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The Unemployment Benefit System: a Redistributive or an Insurance Institution? *

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Abstract

In this paper we analyze how the composition of labor taxation affects unemployment in a unionized economy with capital accumulation and an unemployment benefit system. We show that if the unemployment benefit system is gross Bismarckian then the unemployment rate is reduced if wage taxes are decreased (and thus payroll taxes are increased). However, if the unemployment benefit system is net Bismarckian then the unemployment rate does not depend on how the system is financed. Besides, in a Beveridgean system the labor tax composition does not affect the unemployment rate if and only if the unemployed do not pay taxes and the employed pay a constant marginal tax rate. We also analyze when an unemployment benefit budget-balanced rule makes the economy to have a hysteresis process.

JEL Clasification Code: E24, E62, H53, J50, J65.

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1 Introduction

A common feature of most developed countries is the provision of unemployment benefits for those who eventually become unemployed. We can distinguish two alternative unemployment benefit systems depending on how such benefits are settled. On the one hand, we have the Beveridgean system, where the unemployment benefits are a fixed amount. This system is present at Australia, United Kingdom, Iceland, Ireland, New Zealand or Poland. On the other hand, we have the Bismarckian system, where the unemployment benefits are settled as a proportion of a previous earnings base. This system is present at Belgium, Canada, France, Italy, Netherlands, Spain, Sweden or the United States, among others, if the earnings base is the gross wage, and in Austria or Germany if the earnings base is the net wage.[1] At the same time, in the Beveridgean countries usually there are no specific taxes to finance the unemployment benefits, whereas the Bismarckian countries usually make use of a wage tax levied on workers and a payroll tax levied on firms. Moreover, each country has a different labor tax composition[2] and a different unemployment rate. In this paper we analyze how this labor tax composition affects the unemployment rate in an unionized economy with capital accumulation.

We first begin analyzing the most common system: the Bismarckian unemployment benefit system with benefits based on gross earnings or gross Bismarckian system. Such system is financed exclusively through both a wage and a payroll tax. Since the government uses a budget-balanced rule, then it has to choose between setting the benefit side or the tax side of the system when deciding the unemployment benefit system.[3] When there exists a government budget-balanced rule then indeterminacy may arise, as Schmitt-Grohé and Uribe (1997) show in a real business cycle competitive economy. More specifically, Guo and Harrison (2004)[4] conclude that if government spendings are financed through fixed tax rates (and hence government spendings become endogenous) then indeterminacy is impossible, whereas if any tax (or all of them) is endogenous (and hence government spendings become exogenous) then indeterminacy is possible in the sense that multiple self-fulfilling equilibria may arise. Moreover, we do not know ex-ante the particular equilibrium the economy is converging to. Even though we have a non competitive labor market, intuition suggests that requiring a government budget-balanced rule would induce the same type of results. In fact, when both the payroll and the wage tax are fixed by the government and the (gross) replacement ratio[5] is endogenous (in order to balance the government budget constraint), then the economy converges to an unique equilibrium. However, in the opposite case, when the replacement ratio is fixed and both the payroll and the wage tax are endogenous, then a continuum of self-fulfilling equilibria arise. Instead, if the replacement ratio and one of the two taxes are fixed, then the possibility of having a continuum of self-fulfilling equilibria dissapears, but the possibility of having indeterminacy remains unaltered. In particular, if the wage tax is the endogenous fiscal instrument then two self-fulfilling equilibria arise, whereas if the payroll tax is the endogenous fiscal instrument then indeterminacy does not hold and we have only one equilibrium. Therefore, the tax government choice may cause indeterminacy, and two economies with the same replacement ratio may exhibit a different unemployment rate because of a different labor tax composition. Note that indeterminacy can be avoided just by selecting the payroll tax as the unique instrument to balance the budget. These results are in contrast with Koskela and Vilmunen (1996), Goerke (2000), Egger (2002), Goerke and Madsen (2003) or Beissinger and Egger (2004).

When the wage tax is endogenous, then two different steady state equilibria arise. Expectations are crucial: if agents believe that the wage tax will be high, then their wage demand increases. Firms respond with a low

[1] The institutional details of the unemployment benefit system for the different countries can be found in OECD (2004).

[2] For instance, the wage and payroll taxes were 2.8% and 4%, respectively, in France in 1998, and 1.6% and 6.7%, respectively, in Spain in 2003.

[3] There exists some confusion in some papers between a budget-balanced and a revenue neutral rule when the unemployment benefit system is analyzed. Since we consider a self-financed program, tax revenues are required in order to (exactly) compensate the unemployment benefit spendings. Hence, the reasonable assumption should be to require a budget-balanced rule.

[4] Schmitt-Grohé and Uribe (1997) suggest the same results, too.

[5] The replacement ratio is the proportion of the wage earned when working that is paid to the unemployed.

labor demand and, then, unemployment rises. Thus, a wage demand spillover is created and the unemployment becomes high. Since the government financial necessities rise, the wage tax increases, which implies a reduction of savings and, thus, the economy converges to an equilibrium with low capital and high unemployment. In contrast, if individuals expect a low wage tax rate, then their wage demand is low, too. Since firms respond with a high labor demand, then the unemployment and the wage tax remain at a low rate. Thus, two different equilibria are possible, one with a high level of employment (namely, optimistic equilibrium) and the other with a high level of unemployment (namely, pessimistic equilibrium).

We show that the unemployment rate of the economy is crucially determined by the ratio between the net wage received by the worker and the wage paid by firms (namely, tax wedge), as in Goerke (2000). When both taxes are exogenous and the government adjusts the replacement ratio in order to satisfy the budget-balanced rule, then an increase in the payroll tax accompanied by a decrease in the wage tax such that the tax burden remains constant causes the unemployment rate to fall. In this case, both the replacement ratio and the net wage that workers receive increases. Therefore, under a fixed tax burden unemployment is minimized by charging the total burden on firms. When the payroll tax is endogenous, a reduction in the wage tax reduces the unemployment of the economy. Likewise, when the wage tax is endogenous and the economy exhibits two equilibria, we have that in the optimistic equilibrium an increase in the payroll tax implies both a lower wage tax and a lower unemployment rate. In the pessimistic equilibrium, and surprisingly, a reduction of the payroll tax induces a low wage tax. Hence, in this equilibrium both taxes can be reduced at the same time that the unemployment rate decreases. Therefore, we have that in the gross Bismarkian unemployment benefit system the lower the wage tax is, the lower the unemployment rate is. The rationale when the replacement ratio is exogenous is that a lower wage tax implies a lower wage demand, which affect negatively the unemployment benefits and, thus, government financial necessities. Hence, since the tax base is the same, the increase in the payroll tax in order to satisfy the budget-balanced rule may be smaller than the reduction in the wage tax.

In the Bismarckian unemployment benefit system with benefits based on net earnings or net Bismarckian system, we find that there exists only one equilibrium. Moreover, the unemployment rate does not depend on how the unemployment benefit system is financed. Hence, the equilibrium is consistent with different labor tax combinations. Unemployment is exclusively explained by the technology, the unions' bargaining power and the replacement ratio.

