Unemployment insurance payroll tax, labor market frictions and the cyclical behavior of employment

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Preliminary version

Abstract

This paper studies the dynamic effects of unemployment insurance experience rating systems which relates the firm payroll tax rate to its layoffs history. We build a DSGE business cycle model with search and matching frictions and risk-adverse workers. We incorporate an experience rating of the payroll tax based on the reserve-ratio method. The tax schedule determines the degree to which firms are liable for the expenditures they create through their firing decisions. We evaluate the extent to which such a system affects layoffs and employment over the business cycles. It is shown that this incentive-based method may have a significant impact on both long run levels and the fluctuations of labor market outcomes. Increasing the slope of the tax schedule (more experience rating) dampens shock responses of macroeconomic variables. Furthermore, the existence of statutory tax rates (minimum and maximum payroll tax rates) strongly distorts the way firms adjust employment during booms and busts but let the steady states effects virtually unchanged.

Keywords: Unemployment insurance, income taxation, experience rating, search and matching frictions, DSGE models.

JEL Classification: H29; J23; J38; J41; J64

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1 Introduction

The original feature of the US unemployment insurance (UI thereafter) system lies in the "*experience rated*" structure of the firms' contribution rate. Contribution rates (or UI payroll tax rates) are varied on the basis of employers' layoffs history. Firms that are more likely to cause someone to be unemployed should support the burden of the fiscal cost induced by their dismissal decisions. This incentive-based method has important implications over the business cycles: during recessions, mass layoffs result in higher contribution rates. In other words, it makes the contribution rate countercyclical with a one-lag period, improving the ability of state funds to finance potential liability over economic cycles (see figure 1 and 2). Several question naturally arise: to what extend an experience rating of the UI payroll tax reduces layoffs and stabilize employment? How current systems of financing UI affect firms and workers' decisions that generate unemployment? Does experience rating reduces layoffs in bad times? The goal of this paper is to answer these questions and to show how such a system affects the sensitivity of an economy to macroeconomic shocks.

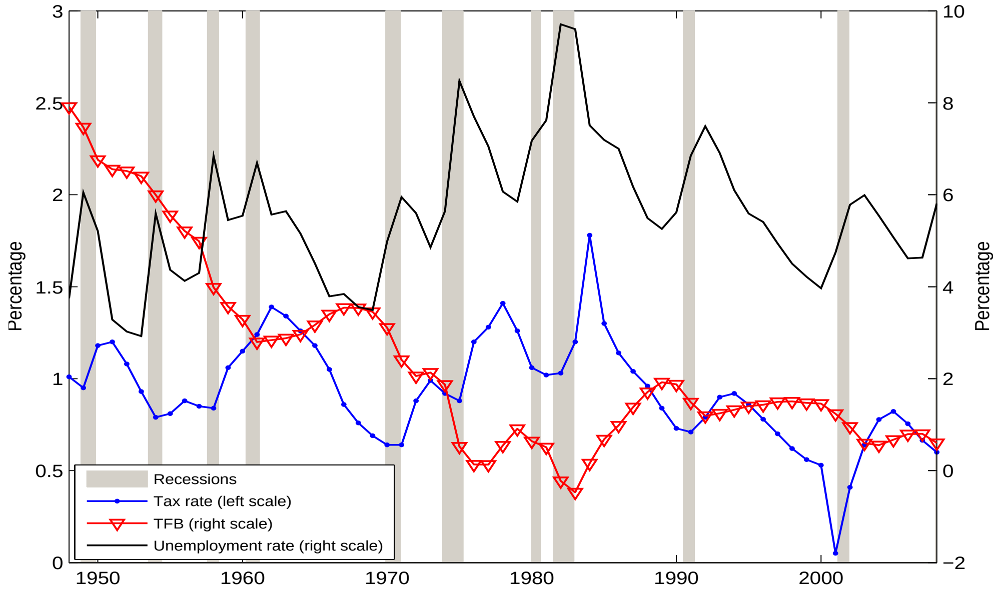

Figure 1: ***Employer tax rates, Trust fund balanced as a percent of total wages and unemployment rate.*** *Sources: BLS and DOLETA.*

Another important aspect we are dealing with concerns the existence of implicit subsidies. As mentioned a large body of studies, current methods of financing UI subsidize unemployment. The reason is that some benefits are not charged to individual employers because firms have gone out of business and the taxes cannot be collected (inactive charges) or the benefit payments made to claimants

Figure 2: ***Benefits paid and contributions collected as a percent of total wages.*** *Benefits paid are given to UI-eligible unemployed workers. Contributions collected correspond to the contribution employers paid on taxable wages to the unemployment insurance.*

is charged to a general account (non-charges). More important, the existence of statutory tax rates (minimum and maximum rates) generates ineffective charges *i.e.* benefits charged to a specific employer who cannot fully fund them. For example, if an employer reaches the maximum rate more layoffs cannot result in higher contribution rates, making the marginal tax cost (MTC) equal to zero. Then the employers avoids the cost of an additional dismissal and reports it in the future. The major consequence is that firms at the minimum rate implicitly subsidized firms at the maximum rate. In this case, experience rating is said to be imperfect since employers never pays for the entire cost of unemployment benefits caused by their actions. It results in fiscal distortions and subsidies among employers[1] which, in turn, may lead to excessive job destruction. These distortions are at the heart of an important debate on the consequences of *imperfect experience rating* on layoffs and employment fluctuations. Then, it is worth questioning whether the statutory tax rates magnify labor turnover when the economy is hit by aggregate shocks. Our dynamic framework with binding constraints allows to asses their impact on labor market outcomes. In order to define the major contribution of the present study we rapidly review the existing literature.

[1]Obviously, such a system creates less subsidies among employers than the ones in all other countries where employers are charged the same rate (flat rated system). The US unemployment insurance can be viewed as a *partial* imperfect experience rating while all other UI systems involve a *full* incomplete experience rating and more implicit subsidies.

Related literature

Experience rating systems have been of a great concern as attest several empirical and theoretical contributions. Among the first theoretical works, Feldstein (1976) and Brechling (1977) use labour demand model and show that UI and implicit subsidies have a powerful effect on layoffs and especially temporary layoffs. They argued that if the economic policy is aimed at a reduction of unemployment, experience rating should be extended. In this line of research, Topel and Welsh (1980), Topel (1984) and Card and Levine (1994) argued that higher payroll tax indexation lowers the incentive for firms to lay workers off during economic downturns and to hire them during booms. A full experience rating would reduce the temporary layoff rate by between 20 - 50 percent in the trough of a recession. Albrecht and Vroman (1999) and Fath and Fuest (2005) also find a positive effect on employment, wages and output and a decrease of shirking in an efficiency wage model. Marceau (1993), Burdett and Wright (1989) and more recently Mongrain and Roberts (2005) reach opposite results. They show that complete experience rating is likely to raise unemployment or to be welfare detrimental for workers. However, empirical contributions (Topel (1983), Marks (1981), Anderson (1993), Card and Levine (1994), Anderson and Meyer (2000) and Woodbury (2004)) share the conventional wisdom according to which more experience rating is likely to decrease unemployment.

However, despite the remarkable attention given to experience rating systems it is highly surprising to note that previous studies have extensively used a simplified UI without statutory tax rate. Then, they do not provide a clear answer on the impact of imperfect experience rating systems on employment. In addition, any frictions in the labor market are considered while they capture the time-consuming search process. Obviously, the interaction between job opening firms and searching workers generates congestion externalities which govern the average duration of unemployment and therefore the fiscal cost associated to a dismissal. The effects of experience rating on hiring and firing incentives are thus not clearly evaluated. Finally aggregate shocks and the potential role of UI for short-run stabilization are also omitted from their analysis, leaving aside the welfare gains coming from smooth fluctuations.

The most closely related papers to our are the ones of Millard and Mortensen (1997), Cahuc and Malherbet (2000), L'Haridon and Malherbet (2009). All consider search and matching frictions in the labor market with endogenous job destruction. The first ones highlight that such a tax reduces firms' layoff rate but also raise unemployment duration. The two last papers outperform the Millard and *al.*'s analysis by introducing a balanced budget rule of the UI trust fund and where unemployment benefits are financed through a combination of a layoff tax and a payroll tax. They study the consequences of introducing an experience rating system in a rigid labor market as in continental Europe. They show that it may reduce the unemployment rate for low-skilled workers and can improve their welfare in the presence of a high minimum wage, a stringent employment protection legislation (EPL) and a dual labor market. It also can improve the efficiency of employment protection and reduce unemployment, job creation and job destruction variability.

However, it is relevant to note that the mechanisms of experience rating slightly depart from a simple layoff tax since 1) the tax firms have to support is proportional to wages 2) an increase in the layoff rate raises, not reduces, the payroll tax rate 3) Employers' contributions are not adjusted instantaneously following a mass layoff event 4) firms are liable for UI benefits paid to claimants over the past, leading to important persistence of the tax level and 5) the tax schedule exhibit strong non-linearities, *i.e.* a maximum rate and a minimum rate. Furthermore, the use of a single firm-worker model assume the parties look immediately for an alternative match partner when the match is dissolved. Then, no feedback matters from the firms employment decisions on the wage schedule of continuing relationships.

All these important aspects are not considered in the literature previously mentioned while their effects are nontrivial for the policy analysis. As Brechling argued, to capture the entire application of UI experience rated payroll tax as well a possible changes in the tax structure, it seems highly desirable that the incentive effects be ascertained in as much detail as possible. The originality of the present paper is to gauge the impact of experience rating from a dynamic and stochastic general equilibrium framework. We give a particular attention on the dynamic effects of statutory tax which have been omitted in previous theoretical studies. Our framework allows large firms to form expectations about the value of a job, taking into considerations the shape of the payroll tax. They decide the number of employment positions to be created as well as the number of matches that must be terminated. The labor market is characterized by search frictions and concave hiring costs, constraining employment adjustment. It is shown that increasing the degree at which firms are liable for the expenditures they create through their firing decisions have a large positive impact on both long run levels and the fluctuations of labor market outcomes. Furthermore, the existence of statutory tax rates (minimum and maximum payroll tax rates) strongly distorts the way firms adjust employment during booms and busts but let the steady states effects virtually unchanged.

The rest of the paper is organized as follows. Section 2 presents the model and the unemployment insurance system. The calibration and a quantitative evaluation of the model are presented in section 3. Section 4 is devoted to simulation exercises and section 5 concludes.

2 The economic environment and the model

Our DSGE model includes Non-Walrasian labor market with endogenous job creation and job destruction in the spirit of Mortensen and Pissarides (1994, 1999). We focus on workers flows between employment and unemployment. Workers "out of the labor force" are thus not taken into account. Time is discrete and our economy is populated by *ex-ante* homogeneous workers and firms. Firms are large and employ many workers. Endogenous separations occur because of firms specific productivity shocks. There are search and matching frictions in the labor market and concave hiring costs. Wages are the outcome of a bilateral Nash bargaining process between the large firm and each workers. The design of unemployment insurance is derived from US legislation under the *Reserve ratio method.*

2.1 The labor market

Search process and recruiting activity are costly and time-consuming for both, firms and workers. There is a continuum of jobs within the firm i. A job j may either be filled and productive or unfilled and unproductive. To fill their vacant jobs, firms publish adverts and screen workers, incurring hiring expenditures. Workers are *ex ante* identical, they may either be employed or unemployed. We also make a distinction between unemployed workers and job seekers engaged in the search process. The number of matches M_t is given by the following Cobb-Douglas matching function :

$$M_t = \chi_t S_t^{\psi} V_t^{1-\psi} \text{ with } \psi \in]0,1[,\ \chi > 0 \tag{1}$$

where $V_t = \int_0^1 v_{it} \mathrm{d}i$ denote the mass of vacancies and v_{it} the number of vacancies posted by firm i. S_t represents the mass of searching workers. The labor force L is assumed to be constant over time. Assuming, $L = 1$ allows to treat aggregate labor market variables in number and rate without distinction. The matching function (1), satisfies the usual assumptions, is increasing, concave and homogenous of degree one. A vacancy is filled with probability $q_t = M_t/V_t$ and a job seeker finds a job with probability $f_t = M_t/S_t$.

At the beginning of each period, match dissolutions occur for two reasons. Firstly, an exogenous fraction of matched workers quits voluntarily employment at rate ρ^x. Secondly, jobs productivity is subject to idiosyncratic shocks *i.i.d.* drawn from a time-invariant distribution $G(.)$ defined on $[0, \bar{\varepsilon}]$. If the firm specific productivity component ε_{it} falls below an endogenous threshold $\underline{\varepsilon}_{it}$, the job is destroyed and the match is over. Endogenous separations occur at rate :

$$\rho_{it}^n = P(\varepsilon_{it} < \underline{\varepsilon}_{it}) = G(\underline{\varepsilon}_{it}) \tag{2}$$

where $G(\underline{\varepsilon}_{it})$ is defined by the conditional expectation $E(\varepsilon|\varepsilon \geq \underline{\varepsilon}_{it})$.

