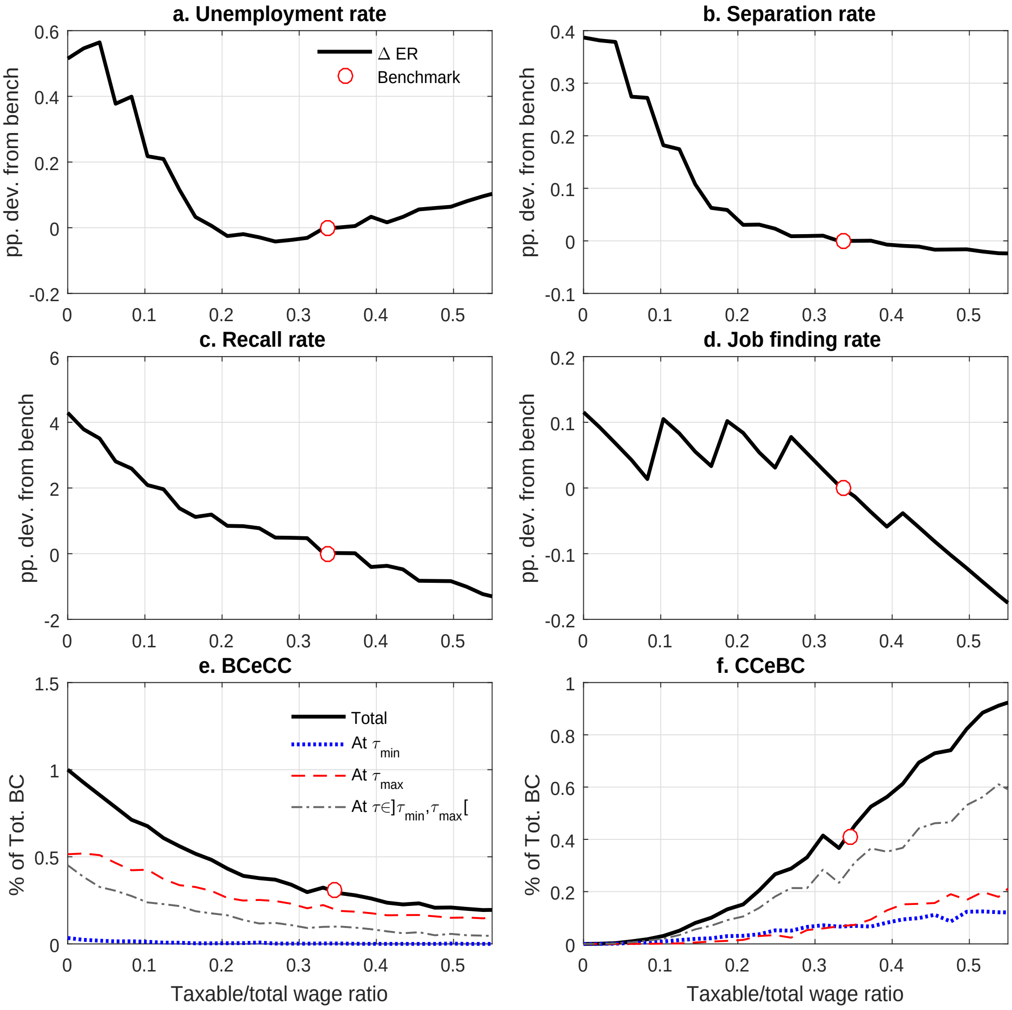

Figure 13: **IMPLICIT SUBSIDIES.** *Unconditional mean.*

and then increases. ER may lower unemployment up to a certain threshold. Above this threshold, raising the burden of UI taxes increases unemployment through its disincentive effects on hirings. The benchmark level of the taxable wage is very close to the ones minimizing unemployment. Overall, reducing the BCeCC affects the labor market outcomes but the model does not involve a very strong effect on unemployment as predicted by Feldstein (1976). Again, the reason is that hirings and separations fall together.