A common characteristic of the countries with the Beveridgean unemployment benefit system is that there are no specific taxes to finance the unemployment benefits. However, most of the papers considering constant unemployment benefits introduce specific taxes to finance them. We discuss this alternative in a general framework where we assume an income tax for the unemployed, a payroll tax, a wage tax and a tax exemption for the workers. This allows to analyze the following cases: unemployed do not pay taxes and employed pay the same marginal tax rate for all their income; employed have two tax brackets: they pay the same marginal tax rate than unemployed for the same income but they pay a higher marginal tax rate for the rest of the income; both unemployed and employed pay a different marginal tax rate for all their respective income; all individuals pay the same marginal tax rate for all their income; unemployed do not pay taxes and employed have a fiscal exemption, as in Koskela and Vilmunen (1996). We consider the case where the instrument used to adjust the government budget is the payroll tax. In contrast with the gross Bismarckian system, now we have two steady state employment rates. We show that, as in the net Bismarckian system, the labor tax composition does not affect the unemployment rates of the economy if and only if the unemployed do not pay taxes and the employed pay a constant marginal tax rate. Otherwise, an increase in the wage tax always makes the unemployment rate to decrease in the optimistic equilibrium and to increase in the pessimistic equilibrium. Therefore, it is the same having two tax brackets than having an exemption. Moreover, we have that a more progressive fiscal system (an increase in the tax exemption) yields a lower unemployment rate. This result coincides with Koskela and Vilmunen (1996) but, in contrast with them, here the result is due to an endogenous increase of the payroll tax and not of the wage tax. Besides, an increase in the tax exemption makes the payroll tax to increase whereas an increase in the wage tax makes the payroll tax to decrease, but in both cases the unemployment decreases.

Since in some countries the gross Bismarckian system has both a minimum and a maximum benefit, we analyze a mixed benefit system with a fixed and a variable part. We show that when the payroll tax is exogenous then two steady state equilibria arise. Moreover, unemployment is reduced in the optimistic equilibrium and increased in the pessimistic equilibrium if there is a shift of the tax incidence from wage taxes to payroll taxes. The main difference with respect to the gross Bismarckian system is that now the pessimistic equilibria may be unstable.

The negotiation between unions and firms is a right-to-manage one, where unions focus on both wage and employment but bargain only on wages. We show that the qualitative results remain unchanged either in a seigniorage model or if unions focus and bargain on both wages and employment. Thus, we obtain the same result as Creedy and McDonald (1991), who show that the qualitative effects of taxes on employment do not depend on the type of negotiation, but a different one to Cardona and Sánchez-Losada (2006), who analyze a segmented labor market.

Other studies have centered on other aspects of the unemployment benefit system. Fredriksson and Holmlund (2001) analyze a system with both unemployment insurance and unemployment assistance, Albrecht and Vroman (1999) analyze the experience rating, Picard (2001) centers on both the job additionality and the unemployment trap in the sense that individuals loose their entitlement to unemployment and welfare when they choose to work, and Corneo and Marquardt (2000) analyze the interaction between the Beveridgean unemployment benefit system, an unfunded public pensions program, and economic growth. From an empirical point of view, the literature has centered on the effects of the labor taxes on the unemployment rate. Layard and Nickell (1986), Nickell and Layard (1999) and Daveri and Tabellini (2000) show that the rise in the labor tax wedge plays an important role in raising the wage pressure and hence the unemployment rate. However, Lockwood and Manning (1993) for the U.K. case and Holm, Honkapohja and Koskela (1994) for the Finnish case show that the tax wedge is not a good measure and, hence, the effects of either a wage tax or a payroll tax may be different, since the tax base of each tax may be different. Among these papers, only Holm et al. (1994) include in the analysis the spending counterpart that the government makes of the collected taxes (in this case the unemployment benefits). None of them analyzes the case where the wage tax increases and the payroll tax decreases, or vice versa.

The paper is organized as follows. In the next section we present the framework economy. In section 3 we analyze the gross Bismarckian unemployment benefit system. In section 4 we discuss alternative unemployment benefit systems and bargaining patterns. Finally, section 5 concludes.

2 The economy

We construct a very simple economy with constant population, whose mass is normalized to one. Individuals are endowed with one unit of labor which they offer inelastically at each period t.

Individuals. We assume Solow individuals: each one saves a constant fraction of her income. Therefore, savings for the individual i are

$$s_{it} = s \cdot I_{it}, \tag{1}$$

where s_{it} are individual savings, I_{it} is the individual income, and $s \in (0, 1)$ is the constant propension to save.[6]

[6] We obtain the same savings using a Cobb-Douglas utility function and an overlapping generations economy à la Diamond. If instead we assume an infinite horizon economy, we would recover the same savings only in steady state.

Firms. There is a continuum of firms, each producing according to a constant returns to scale Cobb-Douglas technology given by

$$Y_t = AK_t^{1-\alpha}L_t^{\alpha} \tag{2}$$

where K_t is capital, L_t is labor, and $\alpha \in (0,1)$. We assume capital depreciates in one period.

Unemployment benefit system: Unemployment benefits may consist of a fixed part, $b_t \geq 0$, and a variable part which is assumed to be a function of the past wage w_{t-1}, i.e. $b_t + f(w_{t-1})$. If $b_t = 0$ and $f(w_{t-1}) = \rho_t w_{t-1}$, where $\rho_t \in (0,1)$ is usually known as the benefit replacement ratio, we have the gross Bismarckian unemployment benefit system. This system is the most common in the OECD countries, and it is financed by workers and firms through proportional taxes on wages (wage tax τ_t and payroll tax ψ_t, respectively). If $f(w_{t-1}) = 0$, we have the Beverigdean unemployment benefit system, which is common in some Anglo-Saxon countries, where unemployment benefits are considered as a redistributive issue and, usually, there are no specific taxes to finance the unemployment program.

In this section, we focus on a self-financed Bismarckian unemployment benefit system based on gross earnings. Even though unemployment benefits are a proportion of the wage received by the worker when employed, in order to make the analysis more tractable we consider that such benefits are related to the average wage of the economy w_t, as in Layard and Nickell (1990), Manning (1993) or Altenburg and Straub (1998).[7] Accordingly, and since all firms are simmetric, the government budget constraint is given by

$$w_t L_t(\tau_t + \psi_t) = (1 - L_t)\rho_t w_t. \tag{3}$$

Note that the employment and the unemployment rates are L_t and $(1 - L_t)$, respectively. An important aspect of this budget-balanced rule is that revenues are also endogenous. Hence, and in contrast with many models that only consider revenue-neutral rules, financial necessities may vary when unemployment changes.

Union bargaining: We consider the right-to-manage bargaining. This bargaining takes place at a decentralized level, so that neither firms nor unions perceive the effects of their actions on the economy via the government budget constraint. The timing of the bargaining is as follows: once the firms have selected the level of capital, firms and unions bargain over wages. After, firms choose the employment level. Hence, given w_t and K_t, the employment level chosen by any firm solves

$$\max_{L_t} \left[AK_t^{1-\alpha}L_t^{\alpha} - w_t L_t(1+\psi_t) - (1+r_t)K_t\right],$$

from where we have

$$(1+\psi_t)w_t = A\alpha K_t^{1-\alpha}L_t^{\alpha-1}. \tag{4}$$

The objective function of the union in the bargaining process is given by the net wage mass, while the firm's objective are profits.[8] The disagreement point of the union is given by $\overline{w}_t$ while the firm's fall-back position is $-(1+r_t)K_t$, since at this point its level of capital has been already selected. Thus, according to the Nash solution and denoting the bargaining power of the union and the firm by β and $(1-\beta)$, respectively, with $\beta \in [0,1]$, the wage solves

$$\max_{w_t} \left[\left(w_t(1-\tau_t) - \overline{w}_t\right)L_t\right]^{\beta}\left[AK_t^{1-\alpha}L_t^{\alpha} - w_t L_t(1+\psi_t)\right]^{1-\beta}$$

[7] Beissinger and Egger (2004) consider that unions are aware on the possibility that current employed could be fired in the next period and, therefore, unions realize that the bargained wage of today affects the unemployment benefits of tomorrow. However, they disregard that firms should also realize that the bargained wage of today affects the bargained wage of tomorrow. Nonetheless, if unions only worry about the current wage of the workers of the firm, as in Oswald (1993), then the steady state equilibria would remain unaltered.