2.2 The sequence of events

At each date, the firm i is characterized by a specific productivity level ε_{it} drawn from the distribution $G(.)$. The firm productivity is also subject to an aggregate productivity shock z_t. The production level of a job in units of output is given by:

$$y_{it} \quad = \quad z_t \varepsilon_{it} \tag{3}$$

The sequence of events and the labor market timing is mainly derived from Den Haan *et al.* (2000). Employment in period t has two components: new and old workers. New employment relationship are formed through the matching process. Matches formed at period t contribute to period $t+1$ employment. The employment pool in t is determined at the beginning of period t while the number of job seekers is determined after the realization of shocks. This timing of events allow workers who lose their job in t to have a probability of being employed in the same period. New and continuing jobs draw from $G(.)$ a specific productivity. At the beginning of period t, $N_{it}\rho^x$ jobs are exogenously destroyed. Then after, idiosyncratic shocks are drawn and firms observe their specific component ε_{it}. If the specific component is below the threshold $\underline{\varepsilon}_{it}$, the employment relationship is severed. Otherwise, the employment relationship goes on. A fraction ρ_t^n of the remaining jobs $(1-\rho^x)N_t$ is destroyed. The number of posted vacancies is determined after the realization of idiosyncratic shock. The number of continuing employment relationships with specific productivity between $\bar{\varepsilon}$ and $\underline{\varepsilon}$ is governed by:

$$\int_{\underline{\varepsilon}_{it}}^{\bar{\varepsilon}} n_{it}(x)dx = (1-\rho_x)(1-\rho_{it}^n)N_{it} \tag{4}$$

The total separation rate is defined by: $\rho_t = \rho^x + (1-\rho^x)\rho_{it}^n$. Finally, the employment law of motion is described by the following equation :

$$N_{it+1} \quad = \quad (1-\rho_x)(1-\rho_{it}^n)N_{it} + v_{it}q_t \tag{5}$$

The number of job seekers corresponds to:

$$S_t \quad = \quad L - \sum_i (1-\rho_x)(1-\rho_{it}^n)N_{it} \tag{6}$$

while the number of unemployed workers $U_t = 1 - \sum_i N_{it}$ is determined at the beginning of period t (as well as employment). Finally, the labor market tightness is defined by $\theta_t = \sum_i V_{it}/U_t$.

2.3 The unemployment insurance

The US unemployment insurance system is of a particular interest. Only employers finance the cost incurred by the unemployment benefit fund. The contribution rate is "*experience rated*" in the sense that it is varied on the basis of employers' experience with the risk of unemployment. Basically, more dismissals or higher unemployment benefits result in a higher contribution rate the next period. The underlying role of this system is to equitably allocate the costs and the risk of unemployment. By adjusting premium rates to the layoffs history, experience rating makes employers responsible for the social cost of unemployment, providing a financial incentive to stabilize employment. But it is also a mean to encourage employers to participate in the system by providing eligibility information.

UI states use different method of experience rating. We will consider the most commonly used method (33 states) known as *reserve-ratio* method. Following Brechling (1977), Baily (1977) Topel (1983) and Anderson and Meyer (1994) we derive the formula for the firms' tax rate under the reserve ratio method. The timing of events slightly differs from the Topel's one to be consistent with both the law of motion of employment (5) and the quarterly frequencies. Under the reserve ratio system, each individual firm i is assigned its own account in the state UI fund. We assume the employer's account is calculated at the beginning of the period t. Each period, the account is credited of the contributions collected and is debited of the benefits paid (by the UI) to the employer's laid off employees, defining the reserve balance. Let B_{it+1} the employer's account in period $t+1$, its law of motion writes:

$$B_{it+1} = B_{it} + \tau_{it}\Upsilon_{it} - b(1 - N_{it}) \tag{7}$$

Contributions collected corresponds to the endogenous tax rate τ_t times the firms taxable payroll Υ_{it} while benefits paid are equal to the unemployment benefits ex-employees receives $b(1 - N_{it})$. A positive reserve balance means that, on average, total contributions exceed total benefits paid. Firms pay more to the UI than the expenditures they create through their firing decisions. Dividing the employer's reserve balance by its average taxable payroll over the past three years gives the reserve ratio. To simplify we assume that the reserve ratio of firm i ($\mathcal{R}_{it+1}$) is determined just after knowing the value of B_{it+1} and is based on the taxable payroll of the current quarter. It writes as follow:

$$\mathcal{R}_{it+1} = \frac{B_{it+1}}{\Upsilon_{it}} \tag{8}$$

Finally, the tax rate is determined according to the tax schedule imposed by the UI state[2]. We assume it is defined at the beginning of the period. Under the reserve ratio method, the tax schedule relate τ_{it+1} to $\mathcal{R}_t$. For example, the Arizona UI payroll tax schedule in 2009 is plotted in figure 3. τ increases in

[2]Of course, the reserve ratio in force is revised each year and is divided by the average

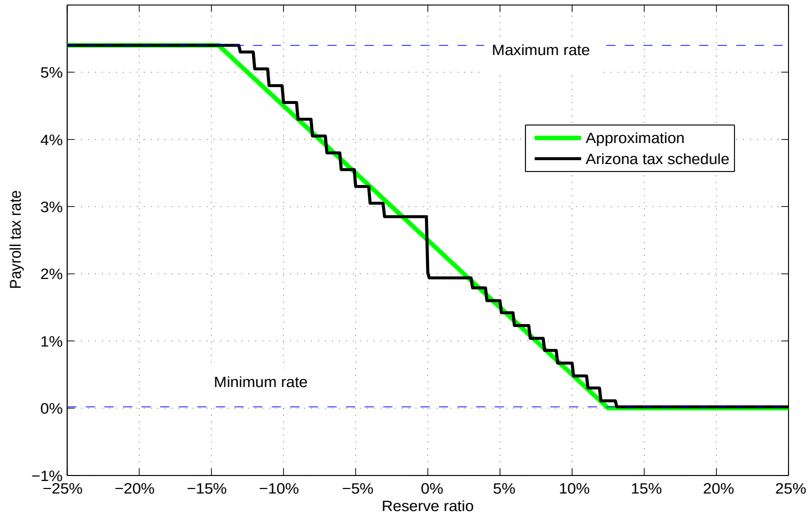

Figure 3: ***Unemployment insurance payroll tax schedule for Arizona (2009).***

step as $\mathcal{R}$ decreases. A positive reserve ratio means the employer's contributions overtake the fiscal cost of a laid off worker. It follows a low tax rate. The UI experience rating system is said to be perfect (or complete) when an employer pays for the entire cost of unemployment benefits that are perceived by his ex-employees. In other words, when UI benefits paid to a job loser increase by one dollar, the benefits charged to the employer increase by the same amount. To model the UI system, one can approximate the tax schedule. We neglect the different thresholds that give a "stairs-shaped" curve and consider a linear tax schedule between the maximum rate ($\tau_{\max}$) and the minimum rate ($\tau_{\min}$). The function that we have to approximate is:

$$\tau(\mathcal{R}) = \max\left[\min\left(\tau_{\max}, \tau(0) - \eta_1\mathcal{R}\right), \tau_{\min}\right] \tag{9}$$

This function is depict in figure 3 (green line).

taxable payroll over the past three years. It is defined as follows:

$$\mathcal{R}_t = \frac{B_t}{\frac{1}{3}\sum_{k=0}^{2}\Upsilon_{t-k}} \quad \text{year t}$$

But, because an increase in the number of lag will generate many state variables we assume that, for the sake of simplicity, employers' accounts and reserve ratios are revised according to quarterly frequencies and based on the current taxable payroll instead of the average payroll over the past three years. However, to be consistent with the UI system we change the shape of the tax schedule. We choose a flatter shape to offset the fast tax adjustment resulting from quarterly frequencies.

2.4 The large family program

To avoid heterogeneity, we suppose that infinitely lived households are members of a large family. There is a perfect risk sharing, family members pool their incomes (labour incomes and unemployment benefits) that are equally redistributed. The expected intertemporal utility of the large family writes:

$$\mathcal{W}_t = E_t \sum_{s=t}^{\infty} \beta^{s-t} \frac{(C_s + (1 - N_t)h)^{1-\sigma}}{1-\sigma} \tag{10}$$

$\beta \in]0,1[$ is the discount factor and $\sigma \in]0,1[\cup]1,\infty[$ is the intertemporal elasticity of substitution. h denotes unemployed workers home production and N_t aggregate employment over each firm. Family consumption corresponds to the home production $(1-N_t)h$ plus the market consumption goods C_t. The dynamic optimization problem consists of choosing a sequence of consumption $\{C_s\}_t^{\infty}$ maximizing the expected intertemporal utility subject to the budget constraint and a set of equations describing the employment motion. Taking the job finding rate $\theta_t q_t$ and individual wages $w_{it}(\varepsilon_{it})$ as given, the large family's choice problem takes the following recursive form :

$$\mathcal{W}(\Omega_t^H) = \max_{C_t} \left\{ \frac{(C_t + (1 - N_t)h)^{1-\sigma}}{1-\sigma} + \beta E_t \mathcal{W}(\Omega_{t+1}^H) \right\} \tag{11}$$

subject to the two aggregate laws of motion of employment (equations (4) and (5) which are both integrated between 0 and 1 over i) and the following budget constraint:

$$C_t = \int_0^1 \int_{\varepsilon_{it}}^{\bar{\varepsilon}} n_{it}(x) w_{it}(x) dx di + bU_t + \Pi_t + T_t \tag{12}$$

with the state vector $\Omega_t = (N_{it}; z_t)$. b denotes the flow value of being unemployed, taken to be unemployment benefits. $w_{it}(\varepsilon_{it})$ is the wage associated to a job in firm i with productivity level ε. $N_{it} = \int_{\varepsilon_{it}}^{\bar{\varepsilon}} n_{it}(x)dx$ is total employment of firm i. Finally, the large family receives instantaneous profits for an amount Π_t and a lump-sum transfer T_t. The optimality conditions of this problem with respect to C_t and $n_t(\varepsilon)$ respectively write[3]:

$$\lambda_t = (C_t + (1 - N_t)h)^{-\sigma} \tag{13}$$

$$\mu_t(\varepsilon_t) = \lambda_t(w_t(\varepsilon_t) - b - h) + \mu_t^1(1 - \theta_t q_t) \tag{14}$$

(13) is the Euler condition. λ_t, $\mu_t(\varepsilon_t)$ and μ_t^1 are Lagrange multipliers of the budget and the two employment constraints ((4) and (5)) respectively. $\mu_t(\varepsilon_t)$ gives the present and expected marginal value of a job with productivity ε. The

[3] See appendix for details

derivative of the Lagrangian associated to the above program with respect to N_{t+1} gives $\mu_t^1 = \beta E_t \mathcal{W}_1'(\Omega_{t+1}^H)$. μ_t^1 corresponds to the worker net expected value from employment. Using the envelop conditions the family's marginal values of a job with productivity ε_t is:

$$\begin{aligned} \mu_t(\varepsilon_t) &= \lambda_t w_t(\varepsilon_t) - \lambda_t b_t - \lambda_t h - \theta_t q_t \beta E_t \mathcal{W}_1(\Omega_{t+1}^H) \\ &+ (1-\rho^x)\beta E_t \int_{\underline{\varepsilon}_{t+1}}^{\overline{\varepsilon}} \mu_{t+1}(x) dG(x) \end{aligned} \quad (15)$$

2.5 The large firm program

The expected discount sum of instantaneous profits of the large firm writes:

$$\mathcal{V}_{it} = E_t \sum_{s=t}^{\infty} \beta^{s-t} \frac{\lambda_s}{\lambda_t} \left[\int_{\underline{\varepsilon}_s}^{\overline{\varepsilon}} z_s x n_{is}(x) dx - (1+\tau_t) \int_{\underline{\varepsilon}_{is}}^{\overline{\varepsilon}} w_{is}(x) n_{is}(x) dx - \Gamma(v_{is}) \right] \quad (16)$$

New jobs and old jobs do not continue if their specific productivity level is below a threshold $\underline{\varepsilon}_{it}$. For the sake of simplicity we assume that total wages and taxable wages are equivalent. Hiring is costly and incurs a cost $\Gamma(v_{is})$ per vacancy posted. We assume, in the line of Rotemberg (2008), that $\Gamma'(v) > 0$ and $\Gamma''(v) < 0$. Because hiring costs corresponds to advertising, screening and interviewing applicants, contact temporary work agencies, training or productivity losses at the beginning of a match relation, it is quite relevant to assume they are subject to economies of scales. Typically, the marginal cost of hiring many workers is not as high as for one worker. The dynamic optimization problem consists of choosing the sequences of vacancies, productivity thresholds and the number of continuing employment relationships, that is $\mathbf{C}_t = (v_{it}, \underline{\varepsilon}_{it}, \{n_{it}(x)\}_{x \in [\underline{\varepsilon}_{it}, \overline{\varepsilon}]})$, maximizing the expected discount sum of instantaneous profit. Assuming the large firm takes both the probability of filling vacancies and the wages as given, the program takes the following recursive form:

$$\mathcal{V}_i(\Omega_{it}^F) = \max_{\mathbf{C}_{it}} \left\{ \int_{\underline{\varepsilon}_{it}}^{\overline{\varepsilon}} z_t x n_{it}(x) dx - (1+\tau_{it}) \Upsilon_{it} - \Gamma(v_{it}) + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \mathcal{V}_i(\Omega_{it+1}^F) \right\} \quad (17)$$

subject to the employment motion ((4) and (5)) and the unemployment insurance system ((8),(7) and (9)). Because of binding constraints, the discontinuous function[4] that relates τ and $\mathcal{R}$ (see equation (9)) can be rewrites as follows:

$$\tau_{it+1} = \eta_0 - \eta_1 \mathcal{R}_{it+1} \quad (18)$$

$$\tau_{it+1} \leq \tau_{\max} \quad (19)$$

$$\tau_{it+1} \geq \tau_{\min} \quad (20)$$

[4]Further details on the approximation method are given in section "Quantitative evaluation of the model".

