EFFECTS OF TAX REFORMS IN A SHIRKING MODEL WITH UNION BARGAINING*

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ABSTRACT

In this paper we introduce a progressive income tax in the shirking model with union bargaining presented by in Altenburg and Straub (2002). Indeed, we differentiate taxation on employees and employers for the fiscal policy analysis.

The main results show that it is possible, with a constant revenue reform, to enhance employment by shifting the tax imposition towards lower firm taxation. And, that it is crucial to consider a proportional or progressive taxation on labour income in order to be able to analyse the effect on unemployment for a constant replacement rate.

JEL Classification: E24; J32; J41; J51

Key words: Labour taxation, union bargaining, efficiency wages

1. Introduction

Unemployment remains one of the main problems in modern economies. Factors such as market rigidities, temporal shocks and the distortions caused by taxes have been used to explain, in theoretical and empirical works, the high and persistent unemployment rates in OECD countries.

Through the analysis of the relationship between taxes and unemployment, fiscal policy has emerged as a possible instrument for boosting employment. Among the different instruments of fiscal policy we can distinguish unemployment benefits, regulations in the labour market, and taxes on capital, consumption and income. Regarding reforms in the income taxes levied on workers and firms, numerous papers have appeared with an aim to designing tax reforms within the labour market capable of increasing the level of employment. The first attempts were made in bargaining models with proportional taxes (Lockwood and Manning (1993) and Muysken et al (1999)). Afterwards, this analysis of tax reforms shifted to the field of efficiency wages, where the effort expended by employees was taken into account (Shapiro and Stiglitz (1984), Andersen and Rasmunssen (1999) and Goerke (2002) among others). Among the different studies of tax reforms, one of the most common conclusions is that it is possible to reduce unemployment by restructuring the taxes levied on employers and employees, in favour of a reduction of the tax charge paid by firms (see Muysken et al (1999)).

On the other hand, the studies focusing on the income tax paid by workers lacked an important evidence in their theoretical frameworks: income tax being progressive in all OECD countries.

Recently, the analysis of tax progressivity has been introduced into the study of the effects of tax reforms on unemployment. Generally, most papers dealing with this area of study conclude that increasing income tax progressivity is good for employment. In union bargaining models this is so because of the reduction in the bargained wage through the diminution in union wage demands, due to the fact that increasing progressivity makes it "cheaper" for unions to buy jobs through wage moderation[1]. And for efficiency wages models it is so because firms have incentives to lower wages

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[1] This statement is proved in Koskela and Vilmunen (1996) for the three union bargaining models: monopoly union, right to manage and efficient bargaining models.

due to the lower reduction in the effort expended by employees when progressivity is greater (Pissarides (1998) and Sorensen (1999)).

However at the same time we can find references in the labour market literature supporting the idea that combining the efficiency wages and the union bargaining models reinforces their negative effects on employment (Hoel (1989), Sanfey (1993) or Garino and Martin (2000)).

The first papers to introduce taxes in a model combining efficiency considerations and wage bargaining were Altenburg and Straub (1998, 2000 and 2002). In those papers, the original shirking model of Shapiro and Stiglitz (1984) was modified to introduce a decentralised wage bargaining process. Within this framework, an analysis of reforms in proportional taxes was made. However, for this kind of model, there are no results about the effects on unemployment of changes in income tax progressivity or in the tax structure.

The objective of this paper is to study the effects on unemployment and production (for a union bargaining model where the effort expended by workers is taken into account) of the following reforms: individual reforms in tax parameters (to separate the individual effect of each parameter); and changes in the tax structure and reforms in income tax progressivity dealing with the problem of keeping government fiscal revenues at a constant level, to avoid altering the government budget. This last reform, those keeping government fiscal revenues constant, is crucial in the design of government policies.

To this end, we adapt the model used in Altenburg and Straub (2002) to consider a Cobb-Douglas production function and assume neutral to risk workers. The complexity of the tax reforms recommended is necessary in order to be able to study their effects on unemployment in this kind of model for a later comparison with other works.

The results reveal that it is possible to alter the level of unemployment by changes in the tax parameters for a constant replacement ratio, invalidating, for a progressive tax structure, Proposition 2 presented in Altenburg and Straub (2002). Furthermore, when a revenue neutral reform is considered, it is better for employment to compensate for the increase in the personal tax allowance through increments in the marginal income tax paid by workers both for a constant replacement ratio and for a constant unemployment benefit.