[8] It is worth to note that the results do not depend on this specification of the union's objective function. Eliminating employment from this function would not affect the qualitative results. Moreover, and as we show in section 4, the results are also maintained when fims and unions bargain over both employment and wages.

subject to the labor demand given by equation (4). The optimal wage is implicitly defined by

$$w_t(1-\tau_t) = Q\overline{w}_t, \tag{5}$$

where $Q = [\beta + \alpha(1-\beta)]/\alpha$ is greater than 1. Since the firm anticipates both the level of employment and the wage, it chooses the level of capital that solves

$$\max_{K_t} \left[AK_t^{1-\alpha}L_t^{\alpha} - w_t L_t(1+\psi_t) - (1+r_t)K_t\right]$$

subject to equations (4) and (5). Solving the problem yields the capital demand.[9]

Since all firms are symmetric, and following Layard, Nickell and Jackman (1991), in equilibrium the disagreement point is given by

$$\overline{w}_t = L_t w_t (1-\tau_t) + (1-L_t)\rho_t w_t, \tag{6}$$

where the first part is the probability of finding a job elsewhere times the net wage and the second part is the probability of being unemployed times the unemployment benefits.

3 Payroll or wage taxes?

When there exists a government budget-balanced rule in the economy then indeterminacy may arise. We begin the analysis in a static framework. We after show that in a dynamic economy where capital accumulation is considered, the main conclusions concerning both indeterminacy and unemployment remain unchanged.

3.1 The static framework: short-run equilibria

In a static framework, the firms' capital remains constant. First, we analyze the indeterminacy problem. Since all firms are symmetric, the government budget constraint (3) can be written as

$$L_t = \frac{\rho_t}{\tau_t + \psi_t + \rho_t}. \tag{7}$$

Using equations (5) and (6) yields

$$L_t = \frac{1-\tau_t - Q\rho_t}{Q[1-\tau_t-\rho_t]}. \tag{8}$$

And, then, from equations (7) and (8) we have that any pair (τ_t, ψ_t) satisfying

$$\frac{1-\tau_t - Q\rho_t}{Q[1-\tau_t-\rho_t]} = \frac{\rho_t}{\tau_t + \psi_t + \rho_t} \tag{9}$$

constitutes an equilibrium, which shows that multiple self-fulfilling equilibria may arise. Moreover, combining equations (7) and (8) yields the employment as a function of both taxes,

$$L_t = \frac{1-\tau_t}{1+\psi_t}Q^{-1}. \tag{10}$$

Hence, the tax wedge determines the employment level of the economy.[10] Figure 1 ilustrates this statement. In particular, the left hand side represents equation (9) and the right hand side relates the obtained taxes from equation (9) to the employment level using equation (10).[11]

[9] Since s is fixed, we do not need the interest rate in order to find the equilibria.

[10] Usually, it is called tax wedge to the ratio between the net wage received by the worker and the wage paid by the firm, i.e. $(1-\tau_t)/(1+\psi_t)$.

[11] The chosen values of...

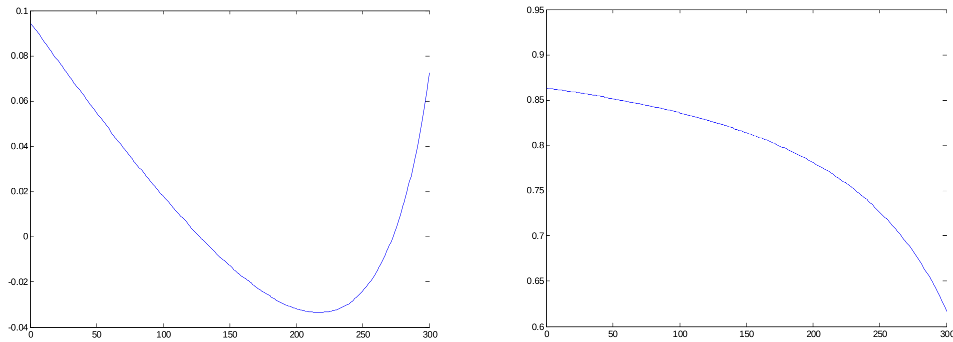

Figure 1. Relationship between taxes and unemployment

Equations (7)-(10) inform us about the number of equilibria. Indeed, from equation (10) we have that when government spendings are financed through fixed tax rates (and hence the replacement ratio becomes endogenous), then there exists only one equilibrium. However, when the replacement ratio is fixed and both the payroll and the wage tax are endogenous, then equation (9) shows that there exists a continuum of pairs (τ_t, ψ_t) compatible with the equilibrium. And since a continuum of tax pairs implies a continuum of different tax wedges, then a continuum of equilibria arise. This is not the case when the replacement ratio and one of the two taxes are fixed. When the wage tax is fixed (and hence the payroll tax becomes endogenous), it turns out from equation (8) that for any τ_t the economy reaches a unique equilibrium. But when the payroll tax is fixed (and hence the wage tax becomes endogenous), then from equation (7) we have that

$$\tau_t = \frac{\rho_t - (\psi_t + \rho_t) L_t}{L_t}. \tag{11}$$

And substituting for τ_t from equation (11) into equation (8) we implicitly get the employment rate as

$$Q(1 + \psi_t) L_t^2 - (1 + \psi_t + \rho_t) L_t + \rho_t = 0, \tag{12}$$

from where we obtain

$$L_t = \frac{(1 + \psi_t + \rho_t) \pm \left[(1 + \psi_t + \rho_t)^2 - 4\rho_t Q (1 + \psi_t)\right]^{1/2}}{2Q(1 + \psi_t)}. \tag{13}$$

Hence, two different (generically) and consistent with the same payroll tax equilibria arise.[12] Note that the government can fix a specific replacement ratio and avoid indeterminacy by fixing the wage tax and adjusting the payroll tax to balance the unemployment benefits budget constraint.

Proposition 1 *When the payroll tax is fixed and the wage tax is endogenously determined by the government budget-balanced rule, then two unemployment rate equilibria arise. However, there exists a unique equilibrium when the wage tax is fixed and the payroll tax is endogenous.*

Expectations cause the same fixed payroll tax to be compatible with two different equilibria, one with a low and the other with a high unemployment rate. When unions expect a low unemployment rate, then they also expect a low wage tax. And, thus, they can reduce their wage demand at the same time that the net wage increases, what makes unemployment to stay low. Hence, low wage taxes are consistent with a low unemployment rate. We refer to this equilibrium as the "optimistic equilibrium". However, when unions expect

[12] For an equilibrium to exist $(1 + \psi_t + \rho_t)^2 \geq 4\rho_t Q (1 + \psi_t)$ has to be imposed. Moreover, when $(1 + \psi_t + \rho_t)^2 = 4\rho_t Q (1 + \psi_t)$, a unique equilibrium is attained.

a high unemployment rate, then they also expect a high wage tax. Therefore, and in view of a low net wage, their wage demand increases, what makes unemployment to increase. Hence, high wage taxes are consistent with a high unemployment rate. We refer to this equilibrium as the "pessimistic equilibrium". Moreover, since in the short-run capital per firm is constant, from the right-to-manage condition we can observe that the gross (net) wage paid by firms in the pessimistic equilibrium is higher (lower) than that of the optimistic one. Therefore, the unemployment benefits are also higher in the pessimistic equilibrium.

We show next how taxes have to be set in order to minimize the unemployment rate.