We restrict the firms tax rate to be below $\tau_{\max}$ and above $\tau_{\min}$. Between the two statutory rates, the tax adjustment is linear, consistent with equation (9). The state vector is given by $\Omega_{it}^F = (N_{it}, \tau_{it}, B_{it}; z_t)$ and $\Upsilon_{it} = \int_{\underline{\varepsilon}}^{\bar{\varepsilon}} n_{it}(x) w_{it}(x) dx$ denotes the taxable payroll. The associated optimality conditions of the above problem with respect to v_{it}, $\underline{\varepsilon}_{it}$ and $n_{it}(\varepsilon_{it})$ are respectively[5]:

$$\frac{\Gamma'(v_{it})}{q_t} = \beta_{t+1} E_t \Lambda_{it}^1 \tag{21}$$

$$z_t \underline{\varepsilon}_{it} = w_{it}(\underline{\varepsilon}_{it})(1+\tau_{it}) - \Lambda_{it}^1 - \Lambda_{it}^3 \left(w_{it}(\underline{\varepsilon}_{it})\tau_{it} + b\right) + \Lambda_{it}^4 \frac{B_{it+1} w_{it}(\underline{\varepsilon}_{it})}{\Upsilon_{it}^2} \tag{22}$$

$$\begin{aligned}\Lambda_{it}(\varepsilon_{it}) = {} & z_t \varepsilon_{it} - w_{it}(\varepsilon_{it})(1+\tau_{it}) + \Lambda_{it}^1 + \Lambda_{it}^3 \left(w_{it}(\varepsilon_{it})\tau_{it} + b\right) \\ & - \Lambda_{it}^4 \frac{B_{it+1} w_{it}(\varepsilon_{it})}{\Upsilon_{it}^2}\end{aligned} \tag{23}$$

$$0 = \Phi_{it}^2 (\tau_{it+1} - \tau_{\max}) \tag{24}$$

$$0 = \Phi_{it}^3 (\tau_{it+1} - \tau_{\min}) \tag{25}$$

where $\beta_{t+1} = \beta\lambda_{t+1}/\lambda_t$ denotes the stochastic discount factor. $\Lambda_{it}(\varepsilon_{it})$, Λ_{it}^1, Λ_{it}^3 and Λ_{it}^4 are the Lagrange multipliers associated to the dynamic of employment ((4) and (5)), the reserve balance (7) and the reserve ratio (8) respectively. Φ_{it}^ℓ, $\ell = 1, 2, 3$ are the payroll tax Lagrange multipliers ((18), (20) and (19)). The last two ones result from the binding constraints and insure that the tax rate will be located in the interval $[\tau_{\min}; \tau_{\max}]$. Equations (21) provides the employment creation condition. It implies that the expected cost of search $\Gamma'(v_{it})/q_t$ must be equal to the benefits of hiring a new worker (with $\Lambda_{it}^1 = \mathcal{V}'_{i1}(\Omega_{it+1}^F)$ being the firm net expected value from a new job). (22) is the destruction condition. It shows that the firm present value of a job with productivity $\underline{\varepsilon}$ is equal to zero. Equation (23) defines the firm marginal surplus from employment with productivity level $z_t \varepsilon_{it}$. By symmetry, all firms takes the same decisions. We can drop subscripts i for individual firms. Using envelop conditions one has:

$$\frac{\Gamma'(V_t)}{q_t} = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} (1-\rho^x) \int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}} \Lambda_{t+1}(x) dG(x) \tag{26}$$

$$\begin{aligned}\Lambda_t(\varepsilon_t) = {} & z_t \varepsilon_t - w_t(\varepsilon_t)(1+\tau_t) + (1-\rho^x)\beta E_t \frac{\lambda_{t+1}}{\lambda_t} \int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}} \Lambda_{t+1}(x) dG(x) \\ & + \Lambda_t^3 (w_t(\varepsilon_t)\tau_t + b_t) - \Lambda_t^4 \frac{B_{t+1} w_t(\varepsilon_t)}{\Upsilon_t^2}\end{aligned} \tag{27}$$

$$\Phi_t^\ell = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \Upsilon_{t+1} (\Lambda_{t+1}^3 - 1) \qquad \ell = 1, 2, 3 \tag{28}$$

$$\Lambda_t^3 = \frac{\Lambda_t^4}{\Upsilon_t} + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \Lambda_{t+1}^3 \tag{29}$$

[5] All calculus are reported in appendix

The Lagrange multiplier associated to the reserve ratio (Λ_t^4) takes the following values:

$$\Lambda_t^4 = \begin{cases} -\eta_1 \Phi_t^1 & \text{if} \quad \tau_{\min} < \tau_t < \tau_{\max} \\ 0 & \text{otherwise} \end{cases} \tag{30}$$

When the tax hits one of the statutory rate, the shadow cost of the tax (Λ_t^4) is zero as shown in the above condition. Otherwise the tax cost is governed by the forward looking dynamics of the firms' tax rate. It is worth noting that we can not simplify the model to remove these forward-looking equations. The large firm model slightly depart from the single worker-firm as firms now take decisions under the dynamics law of motion of unemployment insurance.

2.6 Wage setting mechanism

We now turn to the wage setting structure. At equilibrium, filled jobs generate a return (the marginal value of the job $\Lambda_t(\varepsilon_t)$ plus the corresponding employed worker value $\mu_t(\varepsilon_t)$) greater than the values of a vacant job and of an unemployed worker. The net gain issued from a filled job is the total surplus of the match:

$$S_t(\varepsilon_t) = \frac{\mu_t(\varepsilon_t)}{\lambda_t} + \Lambda_t(\varepsilon_t) \tag{31}$$

Wages are determined through an individual Nash bargaining process between the large family and the large firm who share the total surplus. Each participant threat point corresponds to the value of the alternative option, which is the value of being unemployed or the value of a vacant job. The outcome of the bargaining process is given by the solution of the following maximization problem:

$$w_t(\varepsilon_t) = \arg\max_{w_t(\varepsilon_t)} \left(\frac{\mu_t(\varepsilon_t)}{\lambda_t}\right)^{1-\xi} \Lambda_t(\varepsilon_t)^{\xi} \tag{32}$$

where $\xi \in]0,1[$ and $1-\xi$ denote the firms and workers bargaining power respectively. The optimality conditions of the above problems are given by:

$$\begin{aligned} (1-\xi)\Lambda_t(\varepsilon_t) &= \xi \frac{\mu_t(\varepsilon_t)}{\lambda_t} \Psi_t \\ \text{where} \quad \Psi_t &= 1 + \tau_t(1-\Lambda_t^3) + \Lambda_t^4 \frac{\mathcal{R}_{t+1}}{\Upsilon_t} \end{aligned} \tag{33}$$

This condition slightly differs from the one in standard matching model since the unemployment insurance system now makes the payroll tax rate endogenous. Using (15), (26) and (27), the wage expression of a job with idiosyncratic productivity ε_t is given, after some calculus detail in appendix, by:

$$\begin{aligned} w_t(\varepsilon_t) = {} & (1-\xi)\left(\frac{z_t \varepsilon_t + \Lambda_t^3 b}{\Psi_t} + \frac{\Gamma'(V_t)\theta_t}{\Psi_{t+1}}\right) + \xi(b+h) \\ & + \beta E_t \left(\frac{1}{\Psi_t} - \frac{1}{\Psi_{t+1}}\right)(1-\xi)(1-\rho^x)\frac{\lambda_{t+1}}{\lambda_t}\int_{\varepsilon_{t+1}}^{\bar{\varepsilon}} \Lambda_{t+1}(x)\, dG(x) \end{aligned} \tag{34}$$

2.7 Job creation and job destruction condition

The job creation is governed equation (26). The job destruction condition implies that at the lowest acceptable productivity the match is over. In other words, it is better to break the relation and search for an alternative match partner on the labor market than continuing with productivity $\underline{\varepsilon}_t$. It writes as follow:

$$\Lambda_t(\underline{\varepsilon}_t) = 0 \tag{35}$$

(35) implies $\Lambda_t(\varepsilon_t) - \Lambda_t(\underline{\varepsilon}_t) = \Lambda_t(\varepsilon_t)$. Now, using equation (27) one can easily deduce that:

$$\Lambda_t(x) = \xi z_t(x - \underline{\varepsilon}_t) \qquad \forall\ x \tag{36}$$

We can now evaluate the surplus $\Lambda_t(x)$ in $t+1$ thanks to (36) and replace it in (26) and (27). The wage expression (34) allows to eliminate $w_t(\varepsilon_t)$ from (27). Finally, the job creation and the job destruction conditions can be explicitly calculated as:

$$\frac{\kappa}{q_t} = \xi\beta E_t \frac{\lambda_{t+1}}{\lambda_t}(1-\rho^x)z_{t+1}\int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}}(x - \underline{\varepsilon}_{t+1})dG(x) \tag{37}$$

$$\begin{aligned} 0 &= \left(z_t\underline{\varepsilon}_{t+1} + \Lambda_t^3 - (b+h)\Psi_t\right) - \frac{1-\xi}{\xi}\Gamma'(V_t)\theta_t E_t\frac{\Psi_t}{\Psi_{t+1}} \\ &+ \beta E_t\frac{\lambda_{t+1}}{\lambda_t}(1-\rho^x)z_{t+1}\int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}_{t+1}}(x-\underline{\varepsilon}_{t+1})dG(x)\left(\frac{\Psi_t + \xi(\Psi_{t+1}-\Psi_t)}{\Psi_{t+1}}\right) \end{aligned} \tag{38}$$

2.8 Closing the model

The aggregate output Y_t is obtained through the sum of individual productions :

$$Y_t = N_t(1-\rho^x)z_t\int_{\underline{\varepsilon}_t}^{\varepsilon} x\,dG(x) \tag{39}$$

The aggregation of the individual profits provides the amount of profits Π_t the large family receives, that is :

$$\Pi_t = Y_t - \Upsilon_t(1+\tau_t) - \Gamma(V_t) \tag{40}$$

The above equation together with the large family budget constraint gives the aggregate resource constraint :

$$Y_t = C_t + \Gamma(V_t) \tag{41}$$

The average wage is given by:

$$\bar{w}_t = \int_{\underline{\varepsilon}_t}^{\bar{\varepsilon}} w_t(x)\frac{dG(x)}{1-G(\underline{\varepsilon}_t)} \tag{42}$$

The UI budget constraint is balanced every period according to the following rule:

$$\underbrace{U_t \;\; b_t}_{\substack{\text{Benefits} \\ \text{paid } (BP_t)}} = \underbrace{T_t}_{\substack{\text{Lump- sum} \\ \text{tax}}} + \underbrace{\sum_i N_{it}(1-\rho^x)\bar{w}_{it}\tau_{it}}_{\substack{\text{Contributions} \\ \text{collected } (CC_t)}} \tag{43}$$

3 Model solution and calibration

The economy implies three tax categories: a minimum tax rate, a maximum tax rate and a linear tax adjustment between the thresholds. The model solution features three agents' optimal decision rules. When the tax hits one threshold, the economy switches from one category to another. Then, due to the strong non-linearities of the model, local approximations around the steady state (log-linear and perturbation methods) may lead to spurious approximations. We choose instead a parameterized expectation algorithm (PEA) to solve the model (Marcet (1988), Den Haan and Marcet (1990)). Details on the computation algorithm are provided in appendix. The benchmark economy is calibrated according to quarterly frequencies. We follow Den Haan and *al.* (2000), Andolfatto (1996) and Shimer (2005) to set the US labor market parameters. Baseline parameters are reported in table 1.

Productivity and preferences We set the discount factor to 0.99, which gives an annual steady state interest rate close to 4%. The risk aversion coefficient σ is set to 2. The aggregate productivity shock follows a first-order autoregressive process : $\log z_{t+1} = \rho_z \log z_t + \varepsilon^z_{t+1}$. ρ_z corresponds to the autocorrelation coefficient; it is equal to 0.95. ε^z_{t+1} is a random variable whose realizations are i.i.d. and drawn from a time-invariant Gaussian distribution with mean zero and standard deviation σ_z whose value is choose to match the standard deviation of output. The distribution G(.) of idiosyncratic productivity shocks is Uniform over the range [0;1][6]. Then, $G(\underline{\varepsilon}) = \underline{\varepsilon}$.

Labor market: stocks and flows The probability of being unemployed (ρ) is 3.51 percent on average in the US. We suppose as in Den Haan and *al.* (2000), Zanetti (2007) and Algan (2004) that exogenous separations are two times higher than endogenous ones. We keep the traditional value of 0.5 for the workers bargaining power. The elasticity of the matching function with respect to unemployment is 0.7 according to Shimer (2005)'s estimations.