The paper is organised as follows. In Section 2, we develop the model. The general equilibrium is obtained in Section 3. In Section 4, we analyse the effects of tax reforms on the key variables of the model. The analysis is carried out for individual changes in each tax parameter, under the condition of constant government fiscal revenues and taking into account two different tax structures. The examination is carried out for constant unemployment benefits and for a fixed replacement ratio. Finally, in Section 5, we outline the main conclusions.

2. The model

In this section we develop a theoretical model of the labour market, taking the following two factors into account: the minimum effort required by the firms from the workers and the negotiation that takes place between both parties in determining the gross wage.

We postulate an economy with a large fixed number of identical workers, where many firms (also identical and fixed in number) operate, each of these firms producing a homogeneous good (whose price is normalised to one for analytical convenience) and employing several workers. All firms are unionised, each bargaining with its own union.

Decisions (for each group composed of firm, associated union and affiliated workers) are made in three stages. We apply the Nash bargaining solution within the context of the "right-to manage" approach according to which employment is unilaterally determined by the firms. Thus in the first stage, the wage is set by bargaining between the firm and its union with the outside opportunities taken as given. In stage two, the firm chooses the level of employment. Finally, the firm sets a minimum effort standard that it expects from its employees, and they in turn decide whether or not to comply with this effort standard. The model is solved by backward induction. In this paper we examine the labour market equilibrium and thus we shall focus on the steady state.

2.1. Determining effort

We begin by setting a minimum effort that the workers must comply with. To keep the model simple, we assume that workers live forever and have the following utility function separable in income and effort:

$$U(w,e) = [w(1-t)+tc] - \frac{e^{\theta}}{\theta}$$

where *w* is the gross wage earned by workers. Given that the tax applied to workers is (T), the progressive structure T=t (*w* –*c)* is applied, where *t*>0 is the marginal income tax while c>0 is a personal tax allowance[2].

Thus, w(1-t)+tc is the net wage obtained by workers. Parameter *e* represents the effort expended on a job and parameter θ is the elasticity of the effort expending disutility.

In this utility function, we have considered neutral to risk individuals (lineal function on the after-tax income). This assumption is not only adopted for analytical convenience, but also because the introduction of risk aversion might bias the analysis in favour of tax progressivity (Sorensen, 1999) given that the model does not incorporate a capital market allowing unemployed workers to engage in consumption smoothing[3]. Another assumption is an elasticity of the effort expending disutility θ>1.

Given the individuals' utility function and the tax structure, the firm sets a minimum effort standard *e* that will be required of their workers as a function of the negotiated wage. An employed worker is then faced with the decision of whether to shirk or not. Employees who meet this effort standard (non-shirkers) lose their job at a rate of *δ* per unit of time. This parameter is interpreted as the rate at which jobs break up in the economy, and it applies to all employees. Meanwhile, those workers who fail to meet the effort standard *e* (shirkers) face an additional probability of losing their job *q*, interpreted as the rate at which shirkers are detected and fired. Both rates, *δ* and *q*, are considered exogenous. Thus, a shirker's best choice is to supply zero effort, while a non-shirker's best choice is to exert an effort at exactly the required minimum level.

Let us denote E^s and E^{ns} as the expected lifetime utilities of an employed shirker and non-shirker, D as the expected lifetime utility of a currently unemployed worker (taken as given when the firm and its employees select an effort level) and *r* as the discount rate in the economy. Therefore, the value function of a non-shirker and a shirker can be written as:

$$rE^{ns} = \left[w(1-t)+tc\right] - \frac{e^{\theta}}{\theta} - \delta(E^{ns}-D) \qquad (1)$$

$$rE^s = \left[w(1-t) + tc \right] - (\delta + q)(E^s - D) \tag{2}$$

The minimum effort standard set by the firm, for an employee not to shirk must satisfy that $E^{ns} \geq E^s$. Using equations (1) and (2) yields the following condition on effort

$$e \leq e^*(w, D) \equiv \left[\left(\left[w(1-t) + tc \right] - rD \right) \left(\frac{\theta q}{r + \delta + q} \right) \right]^{\frac{1}{\theta}} \tag{3}$$

This expression represents the highest possible level of effort that the firm can demand from its workers to get them to work at every negotiated wage given D.