6 Conclusion and discussion

The importance of labor market fluctuations have been of a great concern in the literature. The use of temporary layoffs and recalls may lead to an important labor turnover and amplify the propagation of aggregate shocks. In this paper we questioned the extent to which ER stabilizes employment. We show that ER strongly impacts the separation and the recall decisions. Removing ER leads to more layoffs and unemployment despite increasing the recall rate. ER then lowers the turnover rate and reduces the exit probability from unemployment, especially for long-term unemployed. While the macro indexation of the UI is shown to have minor effects on the labor market, switching to a system without ER (flat-tax) will be detrimental for the labor market performances. Our counterfactual experiments show that ER reduces both the fluctuations and the asymmetries of unemployment over the business cycle.

The impact of the UI financing mode on labor market outcomes is a lively debate. The unique feature of the U.S. UI system contrasts with the complete flat-tax system adopted in other countries. However, as pointed out by Feldstein (1976) and Topel (1983) among others, the UI costs are partly experience-rated. On average the degree at which firms are liable for their firing decisions is around 65%[28]. Firms closures and the existence of statutory tax rates (minimum and maximum) involve that every dollar of UI benefit paid to a job loser is not entirely charged to the employer from whom the worker separated. Consequently, the remaining 35% of UI costs are equally shared among firms following a flat-tax scheme. The authors criticize the "incomplete" aspect of ER on behalf of the implicit subsidies it creates. They argue that they are responsible for a significative fraction of layoffs. We test those predictions using our heterogenous firms model. Although the implicit subsidies make firms more prone to use layoffs they also foster hirings. The overall impact on unemployment is ambiguous as both effects play in opposite direction.

What is the optimal level of ER? In a previous study Albertini & Fairise (2013), we show that a layoff tax financing unemployment benefits is able to offset labor market inefficiencies caused by search frictions and real wage rigidities. The question of inefficiencies coming from the recall option naturally arises. On one hand, rehiring avoids congestion externalities and the costly hiring technology from matching frictions. On the other hand, the implicit attachment between the firm and the worker may distort job search strategies. The firm decides the timing of recall while workers only have expectations of being recalled. Fujita & Moscarini (2016) show that around 15% of workers with no rehiring expectations were recalled. Without commitment, some unemployed workers may unnecessary devote time in job search while other

[28]Statistics from the Census Bureau of Labor exhibit an average ERI across states and over the period 1988-2007 of about 0.65.

may wait for a recall that will never happen. Katz & Meyer (1990) report that 83% of unemployed workers with no recall expectations are searching for a job whereas only 52% unemployed workers with recall expectations are searching. Fernández-Blanco (2013) shows that this double job-finding channel involves externalities. The reason is that workers engage in a job search activity given the uncertainty of rehiring. However, unemployed workers do not internalize the impact of search on the loss of the firms' recall option. These labor market inefficiencies leave a room for policy interventions in general and the design of the UI financing in particular.

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A Model

A.1 Transition probabilities

In this subsection, we provide the expression of some key labor market probabilities. For each productivity level p and type ℓ, there exists a threshold of productivity $\underline{\varepsilon}^n(p,\ell)$ below which the employment relation is no longer feasible. Similarly, there exists a value $\underline{\varepsilon}^u(p,\ell)$ above which the unemployed worker no longer searches for a job. We denote by $n(p,\varepsilon,\ell,t)$ the number of employed workers of type ℓ and by $u(p,\varepsilon,\ell,t)$ the number of unemployed workers of type ℓ.

Recall flow

$$\begin{aligned} R(p,\varepsilon,\ell,t) &= \lambda_\varepsilon(1-\delta)\int_{\underline{\varepsilon}^n(p,\ell)}^{\infty} u(p,\varepsilon',\ell,t)dG(\varepsilon'|\varepsilon) \\ &\quad +\psi^u(p)u(p,\varepsilon,\ell,t)\mathbb{1}\{\varepsilon \geq \underline{\varepsilon}^n(p,\ell-1)\}\mathbb{1}\{\ell > 1\} \end{aligned}$$