[6]Results remain unchanged using a log-normal distribution. However the log-normal distribution is more time and resources-consuming since it requires numerical integration over a sparse grid.

Variables	Symbol	Value
Discount factor	β	0.99
Autocorrelation coefficient	ρ_z	0.95
Std. dev. of aggregate shock	σ_z	0.0083
Risk aversion coefficient	σ	2
Matching elasticity	ψ	0.5
Exogenous separation rate	ρ^x	0.0236
Endogenous separation rate	ρ^n	0.0118
Worker bargaining power	ξ	0.5
Replacement rate	ρ^R	0.4
Marginal vacancy cost/wage	$\Gamma'(V)/\bar{w}$	0.23

Table 1: **Baseline parameters.**

The equilibrium unemployment rate U is set to the average rate calculated over the sample: 5.64%. The steady state number of matches must be equal to the number of separations: $M = \rho N$. Following Andolfatto (1996), the rate at which a firm fills a vacancy is 0.9. We can deduce the aggregate number of vacancy $V = M/q$ and the job finding probability of about 0.35. χ is calculated in such a way that $M = \chi S^{\psi} V^{1-\psi}$. We assume the adjustment cost function takes the form:

$$\Gamma(V) = \frac{\phi_V}{1+\gamma} \left(V(\kappa + Qq) \right)^{1+\gamma} \tag{44}$$

where κ stands for the cost of posting a vacancy. It is paid by the firm as long as the job remains unfilled. Q stands for the cost of screening and training workers. It is only paid at the time of hiring. γ and ϕ_V are the adjustment cost function parameters. Under Yashiv (2006) calibration, $\gamma = 1$ which involves a quadratic adjustment cost function. However, as mentioned earlier, there is low evidence the shape of hiring cost is convex. As mentioned Rotemberg (2008) citing Abraham and Wachter (1987), "*placing an advertisement x times does not generally cost x times the amount it costs to place and advertisement once. For example the Boston Globe's May 2005 rates indicate that the cost of placing an advertisement for four additional days within a week is zero once the advertisement runs for Sunday and two additional weekdays (the Sunday rate per agate line is $25, the daily rates once an ad appears on Sunday is $5, and the weekly rate is $35)*". Rotemberg choose a value of $\gamma = -0.8$, which gives an increasing and concave adjustment cost function. We follow its approach and set γ and ϕ_V so as to match the correlation of unemployment and vacancies. The resulting values are $\gamma = -.8$ and $\phi_V = 1$. The remaining parameters: κ, Q and h are only given by solving the system of three equations (37), (38) and (42) in three unknown ($\Gamma(V)$, h and $\bar{w}$) and assuming as in Langot and Chéron (2006) that training and screening costs are two times higher than advertising costs ($2\kappa = Q$).

Unemployment insurance The UI parameters are more complex to calibrate since some variables are only available at annual frequencies and each state use different methods of experience rating and different tax schedules[7]. Fortunately, DOLETA (Department Of Labor, Employment and Training Administration) has produce quarterly total benefits paid, aggregate reserve ratio and trust fund balance using UIDB (Unemployment Insurance Data Base) as well as UI-related data from outside sources (BLS and US department of treasury data on state UI trust fund activities) over the period 1998Q4-2009Q3. Average tax rates and state revenues are extrapolated for the most recent 12 months and can be used as a proxy for our purpose. In addition, we use statistics produced by DOLETA compiled in the report "*Significant measures of state UI tax systems*" to parameterized the tax schedule. Although they are annual statistics they give intersting informations on the number of employers at the minimum and the maximum tax rate over 2006-2009. Finally, we also target the results of Marks (1984) who compute the transition matrix of the different tax categories from a random sample of more than 17000 New Jersey employers. All these statistics are reported in table 2. The tax schedule parameters are set in the following manner:

(i) The steady state payroll tax is set to solve the UI budget consistent with the average net replacement rate calculated by DOLETA of about 40% ($b/\bar{w} = 0.4$). Then $\tau = 0.025$. It is also consistent with the constant estimated by regressing the aggregate reserve ratio (trust fund balance divided by the total payroll) on the average payroll tax rate. We impose the steady state aggregate contributions collected be equal to benefits paid. It follows that the firm's account (B), the reserve ratio ($\mathcal{R}$) and the lump-sum tax (T) are equal to zero. In addition the steady state payroll tax corresponds to the *Y-intercept* of the tax schedule: $\tau = \eta_0$.

(ii) As evoke Marks, employers have a very low probability of moving from one statutory tax rate to the mid-rate category[8]. Our results match reasonably well the probability of staying in the same state two consecutive periods and the transition probabilities from $\tau_{\min}$ and $\tau_{\max}$ to the mid-rate category. On the other hand, the model does not succeed in reproducing the probability of staying in the middle-rate and the transition probabilities from the mid-rate to $\tau_{\min}$ and $\tau_{\max}$.

(iii) The proportion of employers at the minimum (maximum) rate range from 32.4% to 38% (8.5% to 16.5%) according to Marks' study and from 9% to 38% (5% to 7%) according to statistics from DOLETA. Anderson and Meyers (1993)

[7]All but three states use either a reserve-ratio method or a benefit-ratio method to set the tax. Each state choose the tax schedule, involving different value of τmin, τmax, the slope and the level of unemployment benefits.

[8]The mid-rate corresponds to the case where employers are assigned a tax rate between the minimum and the maximum rate *i.e.* $\tau_{\min} < \tau_t < \tau_{\max}$.

Period-to-Period transition probabilities			
Initial status	Status next period		
	$\tau_{\min}$	mid-rate	$\tau_{\max}$
$\tau_{\min}$	0.76 (0.62)	0.24 (0.36)	0.00 (0.02)
mid-rate	0.01 (0.21)	0.98 (.66)	0.01 (0.13)
$\tau_{\max}$	0.00 (0.001)	0.15 (0.175)	0.85 (0.825)
Proportion of tax rate			
Marks (1975-78)	35.75	51.7	12.65
AM (1981)	13.02	82.1	4.88
DOLETA (2005-09)	20.2	74.4	5.4
Model	3.1	91.9	5.0

Table 2: **Makovian matrix of UI tax categories.** *We compute the annual UI payroll tax rate as the average tax rate over four quarters in order to calculate annual transition probabilities. We simulate the model 10^5 times and estimate the markovian matrix associated to the three tax categories. Results are compared to Marks's statistics (in parentheses). The proportion of employers at the minimum and the maximum rate in past studies is the average over the sample period. AM stands for Anderson and Meyers (1993), they compute the marginal tax cost for six states and report the proportion of employment at the minimum and maximum rate where the MTC is equal to zero.*

find that[9] on average, 13% and 5% of employment is at firms that have the minimum and the maximum tax rate respectively. The proportion of maximum rated employers is well reproduced but the proportion of minimum rated employers seems to be poorly matched.

It results the following value : $\tau_{\min} = 1.5\%$, $\tau_{\max} = 4.5\%$, $\eta_0 = 0.025$ and $\eta_1 = 0.15$[10]. A simulated path of the reserve ratio and the payroll tax rate are depicted in figure 4.

[9] In 1981, on six states using the reserve ratio method

[10] As explained Brechling (1977), the slope of the tax schedule is typically 0.3 for a tax that is annually revised. A slope of about 0.15 for a tax that is quarterly revised seems to be a reasonable value. In addition, the estimation using ordinary least squared of the following regression: $\tau_t = \beta_0 + \beta_1 \frac{TFB_{t-1}}{\Upsilon_{t-1}}$ gives $\hat{\beta}_1 = 0.15$ (where TFB stands for the trust fund balance and Υ the taxable payroll) over the period 1938-1997.

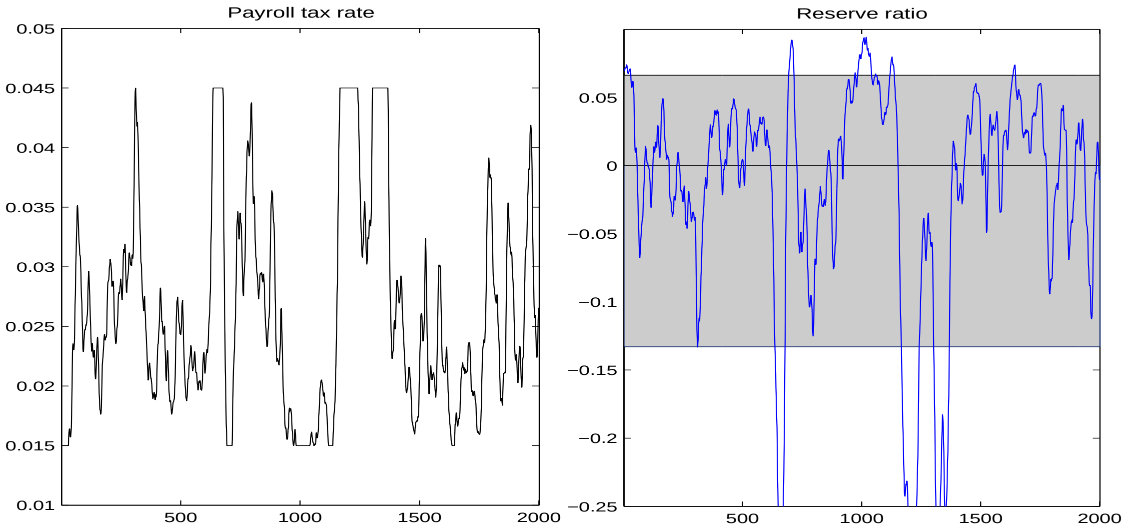

Figure 4: ***Simulated reserve ratio and payroll tax rate.*** *We draw 10000 random variables from the distribution of aggregate shock and simulate the model. We keep only the lasts 2000 observations. In the grey area the tax is experience rated. The upper bound of the grey area is the threshold above which the corresponding tax rate is* $\tau_{\min}$*. The lower bound of the grey area is the threshold below which the corresponding tax rate is* $\tau_{\max}$*.*

How well the model matches the data?

The ability of DSGE model in reproducing simultaneously the volatility of wages, unemployment, vacancies and the job finding rate has been of a great concerned as attests a broad variety of studies: Shimer (2005), Hall(2005), Krause and Lubik (2007), Mortensen and Nagypal (2007), Hagedorn and Manovskii (2008), Pissarides (2009), Rotemberg (2008) and the list is far from being exhaustive[11]. To evaluate whether the model succeeds in reproducing key business cycles facts we simulate mean levels, standard deviations, skewness, correlation and first-order autocorrelation of selected macroeconomic variables. The simulations are reported in table 5.

The mean level of unemployment and the separation rate are somewhat higher than the ones reported in the data, highlighting the non-linearities of the decision rules[12]. The job finding rate is lower than its empirical counterpart as mentioned in the baseline calibration. The model performs pretty well in reproducing the volatility of labor market variables without relying on the real wage

[11]Although this debate is still highly interesting, it is beyond the scope of this paper. We then do not discuss the macroeconomic implications of models in papers previously mentioned and we advise readers to refers to these papers instead.

[12]Recall the deterministic steady of unemployment and the separation rate are precisely set to the empirical mean level.

rigidity assumption. The reason can be fund in the concavity of the adjustment cost function that makes hirings more attractive during expansions, thanks to the economies of scale. In addition, the opportunity cost of vacancies being higher, firms are more willing to reduce them during recessions. The overall impact on the volatility of vacancies and the tightness is magnified. The model is able to generate 75% of the job finding rate volatility and 85% of the unemployment volatility but overestimates the separation rate volatility. It also produces a very realistic persistence of selected series. One of the most interesting aspect is the ability of our DSGE model with endogenous job destruction to match the strong negative correlation between unemployment and vacancies. This results is, one more time, due to the strong concavity of $\Gamma(V)$ that makes the vacancies shock response hump-shaped. However, the model seems to overestimate the correlation between employment and productivity. Finally, the third-order moments and the distribution of time series (see figure 5) reveal the model succeed to mimic the skewness of output, unemployment, tightness and separation rate but not the one of vacancy growth rate and the job finding rate.