However, the firm has to offer a wage that makes workers supply an effort level e^* and meanwhile the workers have no incentive to offer anything more than the minimum effort required. Thus we have the case that $E^s = E^{ns} = E$ (see Appendix 1 for the demonstration).

Notice that for a net wage $w(1-t) + c > rD$, e^* is positive, increasing in w and decreasing in D. For $\theta > 1$, e^* is strictly concave in w.

2.2. The employment decision

In this section we proceed to the determination of the employment function demanded by the firm, which is dependent on the negotiated wage and the minimum effort standard.

Let N be the number of employed workers and L=eN denote the effective labour input. The firm's production function F(L) is assumed to be a Cobb-Douglas one, adopting the functional form F(L)=L^α with $0 < \alpha < 1$ being the production elasticity regarding the effective labour. We then have a short-term production function with the capital taken as fixed, the value of which is normalised to one for convenience.

From this production function, we define the profit function of every firm operating in the economy through the following expression:

$$\pi = \left(e^* N \right)^\alpha - (1 + t_f) w N \tag{4}$$

where $t_f > 0$ is the tax rate on labour that employers have to pay. So, it is assumed that this tax is strictly proportional to the wage[4].

The firm, with the minimum effort standard $e*(w,D)$ already set, chooses the level of employment that will maximise its profit function (4).

The first order condition with respect to N is:

$$\alpha e * (e * N)^{\alpha - 1} = (1 + t_f)w \qquad (5)$$

Equation (5) defines the following employment function:

$$N* = \left[\frac{\alpha(e*)^\alpha}{(1 + t_f)w} \right]^{\frac{1}{1-\alpha}} \qquad (6)$$

This employment function is negatively related to the firm's labour cost per employee $(1+t_f)w$, and positively related to the level of effort the firm demands.

2.3. Determining the wage

Let us now turn to the setting of the negotiated gross wage for each duality union-firm, in which the optimal functions for labour and effort developed above (equations 3 and 6) are taken into account.

For this purpose, we assume the wage to be the result of a Nash bargaining between each firm and its union, which we suppose is only interested in the welfare of its employed members (insiders). Hence, the objective function of the union will be the discounted lifetime utility of an employed worker (E), represented by equation (1). We assume that in the case of disagreement a worker gets the same utility as when entering unemployment, D. So, the union will try to maximise the difference E-D during the bargaining. Upon the substitution of Eq. (3) into Eq. (1), we find the union contribution to the Nash bargain to be:

$$E - D = \left([w(1-t) + tc] - rD \right) \frac{1}{r + q + \delta} \qquad (7)$$

Furthermore, the firm will try to maximise its profit function, knowing its employment demand is a function of the wage. Thus, we obtain the firm's contribution to the Nash bargain by substituting the employment function (6) into the profit function (4). If an agreement is not reached, the fallback position for the firm is given by zero

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[4] An example of this kind of tax is the social security paid by firms.

profits. Following the Nash bargaining approach the firm and the labour union negotiate with respect to the wage so as to solve the optimisation problem

$$max_{w} \Omega = \beta \log\left[\left([w(1-t)+tc]-rD\right)\left(\frac{1}{r+q+\delta}\right)\right]+(1-\beta)\log\pi(w) \qquad (8)$$

so that $\pi_N=0$ and where $0\leq\beta<1$ denotes the relative bargaining power of union. The first-order condition for the wage determination can be written as[5] (see Appendix 2):

$$\Omega_{w} = \beta\frac{(1-t)}{[w(1-t)+tc]-rD}+(1-\beta)\frac{\alpha}{(1-\alpha)}\frac{(\rho(w,D)-1)}{w}=0 \qquad (9)$$

where $\rho \equiv \frac{\partial e*(w,.)}{\partial w}\frac{w}{e*(w,.)}$ is the elasticity of the effort supply with respect to the firm's gross wage.

3. Market Equilibrium

In this section we show the results of a market equilibrium in space (w,u). This market equilibrium is obtained to be able to carry out the analysis of fiscal reforms and their effect on the rate of unemployment and the level of output in the economy. To obtain a partial equilibrium agents take the external option D as given. But for the economy as a whole, this option depends on the choices of wages and employment levels of all firms (it then becoming an endogenous variable). A first step is therefore to calculate the equilibrium for this.