Proposition 2 *A decrease in the wage tax reduces the unemployment rate of the economy.*

P roof. When the replacement ratio is exogenous, it is obvious from equation (10) that a decrease in the wage tax makes the tax wedge to increase and, hence, unemployment decreases. Therefore, the interesting case is that where a decrease in the wage tax is accompanied by an increase in the payroll tax such that the tax burden (i.e. the sum of taxes) remains constant. Differentiating equation (10) we have $dL_t = \left[-\left(1+\psi_t\right) d\tau_t - \left(1-\tau_t\right) d\psi_t\right] Q^{-1} / \left(1+\psi_t\right)^2$, and applying $d\tau_t = -d\psi_t$ we obtain $dL_t/d\psi_t = \left(\psi_t + \tau_t\right) Q^{-1} / \left(1+\psi_t\right)^2 > 0$. When the wage tax is exogenous, it is direct to show from equation (8) that

$$\frac{dL_t}{d\tau_t} = \frac{\rho_t\left(1-Q\right)}{Q\left[1-\tau_t-\rho_t\right]^2} < 0, \tag{14}$$

since $Q > 1$. Thus, a decrease in the wage tax implies an increase in the employment rate. When the payroll tax is exogenous, from equation (12) we have

$$\frac{dL_t}{d\psi_t} = -\frac{L_t\left(QL_t-1\right)}{2Q\left(1+\psi_t\right)L_t - \left(1+\psi_t+\rho_t\right)} = \frac{L_t\rho_t\left(Q-1\right)/\left(1-\tau_t-\rho_t\right)}{\pm\left[\left(1+\psi_t+\rho_t\right)^2 - 4\rho_t Q\left(1+\psi_t\right)\right]^{1/2}}, \tag{15}$$

where we have used equation (8) in the numerator and equation (13) in the denominator. Thus, in the optimistic equilibrium we have that $dL_t/d\psi_t > 0$, which implies from equation (14) that the wage tax implicitly decreases. And in the pessimistic equilibrium we have that $dL_t/d\psi_t < 0$ and, hence, the wage tax implicitly increases. Thus, a decrease in the payroll tax implies an increase in the employment rate and a decrease in the wage tax. ■

Note that this result always holds regardless of the fiscal instrument that the government uses in order to balance the unemployment benefit budget constraint. Then, given a replacement ratio, unemployment is minimized if unemployment benefits are paid exclusively by firms. When the payroll tax is exogenous, the reduction in the wage tax is induced by an increase in the payroll tax in the optimistic equilibrium. However, in the pessimistic equilibrium the wage tax decreases as far as the payroll tax is reduced, too. In both cases the unemployment rate decreases. A reduction of the wage tax decreases the gross wage paid by firms and increases the net wage received by the employees in both equilibria, while unemployment benefits are reduced in the optimistic equilibrium and it depends on the specific values of the parameters in the pessimistic one.

3.2 The dynamics: long-run equilibria

Next, we analyze how the introduction of capital accumulation modifies the conclusions obtained from the static model. In fact, similar results are obtained, but in the dynamic setup low unemployment rates imply high capital stocks, which at the same time reinforce employment.

The introduction of capital implies the existence of a capital market clearing condition: the amount saved at each period t equals the stock of physical capital at $t+1$, i.e.,

$$K_{t+1} = \int_0^1 s_{it} di = s\int_0^1 I_{it} di = sF\left(K_t, L_t\right) = sAK_t^{1-\alpha}L_t^{\alpha}, \tag{16}$$

from where we can isolate the unemployment level,

$$L_t = \left(\frac{K_{t+1}}{sAK_t^{1-\alpha}}\right)^{\frac{1}{\alpha}}. \tag{17}$$

Note that this equation informs us that in steady state the capital-labor proportion K/L is fixed regardless of the unemployment benefit system. But contrary, the capital per capita could be affected by the unemployment benefit system.

Using the government budget constraint (3) and the definition of the disagreement point (6), we get

$$\overline{w}_t = w_t L_t (1 + \psi_t), \tag{18}$$

which combined with equations (5) and (17) yields

$$(1 - \tau_t) = Q\,(1 + \psi_t)\left(\frac{K_{t+1}}{sAK_t^{1-\alpha}}\right)^{\frac{1}{\alpha}}. \tag{19}$$

And, from equations (3), (4) and (17) we have

$$K_{t+1}^{\frac{1}{\alpha}}(\tau_t + \psi_t) = (sA)^{\frac{1}{\alpha}}\,\rho_t\left[1 - \left(\frac{K_{t+1}}{sAK_t^{1-\alpha}}\right)^{\frac{1}{\alpha}}\right]K_t^{\frac{1-\alpha}{\alpha}}. \tag{20}$$

Equations (19) and (20) recover the dynamics of the economy.

As in the static case, and as we can observe from equation (19), when government spendings are financed through fixed tax rates and hence the replacement ratio is endogenous, then there exists only one steady state equilibrium. However, when the replacement ratio is fixed and both the payroll and the wage tax are endogenous, then there exists a continuum of steady state equilibria with a different capital stock and thus a different unemployment rate. Instead, when the replacement ratio and the payroll tax are fixed, and hence the wage tax adjusts to balance the unemployment benefit budget constraint, then substituting for τ_t from equation (19) into equation (20) yields the capital dynamics as

$$(1 + \psi_t + \rho_t)\,K_{t+1}^{\frac{1}{\alpha}} - Q\,(sA)^{-\frac{1}{\alpha}}\,K_t^{\frac{\alpha-1}{\alpha}}\,K_{t+1}^{\frac{2}{\alpha}}\,(1 + \psi_t) - (sA)^{\frac{1}{\alpha}}\,\rho_t K_t^{\frac{1-\alpha}{\alpha}} = 0, \tag{21}$$

from where we have two positive steady state equilibria[13] implicitly defined by

$$Q\,(sA)^{-\frac{1}{\alpha}}\,K^2\,(1 + \psi) - (1 + \psi + \rho)\,K + (sA)^{\frac{1}{\alpha}}\,\rho = 0. \tag{22}$$

Solving this equation yields

$$K = \frac{(sA)^{\frac{1}{\alpha}}}{2Q\,(1 + \psi)}\left[(1 + \psi + \rho) \pm \left[(1 + \psi + \rho)^2 - 4Q\rho\,(1 + \psi)\right]^{1/2}\right]. \tag{23}$$

Hence, there are two steady state equilibria with a different capital level, one pessimistic K_1 and the other optimistic K_2, with $K_1 < K_2$. Since from equation (17) in steady state the capital-labor proportion K/L is fixed, then the higher the capital is, the higher the employment rate is. Moreover, differentiating equation (21), evaluating the resulting expression in steady state, and using equation (22) we have

$$\left.\frac{dK_{t+1}}{dK_t}\right|_{K_{t+1}=K_t} = 1 - \alpha, \tag{24}$$

which indicates that both steady state equilibria are stable without cycles. Next proposition summarizes these results.

[13] We do not consider the zero capital equilibrium.

Proposition 3 *When the wage tax is used to balance the unemployment benefit budget constraint, then two stable without cycles steady state equilibria arise.*

Although we observe from equations (4) and (17) that in any steady state the gross wage paid by the firm is constant, labor demand is not. It depends on the capital level of the economy. And this capital level may differ depending on the agents' expectations about wage taxes. Hence, given a payroll tax rate, the equilibrium negotiated wage is the same in both equilibria, which implies that whereas the unemployment benefits are the same in both equilibria, the net wage is high in the optimistic equilibrium and low in the pessimistic equilibrium.

When the replacement ratio and the wage tax are fixed, and hence the payroll tax adjusts to balance the unemployment benefit budget constraint, then substituting for ψ_t from equation (19) into equation (20) yields the capital dynamics as

$$(1-\tau_t-\rho_t)\, K_{t+1}^{\frac{1}{\alpha}} - \left[(1-\tau_t)\, Q^{-1} - \rho_t\right] (sA)^{\frac{1}{\alpha}}\, K_t^{\frac{1-\alpha}{\alpha}} = 0, \tag{25}$$

from where we have a unique steady state equilibrium,

$$K = \frac{(1-\tau-Q\rho)\,(sA)^{\frac{1}{\alpha}}}{Q\,(1-\tau-\rho)}. \tag{26}$$

Differentiating equation (25), evaluating the resulting expression in steady state, and using equation (26) we have

$$\left.\frac{dK_{t+1}}{dK_t}\right|_{K_{t+1}=K_t} = 1-\alpha, \tag{27}$$

which indicates that the steady state equilibrium is stable without cycles. Next proposition summarizes these results.