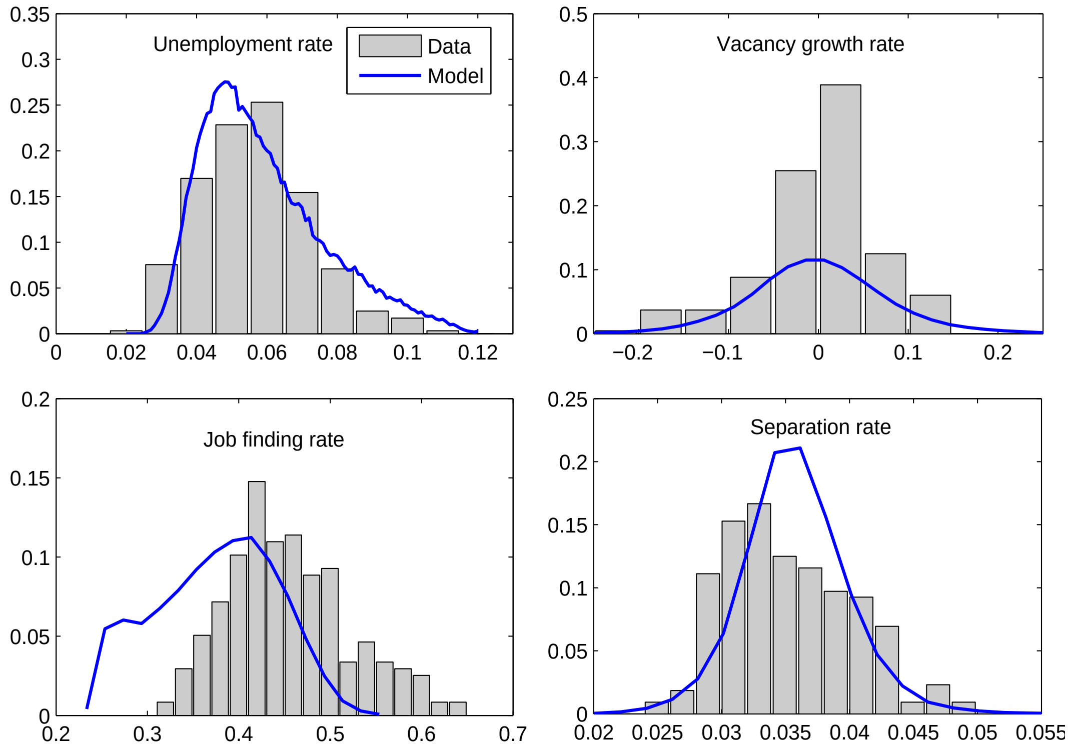

Figure 5: ***Distribution of unemployment rates, growth vacancies rate, job finding rates and separation rates.***

4 Policy experiments

The ability of experience rating in reducing layoffs is still of a great concerned. As mentioned earlier, imperfect experience rating systems result mainly from adjustment delays, non-charged benefits and statutory tax rates. The relevant question we ask is does imperfect experience rating magnifies layoffs and employment fluctuations? The key instruments policy makers can use to influence employment are the slope of the tax schedule, the average level of unemployment benefits, the Y-intercept of the tax schedule and the two statutory tax rates. We vary these instruments and study the consequences on labor market outcomes. Some of the evaluated reforms are depicted in figure 6.

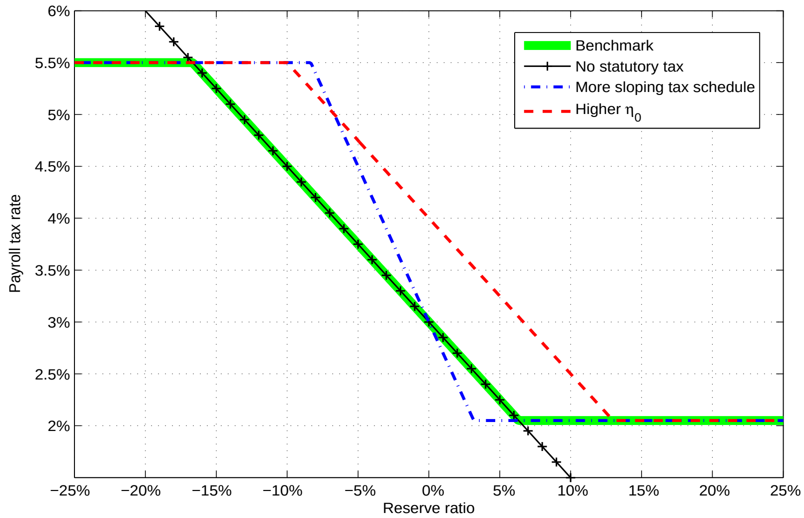

Figure 6: ***Changes in the unemployment insurance payroll tax schedule***

4.1 Does experience rating reduces layoffs in bad times?

Obviously, the underlying question is to what extend an increase in the payroll tax rate creates a real incentive for firms to reduce layoffs? How much stabilization gains can we expect to have if we vary the slope of the tax schedule? We explore the consequences of a less and a more sloping curve ($\eta_1 = 0.1$ $\eta_1 = 0.3$ and $\eta_1 = 0.4$ respectively) for a given level of statutory tax rates. Let first discuss the steady state effects because they characterize mean levels around which the economy fluctuates.

As report in table 5 a two times more slopped tax schedule increases the long-run level of employment by 1% but leave the separation rate unchanged. This is not self-evident since the reform doesn't affect the Y-intercept of the tax schedule as shown in figure 3. Then, contrary to a partial equilibrium analysis which cannot capture the entire application of a change in the tax schedule, one can identify the consequences on employers' expectations. Employers post more vacancies and the number of unemployed decreased by almost 15%, enhancing the job finding rate by around 9.6%. Let us now look on impulse responses functions. Figures 7 depicts the results.

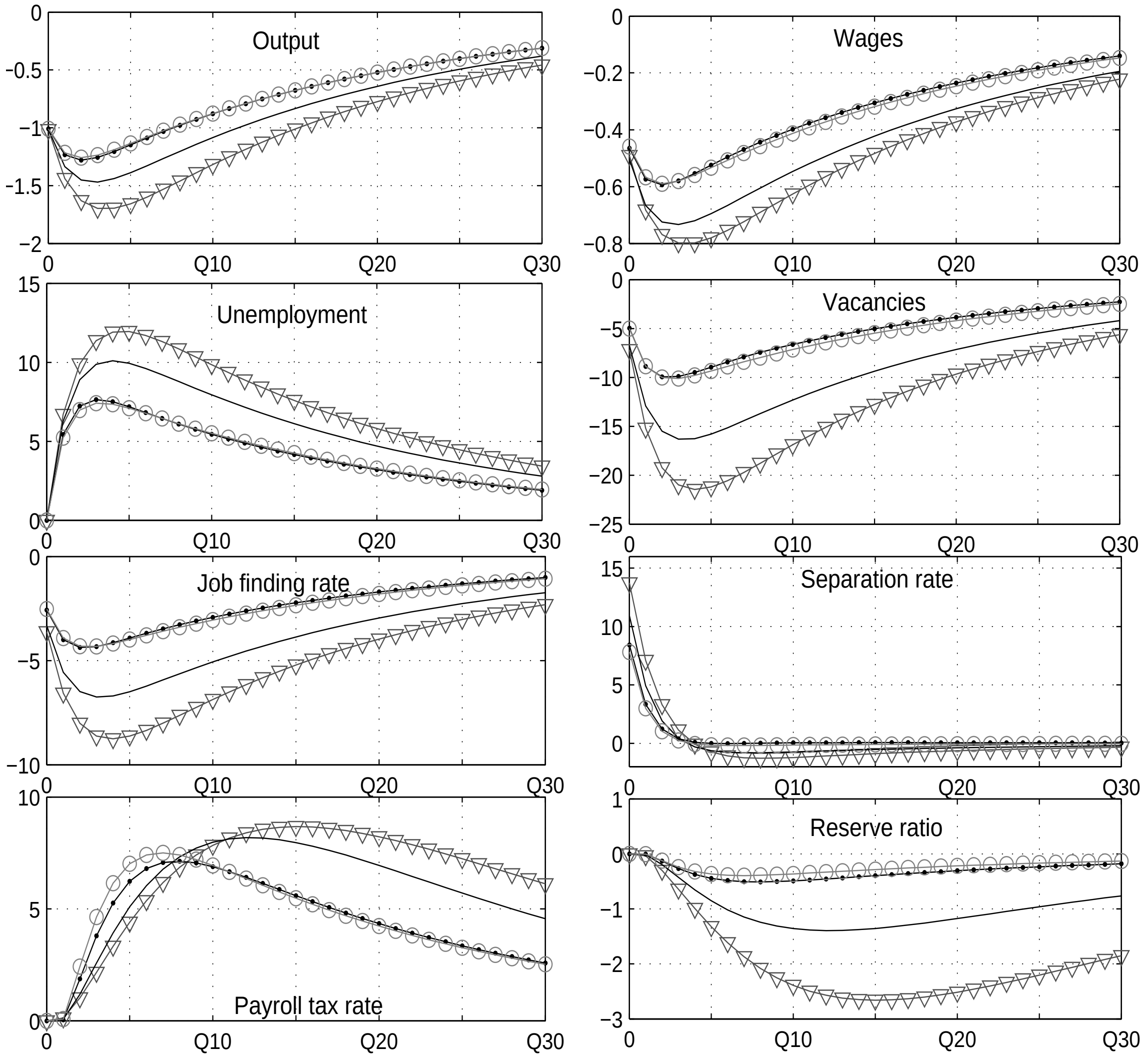

Figure 7: ***Impulse response function to a 1% negative productivity shock*** *Benchmark ($\eta_1 = 0.15$): solid line (no markers), $\eta_1 = 0.1$: downward-pointing triangle markers ,$\eta_1 = 0.3$: point markers, $\eta_1 = 0.4$: circle markers.*

A single negative shock doesn't provide a sufficient impulsion to involve a large negative (positive) reserve ratio and to drive the tax rate to the upper (lower) bound. Following the shock, the job losers rate jumps above its steady state level and rapidly returns to its initial level. The number of unemployed workers increases with a one-lag period, inflating UI expenditures. Benefits paid to job losers raise while the initial decrease of the average payroll reduces the contributions collected after the shock. To balance the UI budget, the payroll tax is adjusted with a one-lag period thanks to the experience rating mechanism. In contrast with standard DSGE models that assume linear hiring costs, our framework allow to reproduce the hump-shaped adjustment of vacancies (see Fujita and Ramey, 2007). This key properties produce the observed strong correlation between unemployment and vacancies that features the US Beveridge curve. Obviously, a less downward slopping curve increases the propagation of the productivity shock and magnifying the response of labor market outcomes. Conversely, a more downward slopping curve makes the response of contributions collected faster, limiting the decline of the reserve ratio. It reduces the firms' incentive to lay workers off as well as hiring them over the cycles. The jump of vacancies and the separation rate are weaker which dampened employment fluctuations. It is worth noting that the effects of $\eta_1 = 0.3$ and $\eta_1 = 0.4$ are roughly the same. Then, from $\eta_1 = 0.3$, increasing the slope of the tax schedule cannot dampen shock responses of macroeconomic variables anymore. This result is a direct consequence of the marginal tax cost level. As shown a large body of studies, including the ones of Topel and Anderson and Meyer among others, the marginal tax cost can be defined as the fraction of an additional dollar in benefits received by its former employees that a firm would pay in higher future taxes. Noting r the nominal interest rate and assuming the growth factor for taxable wages is constant, the marginal tax cost is given by (see the derivation in Topel's study (1983)): $MTC = \eta_1/(r + \eta_1)$. Assuming a 4% nominal interest rate, the MTC is equal to 0.71, 0.79, 0.88 and 0.90 when $\eta_1 = 0.1$, $\eta_1 = 0.15$, $\eta_1 = 0.3$ and $\eta_1 = 0.4$ respectively. It is straightforward that moving η_1 from 0.3 to 0.4 doesn't really affect the MTC.

The standard deviations effects (see table 5) confirm the ability of experience rating in reducing labor market fluctuations. Switching η_1 from 0.15 to 0.3 reduces the volatility of unemployment and vacancies by around 3.3% and 1.1% respectively. More important such a reform makes the volatility of the job finding rate and the separation rate 8.2% and 15.8% lower. Output variability falls by 5.7% while the reform has no impact on average wages volatility nor on the persistence of the variables. However, it reduces the correlation between unemployment and vacancies by 27%.- Looking the probability of reaching the statutory taxes may help to understand the effects of a more downward slopping tax schedule. Indeed, the above reform has two major consequences. It provides a better incentive to smooth employment as demonstrate impulse response function but it may affect the probability to hit the statutory tax rate. What we can learn from the new estimated Markov chain (see table 3) is that setting η_1 to 0.3 makes the probability to hit the maximum rate close to 0. It also strongly reduces the probability of staying in state $\tau_{\min}$ and $\tau_{\max}$ and raises the probability to reach the minimum tax rate by around 42%. As a result, large firms are

Period-to-Period transition probabilities			
Initial status	Status next period		
	$\tau_{\min}$	mid-rate	$\tau_{\max}$
$\tau_{\min}$	0.72	0.28	0.00
mid-rate	0.013	0.986	0.001
$\tau_{\max}$	0.00	0.36	0.64
Proportion of tax rate			
Model	4.4	95.5	0.01

Table 3: Markovian matrix of UI tax categories.

less likely to report the fiscal cost of laid off employees and have to pay more contribution to the UI on average. Then, at this stage the relevant question is to what extend the decrease of the macroeconomic volatility is due to the changes of the transition matrix or to the slope of the tax schedule. To isolate the effect of η_1, we vary the level of $\tau_{\min}$ and $\tau_{\max}$.

4.2 Does statutory tax rates affect employment dynamics?

The existence of minimum and maximum rates limits the UI ability to balanced the budget each period and can distort firms hiring and firing practices. Due to the strong non linearities of the model, we evaluate the consequences of an unconstrained experience rating system and a more constraining UI statutory tax rates[13]. Once again we simulate the model and compute first-order moments, second-order moments and we estimate the Markovian matrix of the tax (see table 5).