Following Altenburg and Straub (2002), when unemployed, a worker is assumed to receive real and untaxed unemployment benefits B, finding a new job with probability *a* per unit of time. Then:

$$rD = B + a(E - D) \qquad (14)$$

Denoting the unemployment rate by *u*, we find that in steady state $a=\delta(1-u)/u$ and combining this identity with equations (2) and (14) we obtain the aggregate value of rD[6]:

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[5] We suppose that the bargaining process takes place over the gross wage (in Altenburg and Straub (2002) it was over the net wage) in order to better appreciate the impact of tax reforms.

[6] A similar macroeconomic equation can be found in Shapiro and Stiglitz (1984) and in Pissarides (1998).

$$rD = \frac{(r + \delta + q)}{\left(r + q + \frac{\delta}{u}\right)} B + \frac{\left(\frac{\delta}{u} - \delta\right)}{\left(r + q + \frac{\delta}{u}\right)} [w(1-t) + tc] \qquad (15)$$

As we can see in expression (15), the external option rD depends on the amount of benefit B, the net wage and the rate of unemployment.

If we focus on the particular case where unemployment benefits are indexed to the net wage, that is, the replacement ratio $b = \dfrac{B}{[w(1-t)+tc]}$ is held fixed, Eq. (15) becomes:

$$rD = \left[1 - \frac{(r + \delta + q)}{\left(r + q + \frac{\delta}{u}\right)}(1-b)\right][w(1-t)+tc] \qquad (16)$$

Substituting Eq. (16) into the optimal expression for effort reflected in Eq. (3), we obtain the aggregate effort supply function for the case where b is held fixed:

$$e(w, u, b) \equiv \left[\left(\frac{\theta q}{r + q + \frac{\delta}{u}}\right)(1-b)[w(1-t)+tc]\right]^{\frac{1}{\theta}} \qquad (17)$$

defined for $0 < u \leq 1$ and $w \geq 0$, increasing in w and u, and decreasing in b; being strictly concave in w and with an elasticity with respect to the wage always less than one.

In this model the labour force size and the number of firms are fixed. Thus, it can be deduced that physical labour units can be normalised so that the aggregate labour force divided by the number of firms is one[7]. Given this, the relationship between effective labour input L and unemployment is:

$$L = (1-u)e \qquad (18)$$

By substituting Eq. (16) into Eq. (9), we obtain the following expression giving the relationship between w and u that has to be satisfied if there is an equilibrium wage setting:

$$\text{WS:} \qquad \frac{\beta}{(1-\beta)} \frac{(1-\alpha)}{\alpha} \frac{\left(r + q + \frac{\delta}{u}\right)}{(r + \delta + q)(1-b)} + \frac{1}{\theta} = \frac{[w(1-t)+tc]}{w(1-t)} \qquad (19)$$

Note that if there is no subsidy ($c=0$) and the income tax is then proportional, equation (19) does not depend on the gross wage w, drawing a vertical line in (w, u)

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[7] This normalisation does not mean that there are as many workers as firms, each firm being able to employ any number of workers (units of physical labour).

space. For this special case of the model, the unemployment rate remains constant, as shown in Altenburg and Straub (2002). (Proposition 2; page 733)

In the same way substituting expressions (17) and (18) into (5), we have an equation in (w, u) space consistent with equilibrium labour demand:

$$\text{LD:} \qquad \left(1 + t_f\right) w = \alpha \left[\frac{\theta q (1-b)}{\left(r + q + \delta/u\right)} \left[w(1-t) + tc\right] \right]^{\frac{\alpha}{\theta}} (1-u)^{\alpha-1} \qquad (20)$$

Finally, the model is solved by the interaction of equations (19) and (20) in (w, u) space (Graphic 1)[8].
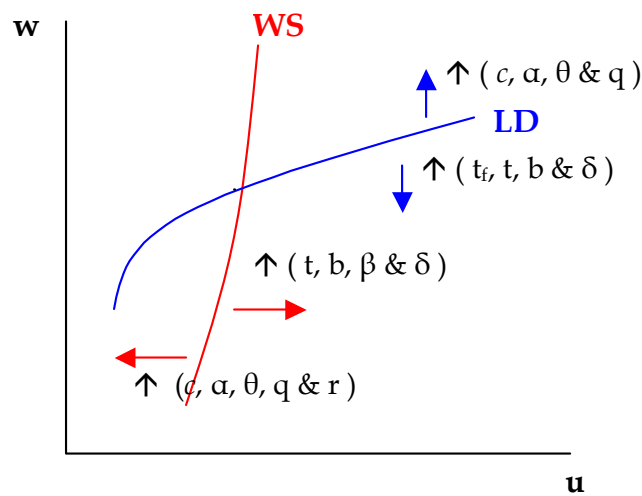
Graph 1