Matching flow

$$\begin{aligned} H(p,\varepsilon,\ell,t) &= \phi(p)\Big(\int_{\underline{\varepsilon}^n(p,\ell)}^{\infty} dF(\varepsilon')\Big)u(p,\varepsilon,\ell,t)\mathbb{1}\{\varepsilon < \underline{\varepsilon}^u(p,\ell)\} \\ &\quad +\phi(p)\Big(\int_{\underline{\varepsilon}^n(p,\ell)}^{\infty} dF(\varepsilon')\Big)u(p,0,M,t) \end{aligned}$$

Separation flow

$$\begin{aligned} S(p,\varepsilon,\ell,t) &= \lambda_\varepsilon\Big(\delta+(1-\delta)\int_0^{\underline{\varepsilon}^n(p,\ell)} dG(\varepsilon'|\varepsilon)\Big)n(p,\varepsilon,\ell,t) \\ &\quad +\psi^n(p)n(p,\varepsilon,\ell,t)\mathbb{1}\{\varepsilon < \underline{\varepsilon}^n(p,\ell+1)\}\mathbb{1}\{\ell < L\} \end{aligned}$$

The recall rate is obtained by dividing the recall flow by the stock of unemployed workers. The (new) job finding rate is computed by dividing the matching flow by the stock of unemployed workers. The separation rate is determined by dividing the separation flow by the stock of employed workers.

A.2 Labor market dynamics

$$\begin{aligned}
\dot{n}(p,\varepsilon,\ell,t) &= -\lambda_\varepsilon n(p,\varepsilon,\ell,t) \\
&+ \lambda_\varepsilon(1-\delta)\int_0^{\underline{\varepsilon}^n(p,\ell)} u(p,\varepsilon',\ell,t)dG(\varepsilon'|\varepsilon) \\
&+ \lambda_\varepsilon(1-\delta)\int_{\underline{\varepsilon}^n(p,\ell)}^{\infty} n(p,\varepsilon',\ell,t)dG(\varepsilon'|\varepsilon) \\
&+ \Big(\psi_u(p)u(p,\varepsilon,\ell+1,t)\mathbb{1}\{\varepsilon \geq \underline{\varepsilon}^n(p,\ell)\} - \psi_n(p)n(p_i,\varepsilon,\ell,t)\Big)\mathbb{1}\{\ell < L\} \\
&+ \psi_n(p)n(p,\varepsilon,\ell-1,t)\mathbb{1}\{\varepsilon \geq \underline{\varepsilon}^n(p,\ell)\}\mathbb{1}\{\ell > 1\} \\
&+ \phi(p)\Big[u(p,0,M,t) + \sum_{l=1}^{L}\int_0^{\underline{\varepsilon}^u(p,\ell)} u(p,\varepsilon',l,t)d\varepsilon'\Big]F(\varepsilon)\mathbb{1}\{\ell = M\}
\end{aligned}$$

$$\begin{aligned}
\dot{u}(p,\varepsilon,\ell,t) &= -\lambda_\varepsilon u(p,\varepsilon,\ell,t) \\
&+ \lambda_\varepsilon(1-\delta)\int_0^{\underline{\varepsilon}^n(p,\ell))} u(p,\varepsilon',\ell,t)dG(\varepsilon'|\varepsilon) \\
&+ \lambda_\varepsilon(1-\delta)\int_{\underline{\varepsilon}^n(p,\ell))}^{\infty} n(p,\varepsilon',\ell,t)dG(\varepsilon'|\varepsilon) \\
&+ \psi_u(p)u(p,\varepsilon,\ell+1,t)\mathbb{1}\{\varepsilon < \underline{\varepsilon}^n(p,\ell)\}\mathbb{1}\{\ell < L\} \\
&+ \Big(\psi_n(p)n(p,\varepsilon,\ell-1,t)\mathbb{1}\{\varepsilon < \underline{\varepsilon}^n(p,\ell)\} - \psi_u(p)u(p,\varepsilon,\ell,t)\Big)\mathbb{1}\{\ell > 1\} \\
&- \phi(p)\Big(\int_{\underline{\varepsilon}^n(p,M)}^{\infty} dF(\varepsilon')\Big)u(p,\varepsilon,\ell,t)\mathbb{1}\{\varepsilon < \underline{\varepsilon}^u(p,\ell)\}
\end{aligned}$$