The overall impact of statutory tax rates on long-run levels is low compared to the previous reform. Indeed, if we remove $\tau_{\min}$ or $\tau_{\max}$, the best we may hope for is a 1% decline of the steady state unemployment rate. When the range of the experience rated tax is reduced by 10% from any one side, vacancies and the tightness are cut back while the unemployment size may increase up to 3%. Decreasing the maximum tax rate involves the same qualitative effects as an increase of $\tau_{\min}$ but the quantitative impact is a tiny bit higher. In both cases, the separation rates remain similar to the benchmark case.

Second-order moments highlight, however, the importance of statutory tax rates in the propagation of macroeconomic shocks. As shown in table 5, a 10% increase of $\tau_{\min}$ leads to a rise of output, employment and the labor market tightness volatility by 5%, 16% and 18% respectively. The separation rate variability

[13]A typical unconstrained experience rating system features no statutory tax rate. Conversely, *"a more constraining UI statutory tax rates"* features a higher level of $\tau_{\min}$ or a lower level of $\tau_{\max}$. In this case, the unemployment insurance has more difficulties to balance its trust fund reserve because the amount of time the tax is experience rated is reduced. In other words, the degree of experience rating is lower.

becomes 3% higher and its persistence is a little bit higher. The intuition is as follow. Once an employer reaches the minimum tax rate he has to pay more to the UI than the fiscal cost he creates through its dismissal decisions. Because the marginal tax cost becomes equal to zero, hiring an additional worker cannot reduce the tax cost anymore. It follows that employers have no interest to increase their employment as long as they receive a proportional "implicit negative subsidy". In good states, if the tax rate falls up to $\tau_{\min}$ employers will be less prone to post vacancies. In this case, a rise of $\tau_{\min}$ may curb the increase of vacancies during expansions and amplify the fall of them during recessions. This last effect is quite intuitive and arise from the very little incentives employers have to avoid the maximum rate. Recall that at the maximum tax rate, further job terminations cannot result in more contributions. Then $\tau_{\max}$ generate a "positive implicit subsidy". To stay at the maximum rate employers can either increase firings or reduce hirings through the job posting activity. The overall impact of a rise in $\tau_{\min}$ on the volatility clearly depends on whether vacancies falls more during downturns than they are dampened during booms. It is shown that the first effect dominates the second.

Conversely, removing $\tau_{\min}$ doesn't affect the cyclical properties of the model. The reason can be found in the week proportion of employer rated at the minimal level. Assuming a higher initial proportion of minimum rated employers would amplify the decrease of labor market volatility coming from removing $\tau_{\min}$. On the other side, such reform raises the probability of staying at the maximum rate while the transition probability from the *mid-rate* to $\tau_{\max}$ remains virtually unchanged. This in turn, increases the amount of time large firms are rated the minimum tax and the maximum tax.

The existence of a maximum rate can magnifies the separation rate. Removing it may reduce the volatility of the separation rate up to 3% but a single 10% decrease of it may increase the separation rate volatility by around 3%. The intuition is as follow. When the maximum rate is reached, the unemployment insurance can't fully recover its expenditures and must report the burden of benefits paid in the future. The gap between benefits paid and contributions collected continues to increase while the payroll tax remains blocked at the legal maximum rate. This deteriorate the reserve ratio until the next trend reversal. During this period the marginal tax cost is equal to zero, making the firing process cheaper. Employers are free to lay workers off at no additional costs. There is no reason he reduces its layoff rate. This may lead to excessive match dissolutions during recessions, a striking feature we can observed through a decrease in the volatility of the separation rate. However, it seems to have no effect on hirings nor on the skewness of aggregate variables (see figure 8).

Period-to-Period transition probabilities				
Initial status	Status next period			
	$\tau_{\min}$	mid-rate	$\tau_{\max}$	
$\tau_{\min}$	0.81	0.19	0.00	
mid-rate	0.013	0.978	0.01	(1)
$\tau_{\max}$	0.00	0.13	0.87	
% Prop.	5.80	88.0	6.12	
$\tau_{\min}$	0.74	0.26	0.00	
mid-rate	0.01	0.93	0.02	(2)
$\tau_{\max}$	0.00	0.10	0.90	
% Prop.	1.9	83.5	14.6	

Table 4: **Markovian matrix of the UI tax categories.** *(1) is the estimated markovian matrix when the minimum rate is increased by 10%. (2) is the estimated markovian matrix when the maximum rate is reduced by 10%.*

5 Conclusion

This paper studies the dynamic effects of unemployment insurance experience rating systems which relates firms' payroll tax rate to their layoffs history. Using a DSGE business cycle model with search and matching frictions and risk-adverse workers, we show that this incentive-based method may have a significant impact on both long run levels and the fluctuations of labour market outcomes. Increasing the slope of the tax schedule (more experience rating) dampens shock responses of macroeconomic variables. Furthermore, the existence of statutory tax rates (minimum and maximum payroll tax rates) strongly distorts the way firms adjust employment during booms and busts but let the steady states effects virtually unchanged. This study confirms the conventional wisdom according to which experience rating can reduce fluctuations of the labor market and highlight new insight on the consequences of statutory tax rates which have been neglected from previous study.

References

Anderson, M. and Meyer, B. (1993): "Unemployment Insurance in the United States: Layoff Incentives and Cross Subsidies," *Journal of Labor Economics*, Vol. 11, No. 1,, pp. S70-S95.

Anderson, M. and Meyer, B. (2000): "The effects of the unemployment insurance payroll tax on wages, employment, claims and denials," *Journal of Public Economics*, Vol. 78, 81-106.

Albrecht, J. and Vroman, S. (1999): "Unemployment Compensation Finance and Efficiency Wages," *Journal of Labor Economics*, Vol. 17, No. 1, pp. 141-167.

Algan, Y. (2004): "La protection de l'emploi : des vertus stabilisatrices ?," working paper.

Brechling, F. (1977): "Unemployment Insurance Taxes and Labor Turnover: Summary of Theoretical Findings," *Industrial and Labor Relations Review*, Vol. 30, No. 4, pp. 483-492.

Burdett, K. and Wright, R. (1989): "Unemployment Insurance and Short-Time Compensation: The Effects on Layoffs, Hours per Worker, and Wages" *Journal of Political Economy*, Vol. 97, No. 6, pp. 1479-1496.

Cahuc, P., and F. Malherbet (2004): "Unemployment compensation finance and labor market rigidity," *Journal of Public Economics*, 88, 481-501.

Card, D., and P. Levine (1994): "Unemployment insurance taxes and the cyclical and seasonal properties of unemployment," *Journal of Public Economics*, 53.

Den Haan, W. and Marcet, A. (1990): "Solving the Stochastic Growth Model by Parameterizing Expectations," *Journal of Business & Economic Statistics.*, Vol. 8. pp. 31-34..

Den Haan, W., G. Ramey, and J. Watson (2000): "Job Destruction and Propagation of Shocks," *American economic review*, 90(3), 482-498.

Fast, C. and Fuest, J. (2000): "Temporary Layoffs and Unemployment Insurance: Is Experience Rating Desirable?," *German Economic Review*, 6(4), 471-483.

Feldstein, M. (1976): "Temporary Layoffs in the Theory of Unemployment," *Journal of political economy*, 84(5), 937-957.

FUJITA, S. AND RAMEY, G. (2007): "Job matching and propagation," *Journal of Economic Dynamics and Control*, vol. 31(11), pages 3671-3698.

HAGEDORN, M. AND MANOVSKII, I. (2008): "The Cyclical Behavior of Equilibrium Unemployment and Vacancies Revisited," *American Economic Review*, vol. 98(4), pp 1692-1706

HALL, R. (2008): "Employment Fluctuations with Equilibrium Wage Stickiness," *American Economic Review*, vol. 95(1), pp. 50-65.

L'HARIDON, O., AND MALHERBET, F. (2009): "Employment protection reform in search economies," *European economic review*, vol. 53(3), pages 255-273.

KRAUSE, M., AND LUBIK, T. (2007): "The (ir)relevance of real wage rigidity in the New Keynesian model with search frictions," *Journal of Monetary Economics*, vol. 54 706-727.

MARCEAU (1993): "Unemployment insurance and market structure," *Journal of Public Economics*, 52, 237-249.

MARCET, A. (1988): "Solving Nonlinear Stochastic Models by Parametrizing Expectations", mimeo, *Carnegie Mellon University.*

MARKS, A. (1984): "Incomplete experience rating in State unemployment insurance", *Monthly labor review*, Research Summaries, 45-49.

MILLARD, S., MORTENSEN, D. (1997). "The unemployment and welfare effects of labour market policy: a comparison of the U.S. and U.K." In: Snower, D.J., de la Dehesa, G. (Eds.), Unemployment Policy: Government Options for the Labour Market. *Cambridge University Press*, New York.

MONGRAIN, S., AND J. ROBERT (2005): "Unemployment insurance and the experience rating: insurance versus efficiency," *International economic review*, Vol. 46, No. 4.

MORTENSEN, D., AND C. PISSARIDES (1994): "Job creation and job destruction in the theory of unemployment," *The review of economic studies*, 61(3), 397- 415.

MORTENSEN, D., AND C. PISSARIDES (1999): "Job reallocation, employment fluctuations and unemployment," *Handbook of Macroeconomics*, vol. 1, chap. 18, pp. 1171-1228. Elsevier Science, New York.

MORTENSEN, D., AND NAGYPAL E. (2007): "More on Unemployment and Vacancy Fluctuations," *Review of Economic Dynamics*, 10 (3), pp. 327-347.

Pissarides C. (2009): "The Unemployment Volatility Puzzle: Is Wage Stickiness the Answer?," *Econometrica*, vol. 77, pp. 1339-1369

Rotemberg, J. (2008): "Cyclical wages in a search-and-bargaining model with large firms," *NBER Chapter*, pp 65-114.

Shimer, R. (2005): "The Cyclical Behavior of Equilibrium Unemployment and Vacancies," *American Economic Review*, 95(1), 25-49.

Topel, R. (1983): "On Layoffs and Unemployment Insurance," *American economic review*, 73(4), 541-559.

Topel, R. (1984): "Experience Rating of Unemployment Insurance and the Incidence of Unemployment," *Journal of Law and Economics,*, 27(1), 61-90.

Topel, R. and Welsh, F. (1980): "Unemployment Insurance: Survey and Extensions," *Economica*, Vol. 47, No. 187, pp. 351-379.

Woodbury, S. (2004): "Layoffs and Experience Rating of the Unemployment Insurance Payroll Tax: Panel Data Analysis of Employers in Three States," *Unpublished manuscript.*

Yashiv, E. (2006): "Evaluating the performance of the search and matching model," *European Economic Review.* Vol. 50, No. 4, pp. 906-936.

Zanetti, F. (2007): "Labor market institutions and aggregate fluctuations in a search and matching model," working paper 333, Bank of England.

A Derivation of the calculus

A.1 Large family program

The first order conditions of the large family program are defined by :

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial C_t} &= (C_t + (1-N_t)h)^{-\sigma} - \lambda_t = 0 \\
\frac{\partial \mathcal{L}}{\partial n_t(\varepsilon_t)} &= -h\,(C_t + (1-N_t)h)^{-\sigma} - \mu_t^1(\theta_t q_t - 1) - \mu_t(\varepsilon_t) + (w_t(\varepsilon_t) - b)\lambda_t = 0 \\
\frac{\partial \mathcal{L}}{\partial N_{t+1}} &= \beta E_t \mathcal{W}_1{}'(\Omega_{t+1}^H) - \mu_t^1 = 0
\end{aligned}$$

The envelop condition writes

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial N_t} &= (1-\rho^x)\int_{\underline{\varepsilon}_t}^{\bar{\varepsilon}} \mu_t(x)dG(x) \equiv \Gamma_1(t) \\
\Longleftrightarrow \Gamma_1(t+1) &= (1-\rho^x)\int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}} \mu_{t+1}(x)dG(x) \equiv \mathcal{W}_1{}'(\Omega_{t+1}^H)
\end{aligned}$$

We use this envelop condition to replace μ_t^1 and $\beta E_t \mathcal{W}_1{}'(\Omega_{t+1}^H)$ in the optimality conditions. Then we obtain the system of equations describes by (13) and (15).