The analysis of both curves lets us appreciate that the LD curve is affected by variations in every fiscal parameter (t, t_f and c), remaining unaltered when the discount rate r or the union bargaining power β are modified. Alternatively, theWS curve is affected by variations in the rest of the parameters except t_f. In addition, its slope is considerably altered when parameters α and θ are changed (a reduction in any of them decreases the WS slope).

To be more precise, a rise in parameter t or a reduction in *c* has an effect on the wage pressure of the union, because employees demand higher wages, and the WS curve shifts to the left. Moreover, the labour demand curve LD also shifts upward due to

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[8] In this wage bargaining model where the elasticity of the labour demand is fixed, the equilibrium is unique as is shown in Altenburg and Straub (2002). In the present analysis we resolve the model in (w,u) space and Altenburg and Straub (2002) in (L,u) space.

the effect of the reforms on effort. The tax parameter t_f only affects the demand for labour by changing the labour cost, given the negotiated wage w. Thus, a rise in t_f shifts the LD curve downward.

4. Fiscal policy results

In this section we proceed to the analysis of fiscal policy decisions within the framework of the aggregate equilibrium. The objective of this analysis is to get tax reforms to reduce the unemployment rate of the economy.

The first step in this analysis is the elaboration of a base economy by giving values to the model parameters. The marginal income tax is specified as t=0.3, the value of the average of the OECD countries[9] in 2000-2001. For the marginal rate affecting firms, we use the average of the OECD countries for the period 1995-96, that is, t_f=0.15 (see Boscá et al. 1999). Also, we suppose a subsidy c=0.1, which allows us to obtain a reasonable ratio c/w for the base economy. Likewise, we fix the ratio b=0.6 as the average for the first year of unemployment in the OECD countries during the period 1995-96 (see Table 2 on page 106 of Martin, 1996).

Regarding the selection of the remaining parameters of the model, we fix the same values as those appearing in Altenburg and Straub (2002): a discount rate r=0.05; an elasticity of the effort expending disutility θ=8; a jobs destruction rate δ=0.1 and a shirker employees detection rate q=0.7[10]. Finally, we fix α=0.7 and β=0.3, allowing us to obtain an unemployment rate u=9.97%, close to the average for the OECD countries over recent years.

Through these parameter values, we use the system formed by equations (17), (18), (19) and (20) to obtain the following results for the key variables of the model corresponding to the base economy:

w	u	e	L
0.5983	0.0997	0.9329	0.8398

From the same equations system we will analyse tax reforms in two different stages. First, we will consider a fixed replacement ratio b= B / Net wage. And secondly,

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[9] Average for taxes levied on a typical worker, as the sum of income and social security tax rates (see OECD, 2002. Taxing wages: 2000-2001).

[10] If a period of unit length is assumed to be a year, the value of the separation rate δ implies that the expected duration of employment for a non-shirker is 10 years, while that of a shirker, $1/(\delta+q)$, is 15 months.

we will maintain the level of unemployment benefits B fixed in real terms at its level for the base economy (B=0.2693), allowing movements in *b*. For the latter purpose, we will aggregate the expression B=b[w(1-t)+ct] to the equation system.

4.1. Reforms in t and t_f

Table 2 shows first the results of individual variations in the marginal tax rate *t* (leaving t_f and *c* constant at their base economy values: t_f=0.15 and *c*=0.1) and then we carry out the same exercise for variations in t_f.

Leaving the replacement ratio fixed, if the income tax rate *t* is reduced, the WS curve shifts to the left because of the increase in the net wage received by workers for each negotiated gross wage. That means that a higher gross wage is necessary to obtain the same level of employment. Moreover, the LD curve shifts upward, since for a given gross wage workers are more productive due to the increase in the net wage (firms can set a higher minimum effort standard), causing the unit labour cost to fall and the number of job contracts to increase. The global effect on the wage and the effort is moderate, but unemployment grows.