Proposition 4 *When the payroll tax is used to balance the unemployment benefit budget constraint, then there exists a unique stable without cycles steady state equilibrium.*

In this economy, the steady state capital-labor proportion is fixed regardless of the unemployment benefit system, which implies a constant gross wage paid by firms. This is a crucial difference with respect to the static model. In this dynamic setup, the capital adjusts in order to maintain the labor productivity in the long-run. Hence, if employment is affected by the fiscal policy, the capital per capita is also affected accordingly. In fact, the effects on employment from a change of the labor taxes are identical to those in the static model. Thus, a reduction of the wage tax has an unambiguous positive effect on employment regardless of the two scenarios we consider: either an exogenous or an endogenous wage tax. Obviously, the evolution of wages can be different since the steady state gross wage paid by firms remains constant. Next, we state and prove this result.

Proposition 5 *A decrease in the wage tax reduces the unemployment rate of the economy.*

P roof. From the proof of Proposition 2 we have that when the replacement ratio is exogenous then a decrease in the wage tax accompanied by an increase in the payroll tax such that the tax burden remains constant implies a decrease in the unemployment rate. When the wage tax is exogenous, it is direct to show from equation (26) that

$$\frac{dK}{d\tau} = \frac{(sA)^{\frac{1}{\alpha}}\,\rho\,(1-Q)}{Q\,[1-\tau-\rho]^2} < 0. \tag{28}$$

When the payroll tax is exogenous, from equations (19) and (23) evaluated in steady state we obtain

$$1-\tau = \frac{\left[(1+\psi+\rho) \pm \left[(1+\psi+\rho)^2 - 4Q\rho\,(1+\psi)\right]^{1/2}\right]}{2}, \tag{29}$$

from where we have

$$\frac{d\tau}{d\psi}=-\frac{1}{2}\left(1\pm\frac{(1+\psi+\rho)-2Q\rho}{\left[(1+\psi+\rho)^2-4Q\rho\,(1+\psi)\right]^{1/2}}\right). \tag{30}$$

Noting that the expression into the brackets is positive (negative) if

$$\left[(1+\psi+\rho)^2-4Q\rho\,(1+\psi)\right]^{1/2}>(<)\mp\left[(1+\psi+\rho)-2Q\rho\right], \tag{31}$$

we directly have that in the optimistic equilibrium $d\tau/d\psi<0$, and direct calculations show that in the pessimistic equilibrium $d\tau/d\psi>0$. Differentiating equation (23) gives

$$\frac{2Q\,(1+\psi)}{(sA)^{\frac{1}{\alpha}}}\frac{dK}{d\psi}=\left(1\pm\frac{(1+\psi+\rho)-2Q\rho}{\left[(1+\psi+\rho)^2-4Q\rho\,(1+\psi)\right]^{1/2}}\right)-\frac{\left[(1+\psi+\rho)\pm\left[(1+\psi+\rho)^2-4Q\rho\,(1+\psi)\right]^{1/2}\right]}{(1+\psi)}. \tag{32}$$

As we have shown, in the pessimistic equilibrium the first bracket on the right hand side is negative. Therefore, we have that $dK/d\psi<0$ and, hence, the wage tax implicitly increases. Thus, a decrease in the payroll tax implies an increase in the capital level (and thus in the employment rate) and a decrease in the wage tax. In the optimistic equilibrium, direct calculations show that the right hand side is positive. Hence, we have that $dK/d\psi>0$, which implies that the wage tax implicitly decreases. ■

The introduction of capital does not change the results. Then, unemployment is minimized if unemployment benefits are paid exclusively by firms. A reduction in the wage tax is consistent with either an increase or a decrease in the payroll tax. Hence, the evolution of the wage earnings depends on the specific equilibrium the economy is converging to. In the pessimistic equilibria, characterized by a high wage tax , a decrease in the payroll tax implies a reduction in the wage tax, which makes the wage to increase and, thus, both the net wage and the unemployment benefits also increase. However, in the optimistic equilibria wages are reduced from restructuring taxes from workers to firms. Hence, unemployment benefits are reduced while net earnings increase and, then, there are more workers with higher net earnings and less unemployed with lower benefits.[14]

4 Alternative unemployment benefit systems and bargaining patterns

In this section, we consider alternative unemployment benefit systems. First, we analyze situations where unemployment benefits are tied to net earnings. We show that a budget balanced rule induces a unique steady state unemployment rate which is independent of the labor tax composition. Second, we analyze situations where both income and payroll taxes are used to finance the system. This new framework allow us to consider Beveridge systems where there are no specific taxes to finance unemployment spending. Finally, we analyze alternative bargaining patterns.

[14] A reduction of unemployment increases inequality. However, previously unemployed agents become employed and get higher earnings. Hence, a welfare analysis should contemplate also such shift from unemployment to employment.

4.1 Net Bismarckian system

The net Bismarckian system is characterized by unemployment benefits being a proportion of the net wage.[15] In this case, the budget balanced rule is given by

$$w_t L_t(\tau_t + \psi_t) = (1 - L_t)\rho_t w_t(1 - \tau_t). \tag{33}$$

In equilibrium, the disagreement point of the unions becomes

$$\overline{w}_t = w_t L_t \left(1 - \tau_t\right) + \left(1 - L_t\right) \rho_t w_t \left(1 - \tau_t\right). \tag{34}$$

And combining it with equation (5), we obtain

$$L_t = \frac{Q^{-1} - \rho_t}{1 - \rho_t}. \tag{35}$$

Hence, there exists an unique equilibrium, which is independent on how spending is financed. Unemployment is exclusively explained by the technology, the unions' bargaining power and the replacement ratio. Moreover, combining equations (33) and (35) we get

$$\psi_t = \rho_t \left(1 - \tau_t\right) \left(\frac{Q - 1}{1 - Q\rho_t}\right) - \tau_t, \tag{36}$$

which shows that the equilibrium is consistent with different labor tax combinations.

Proposition 6 *In a net bismarckian unemployment benefit system, the labor tax composition does not affect the unique unemployment rate of the economy.*

4.2 Beveridgean system

Unemployment benefits are fixed in a Beveridgean system. Even though in most countries where this unemployment benefit system prevails there are no specific taxes to finance it, the government needs to have a similar budget balanced rule as in the previous sections. In general, we assume that the unemployment benefits b are taxed at a different rate $\widehat{\tau}_t$ than wages.[16] For simplicity, we fix $\widehat{\tau}_t = \nu\tau_t$ with $\nu \in [0, 1]$. In order to compare with other authors, we assume that the worker net wage is

$$w_t - \tau_t \left(w_t - ab\right) - ab\widehat{\tau}_t = w_t - \tau_t \left[w_t - ab\left(1 - v\right)\right], \tag{37}$$

where $a \geq 0$ is an arbitrary constant. This case generalizes the analysis. Indeed, if $a = v = 0$ we have the typical system where unemployed do not pay taxes and employed pay the same marginal tax rate for all their income[17]; if $a = 1$ then we have the typical income tax where employed have two tax brackets: they pay the same marginal tax rate than unemployed for the same income but they pay a higher marginal tax rate for the rest of the income; if $a = 0$ and $v \neq 0$ then both unemployed and employed pay a different marginal tax rate for all their respective income; if $v = 1$ then all individuals pay the same marginal tax rate for all their income; and if $v = 0$ and $0 < a \neq 1$ then employed have a fiscal exemption (namely, $a' = ab$). This last case coincides with Koskela and Vilmunen (1996).