A.2 Large firm program

The first order conditions of the large firm program are defined by :

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial V_t} &= -\Gamma'(V_t) + q_t\Lambda_t^1 = 0 \\
\frac{\partial \mathcal{L}}{\partial \underline{\varepsilon}_t} &= -z_t\underline{\varepsilon}_t n_t(\underline{\varepsilon}_t) + w_t(\underline{\varepsilon}_t)n_t(\underline{\varepsilon}_t)(1+\tau_t) - \Lambda_t^1 + \Lambda_t(\underline{\varepsilon}_t)\left(n_t(\underline{\varepsilon}_t) - (1-\rho^x)N_t G'(\underline{\varepsilon}_t)\right) \\
&\quad - \left[(\tau_t w_t(\underline{\varepsilon}_t) + b)\Lambda_t^3 - \Lambda_t^4 \frac{\mathcal{R}_{t+1}}{\Upsilon_t} w_t(\underline{\varepsilon}_t)\right] n_t(\underline{\varepsilon}_t) = 0 \\
\frac{\partial \mathcal{L}}{\partial n_t(\varepsilon_t)} &= z_t\varepsilon_t - w_t(\varepsilon_t)(1+\tau_t) + \Lambda_t^1 - \Lambda_t(\varepsilon_t) + \Lambda_t^3(\tau_t w_t(\varepsilon_t) + b) - \Lambda_t^4\frac{\mathcal{R}_{t+1}}{\Upsilon_t} w_t(\varepsilon_t) = 0 \\
\frac{\partial \mathcal{L}}{\partial N_{t+1}} &= \beta E_t \frac{\lambda_{t+1}}{\lambda_t}\mathcal{V}_1{}'(\Omega_{t+1}^F) - \Lambda_t^1 = 0 \\
\frac{\partial \mathcal{L}}{\partial \tau_{t+1}} &= \beta E_t \frac{\lambda_{t+1}}{\lambda_t}\mathcal{V}_2{}'(\Omega_{t+1}^F) - \Phi_t^\ell = 0 \qquad \ell = 1,2,3 \\
\frac{\partial \mathcal{L}}{\partial B_{t+1}} &= \beta E_t \frac{\lambda_{t+1}}{\lambda_t}\mathcal{V}_3{}'(\Omega_{t+1}^F) - \Lambda_t^3 + \frac{\Lambda_t^4}{\Upsilon_t} = 0 \\
\frac{\partial \mathcal{L}}{\partial \mathcal{R}_{t+1}} &= -\eta_1\Lambda_t^2 - \Lambda_t^4 = 0 \quad \text{if } \tau_{\min} < \tau_t < \tau_{\max}, \qquad \Lambda_t^4 = 0 \quad \text{Otherwise}
\end{aligned}$$

Envelop conditions thus writes :

$$
\begin{aligned}
\frac{\partial \mathcal{L}}{\partial N_t} &= (1-\rho^x)\int_{\underline{\varepsilon}_t}^{\bar{\varepsilon}} \Lambda_t(x)dG(x) \equiv \Gamma_2(t) \\
\frac{\partial \mathcal{L}}{\partial \tau_t} &= \Upsilon_t(\Lambda_t^3 - 1) \\
\frac{\partial \mathcal{L}}{\partial B_t} &= \Lambda_t^3
\end{aligned}
\tag{45}
$$

The following condition applies :

$$
\Gamma_2(t+1) = (1-\rho^x)\int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}} \Lambda_{t+1}(x)dG(x) \equiv \mathcal{V}_1{}'(\Omega_{t+1}^F)
$$

Using this envelop condition to replace Λ_t^1 and $\beta E_t \frac{\lambda_{t+1}}{\lambda_t}\mathcal{V}_1{}'(\Omega_{t+1}^F)$ in the optimality conditions, one gets the system of equations (26), (27), (28) and (29).

A.3 Wage determination

Using the expression of $\Lambda_t(\varepsilon_t)$ and $\mu_t(\varepsilon_t)$ defined by (15) and (27) one has:

$$
\begin{aligned}
&\xi\Psi_t\left[w_t(\varepsilon_t) - (b+h) + (1-\theta_t q_t)\beta E_t \frac{1-\rho^x}{\lambda_t}\int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}_t} \mu_{t+1}(x)dG(x)\right] = \\
&(1-\xi)\left[z_t\varepsilon_t - w_t(\varepsilon_t)(1+\tau_t) + \beta E_t\frac{\lambda_{t+1}}{\lambda_t}(1-\rho^x)\int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}_t} \Lambda_{t+1}(x)dG(x)\right] \\
&+(1-\xi)\left[\Lambda_t^3(\tau_t w_t(\varepsilon_t)+b) - \Lambda_t^4\frac{\mathcal{R}_{t+1}}{\Upsilon_t}w_t(\varepsilon_t)\right]
\end{aligned}
\tag{46}
$$

We can simplify the wage equation using the expression of Ψ_t:

$$
\begin{aligned}
w_t(\varepsilon_t)\Psi_t &= (1-\xi)\left(z_t\varepsilon_t + \Lambda_t^3 b + \beta E_t\Gamma_2(t+1)\right) \\
&\quad +\xi\Psi_t\left(b+h-(1-\theta_t q_t)\beta E_t\frac{\Gamma_1(t+1)}{\lambda_t}\right)
\end{aligned}
\tag{47}
$$

The first-order conditions associated to the Nash sharing rules implies:

$$
\Gamma_2(t+1) = \frac{\xi\Psi_{t+1}}{(1-\xi)\lambda_{t+1}}\Gamma_1(t+1)) \tag{48}
$$

$$
\int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}_t} \Lambda_{t+1}(x)dG(x) = \frac{\xi\Psi_{t+1}}{(1-\xi)\lambda_{t+1}}\int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}_t} \mu_{t+1}(x)dG(x) \tag{49}
$$

One can rewrite (26) in the following way:

$$\Gamma'(V_t)\theta_t = \theta_t q_t \beta E_t \frac{\lambda_{t+1}}{\lambda_t}\Gamma_2(t+1) \tag{50}$$

and using (48) we have:

$$\theta_t q_t \beta E_t \frac{\Gamma_1(t+1)}{\lambda_t} = \theta_t q_t \beta E_t \frac{\lambda_{t+1}}{\lambda_t}\Gamma_2(t+1)\frac{1-\xi}{\xi\Psi_{t+1}} \tag{51}$$

Now, (50) and (51) help to develop the last term of the right hand side of (47):

$$\begin{aligned} w_t(\varepsilon_t) &= \frac{1-\xi}{\Psi_t}\left(z_t\varepsilon_t + \Lambda_t^3 b + \Gamma'(V_t)\theta_t\frac{\Psi_t}{\Psi_{t+1}}\right) + \xi\,(b+h) \\ &\quad + (1-\xi)\beta E_t\frac{\lambda_{t+1}}{\lambda_t}\Gamma_2(t+1)\left(\frac{1}{\Psi_t} - \frac{1}{\Psi_{t+1}}\right) \end{aligned} \tag{52}$$

Replacing the value of $\Gamma_2(t+1)$ by its expression and using the definition of $\Lambda_t(\varepsilon_t)$ given in (36), we obtain the final wage expression (34).

$$\begin{aligned} w_t(\varepsilon_t) &= (1-\xi)\left(\frac{z_t\varepsilon_t + \Lambda_t^3 b}{\Psi_t} + \frac{\Gamma'(V_t)\theta_t}{\Psi_{t+1}}\right) + \xi(b+h) \\ &\quad + \beta E_t\left(\frac{1}{\Psi_t} - \frac{1}{\Psi_{t+1}}\right)(1-\xi)(1-\rho^x)\frac{\lambda_{t+1}}{\lambda_t} z_{t+1}\xi\int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}}(x - \underline{\varepsilon}_{t+1})dG(x) \end{aligned}$$

A.4 Cyclical properties of the model

	US Economy	Bench. model	Slope $\eta_1 = 0.3$	no $\tau_{\min}$	$\tau_{\min}$ +10%	no $\tau_{\max}$	$\tau_{\max}$ -10%	η_0
MEAN LEVELS								
Output	-	100.00	100.79	100.10	99.72	100.09	99.63	99.71
Employment	-	100.00	100.92	100.02	99.87	100.06	99.81	99.86
Productivity	-	100.00	99.89	100.07	99.86	100.04	99.82	99.84
Wages	-	100.00	101.12	100.05	99.86	100.04	99.79	99.83
Vacancy	-	100.00	122.19	101.13	96.85	100.70	96.43	97.10
Tightness	-	100.00	136.78	102.53	99.71	104.70	97.95	98.94
Unemployment	5.64	5.86	4.99	5.79	5.98	5.80	6.03	5.98
Job finding rate	45.21	37.70	41.32	37.90	37.21	37.85	37.06	37.20
Separation rate	3.51	3.58	3.60	3.58	3.59	3.57	3.59	3.58
RELATIVE STANDARD DEVIATIONS								
Output	1.58	1.58	1.49	1.58	1.66	1.58	1.59	1.60
Employment	0.63	0.43	0.41	0.44	0.50	0.43	0.44	0.44
Productivity	1.08	0.70	0.74	0.69	0.67	0.69	0.69	0.69
Wages	0.43	0.50	0.51	0.49	0.49	0.49	0.59	0.50
Unemployment	7.83	6.62	6.45	6.62	6.88	6.55	6.62	6.69
Vacancies	8.83	9.96	9.85	9.95	13.64	9.72	10.20	10.14
Tightness	16.31	15.89	14.52	15.87	18.76	15.61	16.01	16.04
Job finding rate	5.25	4.11	3.77	4.10	4.98	4.01	4.15	4.15
Separation rate	3.58	6.60	5.56	6.60	6.77	6.40	6.78	6.63
SKEWNESS								
Output	-0.30	-0.28	-0.21	-0.26	-0.41	-0.24	-0.25	-0.24
Unemployment	0.51	0.86	1.24	0.87	2.04	0.78	0.85	0.83
Vacancies	0.06	0.21	-0.19	0.25	0.17	0.25	0.20	0.22
Tightness	0.89	0.97	0.45	1.05	0.82	1.00	0.99	1.00
Job finding rate	0.50	-0.12	-0.22	-0.10	0.20	-0.07	-0.14	-0.11
Separation rate	0.45	0.64	0.08	0.90	1.30	0.68	0.58	0.50
AUTOCORRELATION (1)								
Output	0.85	0.85	0.84	0.86	0.86	0.86	0.86	0.86
Unemployment	0.87	0.88	0.86	0.88	0.89	0.88	0.88	0.89
Vacancies	0.91	0.90	0.77	0.90	0.76	0.90	0.89	0.90
Job finding rate	0.80	0.89	0.82	0.90	0.81	0.90	0.89	0.90
Separation rate	0.48	0.39	0.30	0.40	0.44	0.39	0.41	0.40
CORRELATION								
$U_t,\ V_t$	-0.92	-0.91	-0.66	-0.90	-0.69	-0.91	-0.89	-0.90
$U_t,\ Y_t$	-0.84	-0.98	-0.94	-0.98	-0.94	-0.98	-0.98	-0.98
$N_t,\ p_t$	0.26	0.87	0.71	0.87	0.73	0.87	0.87	0.88

Table 5: ***Cyclical properties*** *US statistics are computed using a quarterly HP-filtered data from 1951Q1:2006Q4. Data are constructed by the BLS from the CPS. The help-wanted advertising index is provided by the Conference Broad. Job finding and separation probability are build by Shimer (2005). Mean levels are computed as the average value of gross variables and normalized to 100.00 except the three last rows. All standard deviations are relative to output (except output). The model is simulated 500 times over 120 quarters horizon. Results are report in logs as deviations from an HP trend with smoothing parameter 1600. We discard the first 1000 observations. Skewness is computed on gross time series.*

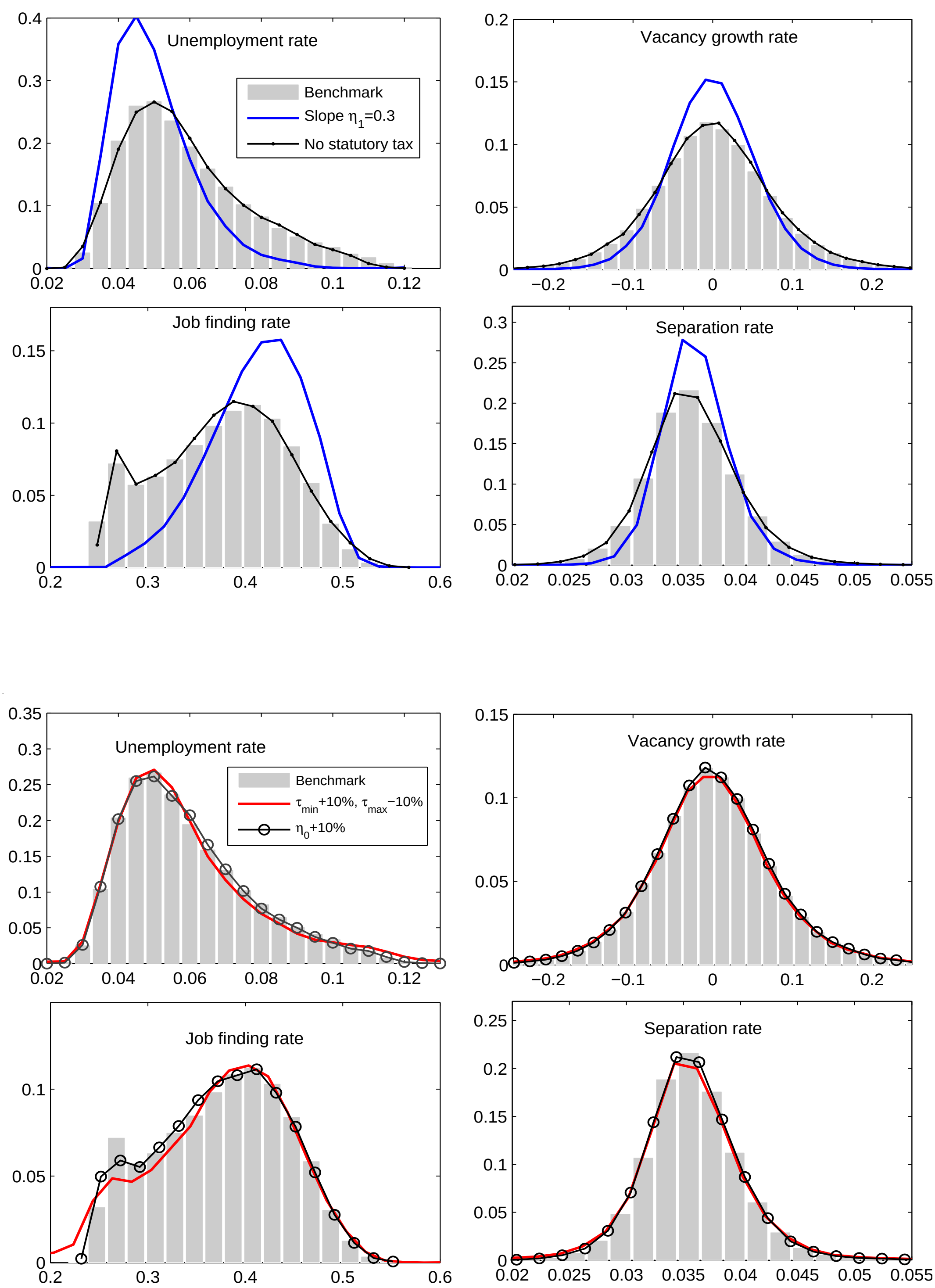

Figure 8: ***Policy effects on time series distributions.***

A.5 Computing and estimating the Markov chains of the tax system

To estimate the probability of moving from one tax categories to another we use the Maximum likelihood function. Assuming $\tilde{\tau}$ corresponds to the case where τ_t lies between the minimum and the maximum tax rate, the states of the Markovian matrix are : $\{\tau_{\min}, \tilde{\tau}, \tau_{\max}\}$. We denote by π the transition matrix with no restriction and π_{ij} the probability of moving from state i to state j. It is defined by