Similarly, reductions in t_f shifts the LD curve upward because, at a given *w,* the cost of labour per efficiency unit is reduced, which makes it profitable for firms to pay a higher wage so as to raise the effort expended by workers. As the WS curve is not affected by changes in t_f, this result increases the negotiated wage and the effort. In our paper and for a constant *b*, the high level of θ=8 is key for the effect on unemployment to be small, since a lower value of θ would reduce the WS slope, and the effect on unemployment would, in both reforms, be higher.

The main result is that *it is possible to alter the level of unemployment by changes in the tax parameters (t and t_f) for a constant replacement rate (b), invalidating, for a progressive tax structure, Proposition 2 presented in Altenburg and Straub (2002).* If we take account of the fact that parameter c=0 (proportional taxation) then Proposition 2 holds. Therefore *it is crucial in this type of model, with a Cobb Douglas function, to consider a proportional or progressive taxation on labour income in order to be able to analyse the effect on unemployment*.

Table 2

Variations in t – Impact on the variables of the model.

Constant b						Constant B					
t	u	w	e	L		t	u	w	e	L	b
0.1	**0.110**	0.615	0.967	0.859		0.1	0.072	0.607	0.965	0.895	0.483
0.2	**0.105**	0.607	0.950	0.850		0.2	0.082	0.602	0.949	0.871	0.536
0.3	**0.099**	0.598	0.932	0.839		0.3	0.099	0.598	0.932	0.839	0.600
0.4	**0.092**	0.587	0.912	0.827		0.4	0.136	0.597	0.914	0.789	0.675
Variations in t_f – Impact on the variables of the model.											
t_f	u	w	e	L		t_f	u	w	e	L	b
0.05	**0.101**	0.661	0.944	0.849		0.05	0.082	0.657	0.943	0.865	0.549
0.15	**0.099**	0.598	0.932	0.839		0.15	0.099	0.598	0.932	0.839	0.600
0.25	**0.098**	0.545	0.922	0.831		0.25	0.124	0.551	0.923	0.808	0.647
0.35	**0.097**	0.501	0.912	0.823		0.35	0.161	0.513	0.915	0.767	0.691

By contrast, when unemployment benefit B is held constant, cutting t or t_f increases the net wages. In addition, given a value of unemployment benefits B, the replacement ratio b decrease leads to an additional indirect effect. This effect stimulates more workers to accept the negotiated wage and, therefore, unemployment decreases. These results are similar to those obtained in Altenburg and Straub (2002) for a constant B[11]. One implication of our findings is that when B is constant it is irrelevant to consider a proportional or progressive taxation on labour income for unemployment in a model with a Cobb Douglas function.

Reforms keeping the fiscal revenues constant

Next we present the results from a new simulation exercise for tax reforms, considering the additional restriction of constant fiscal revenues obtained by the state. The reforms we have seen before are difficult to apply because they reduce governments' revenues. To compensate for this reduction, governments must either increase other taxes, or reduce their spending, which is a difficult political task. Therefore, it is useful to examine how a restructuring of taxes that is revenue-neutral could increase employment. For this purpose we impose on the model the restriction:

$$T= [(t+t_f)\ w - t\ c](1-u) \qquad (21)$$

where T is the government fiscal revenues, derived entirely from the employee population (1-u).

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[11] The same results can be obtained under the following tax structure on employees T=(wt-c).

For this particular case, the simulation results (see Table 3) show that *it is possible to enhance employment by shifting the tax imposition towards lower firm taxation* in a shirking model with union bargaining.

Table 3

Reforms in t & t_f: Constant fiscal revenues.

t	u	w	e	L	t_f
0.1	0.109	0.491	0.939	0.836	0.412
0.2	0.104	0.538	0.936	0.838	0.284
0.3	0.099	0.598	0.932	0.839	0.150
0.4	0.095	0.678	0.929	0.840	0.009

This happens because, for this particular reform the increment in t shifts the WS curve to the left, due to the fact that workers need a higher gross wage to maintain their net wages after the increment in t (WS is not affected by variations in t_f). At the same time the LD curve shifts upward (because the effect of the reduction in t_f dominates the one caused by the increment in t, and the reduction in the unit labour cost makes it profitable for firms to negotiate a higher gross wage). The results when we consider constant unemployment benefits B, are similar (in u, L, e, t_f).