[15] Note that in this setup a high wage tax would imply a low unemployment subsidy. Altough this could seem unreasonable, it prevails in countries as Austria or Germany according to the OECD (2004).

[16] It would be more appropiate to refer these taxes as income taxes.

[17] We say income to the labor income.

Now, equation (5) is given by

$$w_t(1-\tau_t)+Qab\,(1-v)\,\tau_t = Q\overline{w}_t, \tag{38}$$

The budget-balanced rule is given by

$$w_tL_t\psi_t + L_t\tau_t\left[w_t - ab_t\,(1-v)\right] = b\,(1-L_t)\,(1-v\tau_t)\,. \tag{39}$$

The disagreement point in this case can be written as

$$\overline{w}_t = L_t\left(w_t - \tau_t\left[w_t - ab\,(1-v)\right]\right) + b\,(1-L_t)\,(1-v\tau_t)\,. \tag{40}$$

From equations (39) and (40) we have

$$\overline{w}_t = L_tw_t\,(1+\psi_t)\,. \tag{41}$$

And from equations (38), (41) and (4) we get

$$\alpha AK_t^{1-\alpha}L_t^{\alpha-1}\frac{(1-\tau_t)}{(1+\psi_t)} + Qab\,(1-v)\,\tau_t = Q\alpha AK_t^{1-\alpha}L_t^{\alpha}. \tag{42}$$

Combining equations (39) and (4) we obtain

$$\alpha AK_t^{1-\alpha}L_t^{\alpha} = \alpha AK_t^{1-\alpha}L_t^{\alpha}\frac{(1-\tau_t)}{(1+\psi_t)} + abL_t\tau_t\,(1-v) + b\,(1-L_t)\,(1-v\tau_t)\,. \tag{43}$$

Equations (42) and (43) yield the employment equilibria of the economy.

We consider the case where the instrument used to adjust the government budget is the payroll tax. Substituting the payroll tax from (42) into (43), and evaluating in steady state, gives

$$\alpha AK^{1-\alpha}L^{\alpha+1}Q - \alpha AK^{1-\alpha}L^{\alpha} + b\,(1-L)\,(1-\nu\tau) + abL\tau\,(1-v) - Qab\,(1-v)\,\tau L = 0, \tag{44}$$

which can be written as

$$G\,(L,\tau) = \alpha A\,(K/L)^{1-\alpha}\,QL^2 - \left[\alpha A\,(K/L)^{1-\alpha} + (Q-1)\,ab\tau\,(1-v) + b\,(1-\nu\tau)\right]L + b\,(1-\nu\tau) = 0. \tag{45}$$

Since from equation (17) we have that K/L is constant in steady state, and in contrast with the gross Bismarckian system, equation (45) yields (generically) two steady state employment rates, one pessimistic L_1 and the other optimistic L_2, with $L_1 < L_2$. Moreover, since equation (45) is quadratic, we have

$$\frac{\partial G\,(L_1,\tau)}{\partial L} < 0 \text{ and } \frac{\partial G\,(L_2,\tau)}{\partial L} > 0. \tag{46}$$

Differentiating equation (45) yields

$$\frac{\partial L}{\partial \tau} = \frac{(1-L)\,b\nu + (Q-1)\,ab\,(1-v)\,L}{\partial G\,(L,\tau)\,/\partial L}, \tag{47}$$

and, hence, we get

$$\left.\frac{\partial L}{\partial \tau}\right|_{L=L_1} \leq 0 \text{ and } \left.\frac{\partial L}{\partial \tau}\right|_{L=L_2} \geq 0. \tag{48}$$

Except in the case that $a = v = 0$, an increase in the wage tax always reduces (increases) the steady state unemployment rate of the economy in the optimistic (pessimistic) case. Therefore, it is the same having two tax brackets ($a = 1$) than having an exemption ($v = 0$ and $0 < a \neq 1$). Moreover, we have that a more progressive fiscal system (an increase in the tax exemption) yields a lower unemployment rate in the optimistic equilibrium. This result coincides with Koskela and Vilmunen (1996) but, in contrast with them, here the result is due to an endogenous increase of the payroll tax and not of the wage tax. Note that an increase in a makes the payroll tax to increase whereas an increase in τ makes the payroll tax to decrease, but in both cases the unemployment decreases. When unemployed do not pay taxes and employed pay the same marginal tax rate for all their income, $a = v = 0$, then $\partial L/\partial \tau = 0$, which coincides with the net Bismarckian system. In the Appendix we show, as a subcase of the mixed unemployment benefit system, that for this case the optimistic equilibrium is always stable whereas the pessimistic equilibrium may now be unstable.

Proposition 7 *In a Beveridgean unemployment benefit system, the labor tax composition does not affect the unemployment rates of the economy if and only if the unemployed do not pay taxes and the employed pay a constant marginal tax rate. Otherwise, a decrease in the wage tax makes the unemployment rate to decrease in the optimistic equilibrium and to increase in the pessimistic equilibrium.*

4.3 Mixed unemployment benefit system

Given the assumptions that marginal taxes are constant and exclusively levied on workers and firms, the implications of a change in the labor tax composition have been shown to differ under a gross Bismarckian or a Beveridgean system. At this point, a reasonable extension is to ask about the effects of a change in the labor tax composition when the unemployment benefits consist of both a fixed part b and a variable part ρw. Since when unemployed do not pay taxes then labor tax composition does not affect employment in a Beveridgean system, intuition suggests that the positive effect on employment of a reduction in the wage tax under a gross Bismarckian system should prevail. Indeed, in the Appendix it is shown that when the payroll tax is exogenous then two steady state equilibria arise. Moreover, unemployment is reduced in the optimistic equilibrium and increased in the pessimistic equilibrium if there is a shift of the tax incidence from wage taxes to payroll taxes. The main difference with respect to the gross Bismarckian system is that the pessimistic equilibria may be unstable. In fact, numerical simulations suggest that the pessimistic equilibria may be either stable (with or without cycles) or unstable. We observe that when b is sufficiently low then the pessimistic equilibrum is stable without cycles. However, when we increase b then the pessimistic equilibrium first becomes stable with cycles and after unstable.

4.4 Alternative bargaining patterns

Bargaining over wage and employment. We have considered that the negotiation is a right-to-manage one. A different situation arises when the unions bargain on both the wage and the employment level.[18] In this case, after the capital level has been selected by the firm, and according to the Nash solution, the wage and the employment level solve

$$\max_{\{L_t, w_t\}} \; \left[\left(w_t(1-\tau_t) - \overline{w}_t\right) L_t\right]^{\beta} \left[AK_t^{1-\alpha}L_t^{\alpha} - w_t L_t(1+\psi_t)\right]^{1-\beta},$$

from where the following optimal conditions are satisfied:

$$\overline{w}_t \left(1+\psi_t\right) = \left(1-\tau_t\right) \alpha A K_t^{1-\alpha} L_t^{\alpha-1}, \tag{49}$$

$$w_t L_t (1+\psi_t) = \beta A K_t^{1-\alpha} L_t^{\alpha} + (1-\beta)\overline{w}_t \left(1+\psi_t\right) L_t / \left(1-\tau_t\right). \tag{50}$$

Substituting for the payroll tax from equation (49) into equation (50) we obtain

$$w_t \left(1-\tau_t\right) = Q\overline{w}_t. \tag{51}$$

[18] This model is usually called the efficient bargaining model. However, since in our model there is a previous decision on capital that is not considered in the bargaining, we do not use this term in order to avoid any confusion about efficiency.

And using equations (6) and (51) we get the employment as a function of the wage tax,

$$L_t = \frac{1-\tau_t-\rho_t Q}{Q\left(1-\tau_t-\rho_t\right)}. \tag{52}$$

Note that this is the same condition as that in the right-to-manage model and, thus, the same results apply.