A special case occurs with $\varepsilon = 0$. One has:

$$\begin{aligned}
\dot{u}(p,0,M,t) &= \lambda_\varepsilon\delta\Big[\sum_{l=1}^{L}\int_0^{\underline{\varepsilon}^n(p,\ell)} u(p,\varepsilon',\ell,t)d\varepsilon' + \sum_{l=1}^{L}\int_{\underline{\varepsilon}^n(p,\ell)}^{\infty} n(p,\varepsilon',\ell,t)d\varepsilon'\Big] \\
&- \phi(p)\Big(\int_{\underline{\varepsilon}^n(p,M)}^{\infty} dF(\varepsilon')\Big)u(p,0,M,t)
\end{aligned}$$

B Data

B.1 Aggregate time series

Variables	Type	Source	Code
Output	Quantities, quarter, s.a, Index numbers, 2005=100	Bureau of Economic Analysis (BEA)	Table 1.1.3
Unemployment	Monthly, rate/level, s.a, 16 years and over	Bureau of Labor Statistics (BLS)	LNS13000000 LNS14000000
Unemployment by duration	Monthly, level, s.a, <5 weeks	Bureau of Labor Statistics (BLS)	LNS13008396
Unemployment by reason	Monthly, level, not s.a., 16 years and over, and by duration (<5 weeks) for Temporary layoffs, permanent layoffs, and quits	Bureau of Labor Statistics (BLS)	LNU03023665 LNU03023685 LNU03023717 LNU03023653 LNU03025699 LNS13023705
Employment	Level, Civilian, s.a 16 years and over Quarterly	Federal Reserve Bank of St. Louis (BLS)	LNS12000000

Table 5: DATA SOURCES AND DEFINITION.

B.2 UI data

The UI data are obtained from the department of labor, employment and training administration (DOLETA) using the Experience rating report **ETA 204**[29]. The nomenclature is the following one:

Experience factor		AVG tax Rate	No. of Account	Total Payroll (000)	Taxable Payroll (000)	Benefits charged	Estimated contribution (000)
More than	Equal to or less than						
c1		c2	c3	c4	c5	c6	c7
-∞	-80						
-80	-60						
-40	-20						
⋮	⋮						
40	45						
45	+∞						

Table 6: EXPERIENCE RATING REPORT. *The experience factor corresponds to the one under the reserve ratio method (Table ar204r). The experience factor under the benefit ratio method (Table ar204b) is different but the number of subintervals is the same as for the reserve ratio method.*

[29]The data are available at this address `https://oui.doleta.gov/unemploy/DataDownloads.asp`

- The experience factor (c1) is divided into 70 subintervals. It corresponds to a reserve ratio index. The table 6 is available for each State of the U.S. practicing either the reserve ratio method or the benefits ratio method and for every year since - at best - 1986[30] and until 2016. All other columns are functions of this experience factor. The values allow us to build the distributions.

- The average tax rate (c2) is the tax rate that applies in the state for a given level of experience factor.

- The number of accounts (c3) gives the number of firms that have an account in the State UI fund.

- The total payroll (c4), in thousand (000), corresponds to the sum of wages in firms with a given experience factor while the taxable payroll (c5), also in thousand (000), corresponds to the sum of wages that are subject to the UI tax.

- Benefits charged (c6) and contribution collected (c7) sums UI benefits paid to eligible unemployed workers and the contributions of firms respectively.