The most recent theoretical literature on these types of reforms shows rather different results for unemployment. On the one hand, Goerke (2002) shows in an efficiency wage model that a revenue-neutral tax reform which increases t and reduces t_f will raise unemployment. On the other, Koskela and Schob (1999) show that the same reform may decrease the unemployment rate and gross wage in a trade union bargaining model. We should like to point out that this issue regarding unemployment appears in our model although we take into account at the same time the efficiency wages approach.

Similarly, *when we take into account the following tax structure $T = tw - c$ on* labour income, *the effects of the same tax reform leaves (u, L, e and the net wage) unaltered and only changes the wage*. These issues are demonstrated in Picard and Toulemonde (2001).

4.2. Changes in subsidy *c*

As it is shown in Table 4, *increasing subsidy c (that is, making the income tax system more progressive) reduces the unemployment rate*[12]. The explanation is that, when c increases, employees get a higher net wage for a given bargained gross wage.

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[12] This result is commonly maintained both for efficiency wages and for union bargaining models (Koskela and Vilmunen (1996), Sorensen (1999), and Koskela (2001)).

This encourages more workers to accept each level of negotiated wage (the WS curve shifts to the left) and thus a lower gross wage is required to expend the same level of effort (the LD curve shifts upward). The global effect on the wage and the effort is very small, but employment increases considerably[13]. Thus, the effect on employment shifts completely to L. The same result is obtained for a constant replacement ratio and for a fixed unemployment benefit, although for the last case, the effects on the unemployment rate are greater through the reduction in the replacement rate (b).

Table 4

Variations in *c* – Impact on the variables of the model.

constant *b*						constant B				
C	*u*	*w*	*e*	L		*c*	*u*	*w*	*e*	L	*b*
0.05	0.106	0.600	0.933	0.834		0.05	0.115	0.602	0.934	0.826	0.616
0.10	0.099	0.598	0.932	0.839		0.10	0.099	0.598	0.932	0.839	0.600
0.15	0.093	0.596	0.932	0.844		0.15	0.087	0.595	0.931	0.850	0.583
0.20	0.088	0.595	0.931	0.849		0.20	0.077	0.593	0.930	0.858	0.566

Increasing progressivity produced by rises in *c* causes a reduction in fiscal revenues, so it is important to consider the restriction of constant fiscal revenues.

If we consider reforms *leaving government fiscal revenues constant*, there are two possibilities: compensating the rises in *c* by increasing *t* or t_f. As can be seen in Table 5, *it is better for employment to compensate the rise in parameter c through increments in t* both for a constant replacement ratio and for a constant unemployment benefit. Notice that in this case, the rise progressivity is somewhat bigger than when a boost in c is balanced with a rise in t_f. This result is consistent with recent papers on the effects of progressive taxation (Sorensen (1999), and Koskela and Vilmunen (1996)).

Another interesting result is that *it is possible to enhance employment leaving the economy production virtually unaltered by increasing parameter c when unemployment benefits are constant*[14]. This result is robust under different values of parameter *θ*.

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[13] The same result can be obtained under the following tax structure on employees: T=wt-c.
[14] The value of L changes after the fourth decimal.

Table 5

Variations in *c* leaving t or t$_f$ fluctuating – Constant government fiscal revenues

	Constant *b*					constant B					
C	*u*	*w*	*e*	L	*t*	*u*	*w*	*e*	L	*b*	*t*
0.05	0.107	0.602	0.938	0.837	0.273	0.106	0.602	0.938	0.839	0.596	0.272
0.10	0.099	0.598	0.932	0.839	0.300	0.099	0.598	0.932	0.839	0.600	0.300
0.15	0.090	0.593	0.925	0.841	0.333	0.092	0.593	0.925	0.839	0.604	0.334
0.20	0.079	0.586	0.915	0.842	0.377	0.083	0.587	0.915	0.839	0.611	0.379
C	*u*	*w*	*e*	L	*t$_f$*	*u*	*w*	*e*	L	*b*	*t$_f$*
0.05	0.107	0.623	0.938	0.837	0.111	0.105	0.623	0.938	0.839	0.596	0.110
0.10	0.099	0.598	0.932	0.839	0.150	0.099	0.598	0.932	0.839	0.600	0.150
0.15	0.092	0.573	0.927	0.841	0.192	0.094	0.573	0.927	0.839	0.603	0.193
0.20	0.086	0.547	0.921	0.842	0.239	0.088	0.547	0.921	0.839	0.607	0.241