Seigniorage. In the seigniorage model, employment is not considered by unions, who only focus on wages (see, for instance, Oswald, 1985). Then, firms and unions bargain over wages and the firm has the right-to-manage. While both the government budget constraint and the disagreement point are the same as in section 3, the optimal condition from the Nash problem is now slightly different. Combining such condition with the right-to-manage condition (4) yields

$$w_{it}(1-\tau_t) = \widehat{Q}\overline{w}_{it}, \tag{53}$$

where $\widehat{Q} = \alpha\left(1-\beta\right)/\left(\alpha-\beta\right) > 1$. Hence, all the results of section 3 remain qualitatively unchanged.

Corporatist institutions. The analysis of this paper assumes a decentralized negotiation. Thus, both unions and firms bargain at the firm level without taking into account the indirect effects that their decisions have on the unemployment benefit system. In contrast, in a corporatist economy or an economy with a centralized negotiation, unions and firms would have into account this indirect effect and, as a result, unemployment would be lower. Moreover, the existence of hysteresis would disappear, since expectations would be coordinated among the agents.

5 Final Remarks

We have shown that the composition of labor taxes specifically used to finance an unemployment benefit system has an important effect on the unemployment rate in an unionized economy with capital accumulation. Moreover, we have shown when an unemployment benefit budget-balanced rule makes the economy to have indeterminacy in the sense that multiple self-fulfilling equilibria may arise. In particular, when the unemployment benefit system is gross Bismarckian, then the tax wedge determines the unemployment rate of the economy. Moreover, the lower the wage tax is, the lower the unemployment rate is. When the unemployment benefit system is net Bismarckian, then the unemployment rate does not depend on how the unemployment benefit system is financed. Hence, unemployment is exclusively explained by the technology, the unions' bargaining power and the replacement ratio. When the unemployment benefit system is Beveridgean, then the labor tax composition does not affect the unemployment rate if and only if the unemployed do not pay taxes and the employed pay a constant marginal tax rate. We show that the qualitative results do not change if we change the type of negotiation between unions and firms.

In the analysis, we have assumed that individuals save a constant fraction of their income. This assumption is not innocuous. With this type of savings, if the unemployment benefit system was financed exclusively through taxes on capital income, then the unemployment benefit system would be neutral for the unemployment. This informs us that a deeper insight should be made.

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Appendix: The mixed unemployment benefit system

The right-to-manage and the wage conditions arising form the Nash bargaining are identical to those of section 2, given by equations (4) and (5), respectively. But the government budget constraint and the unions' disagreement point differ. When benefits consist both on a fixed part b_t and a variable part wich is a proportion of the wage $\rho_t w_t$, the government budget constraint becomes

$$w_t L_t(\tau_t + \psi_t) = (1 - L_t)(\rho_t w_t + b_t), \tag{A.1}$$

while the disagreement point of the unions is

$$\overline{w}_t = w_t L_t(1 - \tau_t) + (1 - L_t)(\rho_t w_t + b_t). \tag{A.2}$$

Note that unemployed do not pay taxes. Combining equations (5), (A.1) and (A.2), and after (17) yields

$$(1 - \tau_t) = Q(1 + \psi_t)\left(\frac{K_{t+1}}{sAK_t^{1-\alpha}}\right)^{\frac{1}{\alpha}}. \tag{A.3}$$

And from equations (4) and (A.1), and after (17) we have

$$\alpha K_{t+1}(\tau_t + \psi_t) = \left(s - s^{\frac{\alpha-1}{\alpha}} A^{-\frac{1}{\alpha}} K_{t+1}^{\frac{1}{\alpha}} K_t^{\frac{\alpha-1}{\alpha}}\right)\left(\rho_t \alpha s^{\frac{1-\alpha}{\alpha}} A^{\frac{1}{\alpha}} K_{t+1}^{\frac{\alpha-1}{\alpha}} K_t^{\frac{1-\alpha}{\alpha}} + b_t(1 + \psi_t)\right). \tag{A.4}$$

We consider the case where the instrument used to adjust the government budget is the wage tax. Hence, substituting for τ_t from equation (A.3) into equation (A.4), we have the dynamics of the economy,

$$\alpha K_{t+1}\left(1 + \frac{\rho_t}{1 + \psi_t}\right) - \alpha Q s^{-\frac{1}{\alpha}} A^{-\frac{1}{\alpha}} K_{t+1}^{\frac{1+\alpha}{\alpha}} K_t^{\frac{\alpha-1}{\alpha}} - \frac{\rho_t}{1 + \psi_t}\alpha s^{\frac{1}{\alpha}} A^{\frac{1}{\alpha}} K_{t+1}^{\frac{\alpha-1}{\alpha}} K_t^{\frac{1-\alpha}{\alpha}} + s^{\frac{\alpha-1}{\alpha}} A^{-\frac{1}{\alpha}} K_{t+1}^{\frac{1}{\alpha}} K_t^{\frac{\alpha-1}{\alpha}} b_t - s b_t = 0, \tag{A.5}$$

from where the steady state equilibrium solves

$$\alpha Q s^{-\frac{1}{\alpha}} A^{-\frac{1}{\alpha}} K^2 - \left[\alpha\left(1 + \frac{\rho}{1 + \psi}\right) + s^{\frac{\alpha-1}{\alpha}} A^{-\frac{1}{\alpha}} b\right] K + \left(\frac{\rho}{1 + \psi}\alpha s^{\frac{1}{\alpha}} A^{\frac{1}{\alpha}} + sb\right) = 0. \tag{A.6}$$

Note that in a Beveridgean system, $\rho = 0$, taxes do not affect capital and, thus, unemployment. Instead, in a mixed unemployment benefit system we always have two equilibria, one pessimistic K_1 and the other optimistic K_2, with $K_1 < K_2$. Using equations (A.1) and (4) we get

$$L_t = \frac{\rho_t \alpha A (sA)^{\frac{1-\alpha}{\alpha}} + b_t(1 + \psi_t)}{\alpha A (sA)^{\frac{1-\alpha}{\alpha}}(\tau_t + \psi_t + \rho_t) + b_t(1 + \psi_t)}, \tag{A.7}$$

which combined with equations (17) and (A.3) yield a continuum of equilibrium pairs (τ_t, ψ_t) which are implicitly defined by

$$\frac{\rho_t \alpha A (sA)^{\frac{1-\alpha}{\alpha}} + b_t(1 + \psi_t)}{\alpha A (sA)^{\frac{1-\alpha}{\alpha}}(\tau_t + \psi_t + \rho_t) + b_t(1 + \psi_t)} = \frac{1 - \tau_t}{Q(1 + \psi_t)}. \tag{A.8}$$

In contrast with the gross Bismarckian unemployment benefit system, since $b_t > 0$ then for each wage tax we have that two different values of the payroll tax can arise. Hence, two equilibria are attained regardless of the tax used to adjust the government budget.