B.3 Equivalence in the model

In order to perform an adequate comparison between the data and the model's outcome, we compute the distributions as a function of the tax rate rather than a proxy for the experience rating factor. Indeed, our goal is to reproduce the behavior of the tax rate across employers, taxable wages, total wages and the contributions collected. In Figure 3, we distribute the observed employers and wages over seven intervals of the tax rate. To build the distribution, consider a sequence of aggregate productivity shock $\{p(t)\}_{t\in[0,T]}$. The distributions are computed for an interval of tax $[\tau_i;\tau_{i+1}]$:

- The proportion of employers account (c3) for which the tax rate is between $[\tau_i;\tau_{i+1}]$:

$$\frac{\frac{1}{T}\int_0^T \sum_{\ell=1}^{L} \int_{\underline{\varepsilon}^n(p(t),\ell)}^{\infty} n(p(t),\varepsilon,\ell,t)\mathbb{1}\{\tau(p(t),\ell)\ \in [\tau_i,\tau_{i+1}[\}\, d\varepsilon\, dt}{\frac{1}{T}\int_0^T \sum_{\ell=1}^{L} \int_{\underline{\varepsilon}^n(p(t),\ell)}^{\infty} n(p(t),\varepsilon,\ell,t)\, d\varepsilon\, dt}$$

- The proportion of total payroll (c4) for which the tax rate is between $[\tau_i;\tau_{i+1}]$:

$$\frac{\frac{1}{T}\int_0^T \sum_{\ell=1}^{L} \int_{\underline{\varepsilon}^n(p(t),\ell)}^{\infty} n(p(t),\varepsilon,\ell,t)w(p(t),\varepsilon,\ell)\mathbb{1}\{\tau(p(t),\ell)\ \in [\tau_i,\tau_{i+1}]\}\, d\varepsilon\, dt}{\frac{1}{T}\int_0^T \sum_{\ell=1}^{L} \int_{\underline{\varepsilon}^n(p(t),\ell)}^{\infty} n(p(t),\varepsilon,\ell,t)w(p(t),\varepsilon,\ell)\, d\varepsilon\, dt}$$

[30]For some States, data are only available since 2004.

- The proportion of taxable payroll (c5) for which the tax rate is between $[\tau_i; \tau_{i+1}]$:

$$\frac{\frac{1}{T}\int_0^T \sum_{\ell=1}^{L} \int_{\underline{\varepsilon}^n(p(t),\ell)}^{\infty} n(p,\varepsilon,\ell) w^{\tau}(p,\varepsilon,\ell) \mathbb{1}\{\tau(t,\ell) \ \in [\tau_i, \tau_{i+1}]\} \, d\varepsilon \, dt}{\frac{1}{T}\int_0^T \sum_{\ell=1}^{L} \int_{\underline{\varepsilon}^n(p(t),\ell)}^{\infty} n(t,\varepsilon,\ell) w^{\tau}(p,\varepsilon,\ell) \, d\varepsilon \, dt}$$

- The estimated contribution (c7) for which employers are rated a tax between $[\tau_i; \tau_{i+1}]$:

$$\frac{\frac{1}{T}\int_0^T \sum_{\ell=1}^{L} \int_{\underline{\varepsilon}^n(p(t),\ell)}^{\infty} n(p,\varepsilon,\ell) w^{\tau}(p,\varepsilon,\ell) \tau(p,\ell) \mathbb{1}\{\tau(p,\ell) \ \in [\tau_i, \tau_{i+1}]\} \, d\varepsilon \, dt}{\frac{1}{T}\int_0^T \sum_{\ell=1}^{L} \int_{\underline{\varepsilon}^n(p(t),\ell)}^{\infty} n(p,\varepsilon,\ell) w^{\tau}(p,\varepsilon,\ell) \tau(p,\ell) \, d\varepsilon \, dt}$$

C UI budget and the implicit subsidies

C.1 Aggregate UI budget

In Section 5.1 the alternative scenarios are simulated under the assumption that the average UI budget is the same. Recall that this deficit (or surplus) is financed by a lump-sum tax. The average UI deficit is computed as follows. We consider a sequence of aggregate productivity shock $\{p(t)\}_{t\in[0,T]}$ and compute time series of the variables.