$$\pi_{ij} = Pr(\tau_{t+1} = j | \tau_t = i)$$

Defining the transition counts $\mathcal{K}_{ij}$ as the number of times the state i is followed by j, the log-likelihood function can be written in the following manner:

$$\mathcal{L}(\pi) = \sum_{i,j} k_{ij} \log \pi_{ij} \qquad \text{with} \quad k_{ij} = \log \mathcal{K}_{ij}$$

The estimation procedure consists of choosing the value of π_{ij} that maximizes the log-likelihood function subject to:

$$\sum_j \pi_{ij} = 1$$

With $m = 3$ states, the above optimization problem is characterized by 3 Lagrange multipliers (λ_i) and takes the following form:

$$\hat{\pi}_{ij} = \arg\max_{\pi_{ij}} \quad \mathcal{L}(\pi) - \sum_{i=1}^{j} \lambda_i \left(\sum_j \pi_{ij} - 1 \right)$$

The first-order conditions with respect to π_{ij} are:

$$0 = \frac{k_{ij}}{\hat{\pi}_{ij}} - \lambda_i \iff \hat{\pi}_{ij} = \frac{k_{ij}}{\lambda_i}$$

Using the constraint we have $\lambda_i = \sum_{j=1}^{m} k_{ij}$. By replacing it in the first-order conditions we obtain the maximum likelihood estimator of the transition probability $\hat{\pi}_{ij}$ from state i to state j:

$$\hat{\pi}_{ij} = \frac{k_{ij}}{\sum_{j=1}^{m} k_{ij}}$$

A.6 PEA: computation algorithm

The parameterized expectation algorithm consists of approximating the conditional expectations of the system described previously. We approximate the expectation functions of the model using Chebyshev polynomials of the state variables. This parametric function displays suitable orthogonality and convergence properties to minimize the error distance approximation. We consider a second-order Chebyshev polynomial and a tensor product base. When the expectation functions are evaluated at each point of the grid, we check, using the law of motion of states variables if the resulting value of the tax rate τ_{t+1} hits $\tau_{\min}$ and $\tau_{\max}$. If it is the case we impose τ_{t+1} to be equal to the upper bound or to the lower bound and use the rule describes in equation (30) to determine the expectation functions. Otherwise the next period tax rate is compute using the law of motion: $\tau_{t+1} = \eta_0 - \eta_1 \mathcal{R}_{t+1}$. Once the tax category is determined, we are able to evaluate the expectation functions on the state-space representation of the model using Gauss-hermite quadratures with 30 nodes. To better understand how PEA works let decompose the model into three blocs. Whatever the tax level the equilibrium conditions applied:

$$
\begin{aligned}
N_{t+1} &= N_t(1-\rho_t) + M_t \\
B_{t+1} &= B_t + \tau_t \Upsilon_t - U_t b \\
R_{t+1} &= \frac{B_{t+1}}{\Upsilon_t} \\
\log z_{t+1} &= \rho_z \log z_t + \varepsilon^z_{t+1} \\
Y_t &= C_t + \Gamma(V_t) \\
Y_t &= N_t(1-\rho^x) \int_{\underline{\varepsilon}_t}^{\overline{\varepsilon}} x dG(x) \\
\lambda_t &= (C_t + (1-N_t)h)^{-\sigma} \\
\frac{\Gamma'(V)}{q_t} &= \frac{\xi \varphi_1}{\lambda_t}
\end{aligned}
$$

The fifth, sixth and seventh equation of the above system can be merged to remove Y_t and C_t. It is worth noting that the expectation function φ_1 (defined below) which corresponds to the firm expected value from a filled job is the same whatever the tax rate. However, the job destruction condition and the Lagrange multiplier associated to the tax dynamic, the firms' account dynamic and the reserve ratio are quite different. To simplify notations we define:

$$
\begin{aligned}
\Psi_t &= 1 + \tau_t(1-\Lambda^3_t) + \Lambda^4_t \frac{\mathcal{R}_{t+1}}{\Upsilon_t} \\
\Psi^m_t &= 1 + \tau_{\min}(1-\Lambda^3_t) \\
\Psi^M_t &= 1 + \tau_{\max}(1-\Lambda^3_t)
\end{aligned}
$$

The unconstrained model ($\tau_{\min} < \tau_t < \tau_{\max}$) is characterized by the following equations:

$$
\begin{aligned}
\bar{w}_t &= (1-\xi)\left(\frac{z_t\int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}} xdG(x) + \Lambda_t^3 b}{\Psi_t} + \Gamma'(V_t)\theta_t\varphi_3\right) + \xi(b+h) + \frac{\varphi_1\xi(1-\xi)}{\Psi_t\lambda_t} - \frac{\varphi_2}{\lambda_t} \\
0 &= \left(z_t\underline{\varepsilon}_{t+1} + \Lambda_t^3 - (b+h)\Psi_t\right) - \frac{1-\xi}{\xi}\Gamma'(V_t)\theta_t\Psi_t\frac{\varphi_3}{\lambda_t} + \frac{\varphi_1}{\lambda_t}\xi^2 + \frac{\varphi_2}{\lambda_t}\Psi_t \\
\Lambda_t^3 &= \frac{\Lambda_t^4}{\Upsilon_t} + \frac{\varphi_5}{\lambda_t} \\
\Lambda_t^4 &= -\eta_1\Phi_t^1 \\
\Phi_t^1 &= \frac{\varphi_4}{\lambda_t}
\end{aligned}
$$

When $\tau_t = \tau_{\min}$, the marginal tax cost is zero ($\Lambda_t^4 = 0$) and the economy is described by:

$$
\begin{aligned}
\bar{w}_t &= (1-\xi)\left(\frac{z_t\int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}} xdG(x) + \Lambda_t^3 b}{\Psi_t^m} + \Gamma'(V_t)\theta_t\varphi_7\right) + \xi(b+h) + \frac{\varphi_1\xi(1-\xi)}{\Psi_t^m\lambda_t} - \frac{\varphi_6}{\lambda_t} \\
0 &= \left(z_t\underline{\varepsilon}_{t+1} + \Lambda_t^3 - (b+h)\Psi_t^m\right) - \frac{1-\xi}{\xi}\Gamma'(V_t)\theta_t\Psi_t^m\frac{\varphi_7}{\lambda_t} + \frac{\varphi_1}{\lambda_t}\xi^2 + \frac{\varphi_6}{\lambda_t}\Psi_t^m \\
\Lambda_t^3 &= \frac{\varphi_5}{\lambda_t} \\
\Phi_t^2 &= \frac{\varphi_4}{\lambda_t}
\end{aligned}
$$

When $\tau_t = \tau_{\max}$, the marginal tax cost is zero ($\Lambda_t^4 = 0$) as in the previous case. Agents' decisions now involves:

$$
\begin{aligned}
\bar{w}_t &= (1-\xi)\left(\frac{z_t\int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}} xdG(x) + \Lambda_t^3 b}{\Psi_t^M} + \Gamma'(V_t)\theta_t\varphi_9\right) + \xi(b+h) + \frac{\varphi_1\xi(1-\xi)}{\lambda_t\Psi_t^M} - \frac{\varphi_8}{\lambda_t} \\
0 &= \left(z_t\underline{\varepsilon}_{t+1} + \Lambda_t^3 - (b+h)\Psi_t^M\right) - \frac{1-\xi}{\xi}\Gamma'(V_t)\theta_t\Psi_t^M\frac{\varphi_9}{\lambda_t} + \frac{\varphi_1}{\lambda_t}\xi^2 + \frac{\varphi_8}{\lambda_t}\Psi_t^M \\
\Lambda_t^3 &= \frac{\varphi_5}{\lambda_t} \\
\Phi_t^3 &= \frac{\varphi_4}{\lambda_t}
\end{aligned}
$$

The expectation functions are the following ones:

$$\begin{aligned}
\varphi_1 &= \beta E_t \lambda_{t+1}(1-\rho^x) z_{t+1} \int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}} (x - \underline{\varepsilon}_{t+1}) dGx \\
\varphi_2 &= \beta \xi (1-\xi) E_t \frac{\lambda_{t+1}}{\Psi_{t+1}} (1-\rho^x) z_{t+1} \int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}} (x - \underline{\varepsilon}_{t+1}) dGx \\
\varphi_3 &= (1-\xi) E_t \frac{1}{\Psi_{t+1}} \\
\varphi_4 &= \beta E_t \lambda_{t+1} \bar{w}_{t+1} N_{t+1} (1-\rho^x)(\Lambda^3_{t+1} - 1) \\
\varphi_5 &= \beta E_t \lambda_{t+1} \Lambda^3_{t+1} \\
\varphi_6 &= \beta \xi (1-\xi) E_t \frac{\lambda_{t+1}}{\Psi^m_{t+1}} (1-\rho^x) z_{t+1} \int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}} (x - \underline{\varepsilon}_{t+1}) dGx \\
\varphi_7 &= (1-\xi) E_t \frac{1}{\Psi^m_{t+1}} \\
\varphi_8 &= \beta \xi (1-\xi) E_t \frac{\lambda_{t+1}}{\Psi^M_{t+1}} (1-\rho^x) z_{t+1} \int_{\underline{\varepsilon}_{t+1}}^{\bar{\varepsilon}} (x - \underline{\varepsilon}_{t+1}) dGx \\
\varphi_9 &= (1-\xi) E_t \frac{1}{\Psi^M_{t+1}}
\end{aligned}$$

The PEA procedure consists of approximating the unknown functions φ_i by Chebyshev polynomials. The algorithm is as follows:

Step 1 *Set the parameters values and the deterministic steady state of all endogenous variables in the unconstrained model* $\{N, B, \tau, z, \bar{w}, \theta, \underline{\varepsilon}, \lambda, \Lambda^2, \Lambda^3\}$.

Step 2 *Choose the order of the Chebyshev polynomial n and the number of nodes (which are at least equal to the order of the Chebyshev polynomial plus one). Build the Chebyshev polynomials using the following recursion:*

$$T_n(x) = \cos(n \arccos(x))$$

Step 3 *Compute the grid of the four state variables: (*N, B, τ *and the stochastic process* z*), imposing the steady states to be equidistant from the upper bound and the lower bound of the grid. Use the Kronecker product to get the tensor product base.*

Step 4 *Initialize the policy rules of the forward-looking variables using their steady state level on the first row.*

Step 5 *Initialize the expectation functions* φ_i*. As a first guess, we evaluate* *them at the deterministic steady state.*

Step 6 *Given the value of expectation functions, determine the policy rules of the three models using a Newton algorithm.*

Step 7 *Given the policy rules, compute the next period states variables at each node of the grid and the next period forward-looking variables.*

Step 8 *Check if the next period tax rate hits one of the statutory tax rate in order to define a unique policy rule for each variable that takes into account the regime-switching.*

Step 9 *Given the new policy rules, compute the new expectation functions using ordinary least square.*

Step 10 *Check if the expectation functions are the same as in step 5 using an Euclidian norm. Otherwise, define the new expectation functions as the initial value and return to step 6. Repeat this procedure until convergence.*

When one policy parameter is changed, 1) we use a Newton algorithm to solve the deterministic steady state, 2) we rebuild the grid of the state variables and 3) we recompute the PEA algorithm to solve for the new expectation functions and the new policy rules.