Next, we analyze the stability properties of the equilibria. Implicit differentiation of equation (A.5) and, after, evaluating in steady state yields

$$\frac{dK_{t+1}}{dK_t} = \frac{H - \alpha H}{H - \alpha M}, \tag{A.9}$$

where

$$H = \alpha Q s^{-\frac{1}{\alpha}} A^{-\frac{1}{\alpha}} K^2 - s^{\frac{\alpha-1}{\alpha}} A^{-\frac{1}{\alpha}} bK - \frac{\rho}{1+\psi} \alpha s^{\frac{1}{\alpha}} A^{\frac{1}{\alpha}}, \tag{A.10}$$

and

$$M = -\alpha Q s^{-\frac{1}{\alpha}} A^{-\frac{1}{\alpha}} K^2 + \alpha \left(1 + \frac{\rho}{1+\psi}\right) K - \frac{\rho}{1+\psi} \alpha s^{\frac{1}{\alpha}} A^{\frac{1}{\alpha}}. \tag{A.11}$$

From equation (A.6) we have that $M = sb - s^{\frac{\alpha-1}{\alpha}} A^{-\frac{1}{\alpha}} bK$, which is positive.[19] Sufficient conditions for the equilibria to be stable without cycles are that either $H \leq 0$, or $H > 0$ and $H > M$. A sufficient condition for the equilibria to be stable with cycles is that $H > 0$ and $H < M\alpha/(2-\alpha)$. Using equations (A.6), (A.10) and (A.11) we have that

$$H - M = 2\alpha Q s^{-\frac{1}{\alpha}} A^{-\frac{1}{\alpha}} K^2 - \left[s^{\frac{\alpha-1}{\alpha}} A^{-\frac{1}{\alpha}} b + \alpha \left(1 + \frac{\rho}{1+\psi}\right)\right] K, \tag{A.12}$$

which is positive at the optimistic equilibrium and negative at the pessimistic one. [20] Hence, the optimistic equilibrium is always stable, since $H > M > 0$. In the pessimistic equilibrium we have that $H - M < 0$. Thus, in order to have stability it must be the case that either $H < 0$, or $H > 0$ and $(2-\alpha)H < \alpha M$. These last two conditions can be reduced to $(2-\alpha)H - \alpha M < 0$. Note that if $b = 0$ then this condition is satisfied, since $M = 0$ and $H < M$. However, for high values of b the stability properties of the pessimistic equilibria change. We can define a subspace of the parameter space $\Theta \subset \Re^6$ such that if the vector $\theta = (\alpha, \beta, s, b, \rho, \psi)$ belongs to the subspace Θ, then the pessimistic equilibrium is locally stable, and it is unstable otherwise. As an example, we show in Table 1 some numerical results (the subscripts 1 and 2 refer to the pessimistic and the optimistic equilibrium, respectively).[21] Note that the last four rows are the beveridgean benefit system when $v = 0$. Also note that in the case of $b = 0.45$ and $\rho = 0.55$ the wage taxes for the pessimistic equilibrium are increasing with ψ.

In order to show the effects of a change in the labor tax composition, first we need to solve equation (A.6),

$$K = \frac{\alpha\left(1+\frac{\rho}{1+\psi}\right) + s^{\frac{\alpha-1}{\alpha}} A^{-\frac{1}{\alpha}} b \pm \sqrt{\left[\alpha\left(1+\frac{\rho}{1+\psi}\right) + s^{\frac{\alpha-1}{\alpha}} A^{-\frac{1}{\alpha}} b\right]^2 - 4\alpha Q s^{-\frac{1}{\alpha}} A^{-\frac{1}{\alpha}} \left(\frac{\rho}{1+\psi} \alpha s^{\frac{1}{\alpha}} A^{\frac{1}{\alpha}} + sb\right)}}{2\alpha Q s^{-\frac{1}{\alpha}} A^{-\frac{1}{\alpha}}}. \tag{A.13}$$

The equilibria exist if the term into the root is positive, which we assume. Differentiating K with respect to ψ gives $dK/d\psi = (dK/dB)(dB/d\psi)$, where $B = \rho/(1+\psi)$ and therefore $sign\,(dB/d\psi) < 0$. Hence,

$$sign\left(\frac{dK}{d\psi}\right) = -sign\left(\frac{dK}{dB}\right) = -sign\left(C \pm \left[\alpha\left(1+\frac{\rho}{1+\psi}\right) + s^{\frac{\alpha-1}{\alpha}} A^{-\frac{1}{\alpha}} b - 2\alpha Q\right]\right), \tag{A.14}$$

where C is the root of equation (A.13). Substituting C from equation (A.13) into (A.14) for each equilibrium and noting from equation (17) that $Ks^{-\frac{1}{\alpha}} A^{-\frac{1}{\alpha}} = L < 1$ for both equilibria, we have that $sign\,(dK_1/d\psi) < 0$ and $sign\,(dK_2/d\psi) > 0$.

[19] Note that $sb - s^{\frac{\alpha-1}{\alpha}} A^{-\frac{1}{\alpha}} bK = sb\left(1 - s^{-\frac{1}{\alpha}} A^{-\frac{1}{\alpha}} K\right) > 0$ since in steady state $s^{-\frac{1}{\alpha}} A^{-\frac{1}{\alpha}} K = L < 1$.

[20] Since equation (A.6) is quadratic, then by differentiating equation (A.6) and multiplying the resulting expression by K gives directly the sign of (A.12) for each equilibrium.

[21] We have chosen the following values for the parameters: $A = 4$, $s = 0.1$, $\beta = 0.02$ and $\alpha = 0.66$. Also, in this numerical example we have included some cases where the pessimistic equilibrium is unstable, i.e. $(2-\alpha)H_1 - \alpha M_1 > 0$, in a larger proportion than the observed in other simulations, where these cases are unusual. Also, the cases where the pessimistic equilibrium is stable with cycles, i.e. $H_1 > 0$, appear in other simulations in a smaller proportion than the suggested in this table.

b	$\psi(\%)$	ρ	L_1	L_2	w	$\tau_1(\%)$	$\tau_2(\%)$	H_1	$(2-\alpha)\,H_1 - \alpha M_1$
0.4	1	0.55	0.829	0.940	1.63	15.4	4.0	$-$	
0.4	2	0.55	0.820	0.943	1.61	15.2	2.8	$-$	
0.4	3	0.55	0.813	0.945	1.60	15.3	1.6	$-$	
0.4	4	0.55	0.806	0.947	1.58	15.2	0.4	$-$	
0.45	1.5	0.55	0.886	0.910	1.62	9.1	6.6	$+$	$-$
0.45	2	0.55	0.876	0.917	1.61	9.6	5.4	$-$	
0.45	3	0.55	0.863	0.925	1.60	10.1	3.7	$-$	
0.45	4	0.55	0.853	0.930	1.58	10.3	2.2	$-$	
0.45	5	0.55	0.844	0.934	1.57	10.4	0.8	$-$	
0.55	4	0.5	0.884	0.911	1.58	7.0	4.2	$+$	$-$
0.55	5	0.5	0.870	0.921	1.57	7.6	2.2	$-$	
0.55	6	0.5	0.860	0.927	1.55	7.8	0.7	$-$	
0.77	1	0.35	0.882	0.913	1.63	9.9	6.7	$+$	$+$
0.77	2	0.35	0.871	0.920	1.61	10.1	5.1	$+$	$-$
0.77	3	0.35	0.863	0.925	1.60	10.1	3.7	$+$	$-$
0.77	4	0.35	0.857	0.928	1.58	9.9	2.4	$+$	$-$
0.77	5	0.35	1.57	0.851	0.931	9.7	1.1	$+$	$-$
0.85	1	0.3	1.63	0.879	0.915	10.3	6.5	$+$	$-$
0.85	2	0.3	1.61	0.870	0.921	10.2	5.0	$+$	$-$
0.85	4	0.3	1.58	0.858	0.928	9.8	2.4	$+$	$-$
0.85	6	0.3	1.55	0.848	0.932	9.1	0.08	$+$	$-$
1	1	0.2	0.859	0.927	1.63	12.3	5.3	$+$	$-$
1	3	0.2	0.851	0.931	1.60	11.3	3.1	$+$	$-$
1	5	0.2	0.845	0.934	1.57	10.3	0.9	$+$	$-$
1.3	1	0	0.832	0.939	1.63	15.1	4.1	$+$	$-$
1.3	3	0	0.832	0.939	1.60	13.4	2.2	$+$	$-$
1.33	1	0	0.864	0.924	1.63	11.8	5.6	$+$	$+$
1.33	3	0	0.864	0.924	1.60	10.0	3.7	$+$	$+$

Table 1. Stability properties of the equilibria and taxes.