- Total contributions collected by the UI

$$CC(t) \ = \ \sum_{\ell=1}^{L} \int_{\underline{\varepsilon}^n(p(t),\ell)}^{\infty} n(p(t),\varepsilon,\ell,t) w^{\tau}(p(t),\varepsilon,\ell) \tau(p(t),\ell) \, d\varepsilon$$

- Total benefits paid to laid off employees

$$BP(t) \ = \ \sum_{\ell=1}^{L} \int_{0}^{\underline{\varepsilon}^n(p(t),\ell)} u(p(t),\varepsilon,\ell,t) b \, d\varepsilon$$

- Total wages

$$ToTw(t) \ = \ \sum_{\ell=1}^{L} \int_{\underline{\varepsilon}^n(p(t),\ell)}^{\infty} n(p(t),\varepsilon,\ell,t) w(p(t),\varepsilon,\ell) \, d\varepsilon$$

- The average UI deficit expressed as a percentage of total wage

$$D \ = \ \int_0^T \frac{CC(t) - BP(t)}{ToTw(t)} \, dt$$

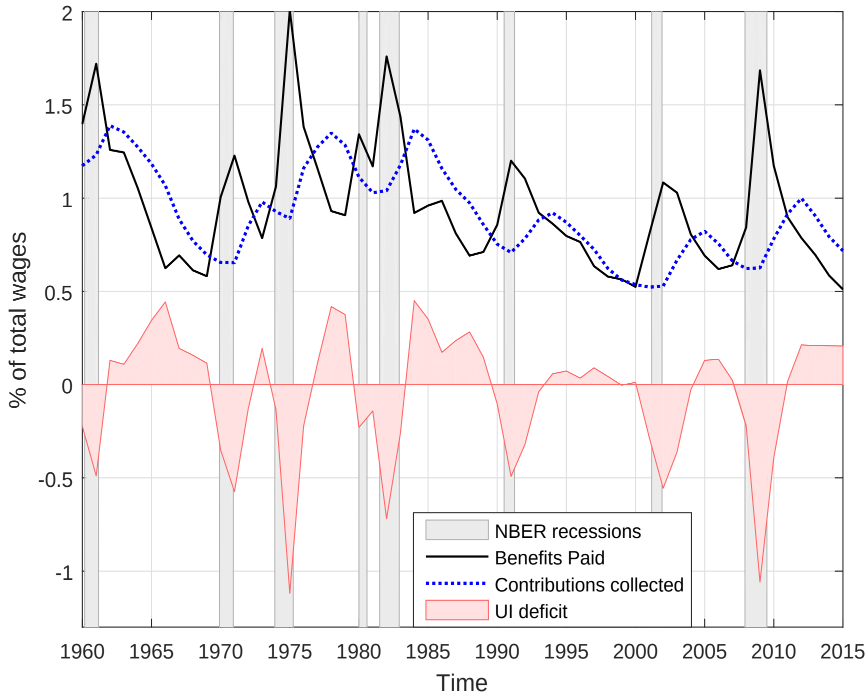

Figure 14: **Aggregate UI budget.**

Doleta provides historical time series for $CC/ToTw$ and $BP/ToTw$ on a yearly basis. Figure 14 shows the path of benefits paid, contributions collected and the UI deficit. The average UI deficit is about -0.10% of total wage over the period 1998-2015. From 1998 to 2016 the average UI deficit is about -0.10% of total wages.

C.2 Implicit subsidies

Consider a finite number of firms indexed by $i = \{1, ..., I\}$. For each firm i the two indicator writes:

$$\begin{aligned} BCeCC_i &= \int_0^T \mathbb{1}\{BC_i(t) > CC_i(t)\}(BC_i(t) - CC_i(t))\, dt \\ CCeBC_i &= \int_0^T \mathbb{1}\{CC_i(t) > BC_i(t)\}(CC_i(t) - BC_i(t))\, dt \end{aligned}$$

The average value, expressed in percentage of total benefits paid, is defined as follows:

$$\overline{BCeCC} = \frac{\sum_{i=1}^{I} BCeCC_i}{\int_0^T \sum_{i=1}^{I} BC_i(t)dt}$$

$$\overline{CCeBC} = \frac{\sum_{i=1}^{I} CCeBC_i}{\int_0^T \sum_{i=1}^{I} BC_i(t)dt}$$

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