5. Conclusions.

In this paper, we have studied the impact on unemployment of tax reforms in a labour market model that combines two common explanations for unemployment: union bargaining and efficiency wages. For this purpose, we have adapted the model presented in Altenburg and Straub (2002). Concretely, we have analysed the particular case of constant elasticity production and we have supposed neutral to risk workers (which have no influence on the results). Additionally, we have introduced a tax structure differentiating between taxes levied on employees and employers, we have assumed a progressive income tax, and that bargaining takes place on the gross wage.

The analysis consists of obtaining the aggregate equilibrium of a base economy. Next we proceed to the study of tax reforms considering two different stages. First, we have analysed individual reforms for each fiscal parameter, keeping the rest of them at their values for the base economy. Secondly, we have introduced the restriction of constant government fiscal revenues.

Three main conclusions can be derived from our analysis. First, it is important to take the progressive taxation on labour income into account when changes in tax structures are analysed in a shirking model with union bargaining. The results of simulations show that, when the replacement ratio is constant, it is possible to alter the level of unemployment through changes in the tax parameters (t or t$_f$). This result contrasts with those obtained by Altenburg and Straub (2002). In comparison, when unemployment benefit B is held constant, the results obtained in this work, with progressive taxation, are similar to those obtained in Altenburg and Straub (2002).

Secondly, when we consider constant fiscal revenues the effects on unemployment are the same as those in Koskela and Schob (1999), in the sense that it is possible to enhance employment by shifting the tax imposition towards lower firm taxation. However, we also take into account simultaneously the efficiency wages approach. Finally, increasing the subsidy to employees c (that is, making the income tax system more progressive) reduces the unemployment rate. Moreover, and for constant fiscal revenues, it is better for employment to compensate for the increase in parameter c through increases in t (instead of t_f) both for a constant replacement ratio and for a constant unemployment benefit due to the larger increase in the tax progressivity.

Appendix 1

From equations (1) and (2), and using the condition $E^{ns}=E^s=E$, we get the following equations system:

$$(r+\delta)E = [w(1-t)+c] - \frac{e^\theta}{\theta} + \delta D \qquad \text{(A.1)}$$

$$(r+\delta+q)E = [w(1-t)+c] + (\delta+q)D \qquad \text{(A.2)}$$

Dividing (A.1) by (A.2) we have:

$$(r+\delta+q)\frac{e^\theta}{\theta} = q([w(1-t)+c] - rD) \qquad \text{(A.3)}$$

And from Eq. (A.3) we obtain the optimal condition on effort:

$$e \le e^*(w,D) \equiv \left[([w(1-t)+c] - rD)\left(\frac{\theta q}{r+\delta+q}\right) \right]^{\frac{1}{\theta}} \qquad \text{(A.4)}$$

Appendix 2

Maximising with respect to the gross wage, the following function solves the Nash bargaining problem:

$$\text{Max } \Omega = \beta \log([w(1-t)+c] - rD) + (1-\beta)\log[(eN)^\alpha - (1+t_f)wN] \qquad \text{(A.5)}$$

Deriving with respect to w, we have:

$$\beta \frac{(1-t)}{w(1-t)+c-rD} + (1-\beta)\frac{\partial \pi / \partial w}{(eN)^\alpha - (1+t_f)wN} = 0 \qquad \text{(A.6)}$$

Alternatively, the wage maximising the profit of a firm is:

$$\frac{\partial \pi}{\partial w} = \alpha(eN)^{\alpha-1}\left[\frac{\partial e}{\partial N}N + \frac{\partial N}{\partial w}e\right] - (1+t_f)N - (1+t_f)w\frac{\partial N}{\partial w} \qquad \text{(A.7)}$$

and, using Eq. (5) of the text, (A.7) becomes:

$$(1+t_f)N\left[\frac{\partial e}{\partial w}\frac{w}{e} - 1\right] = (1+t_f)N[\rho - 1] \qquad \text{(A.8)}$$

with ρ being the elasticity of the effort supply with respect to the firm's gross wage.

Hence, the first order condition (A.6) can be rewritten as:

$$\beta \frac{(1-t)}{w(1-t)+c-rD} + (1-\beta)\frac{(1+t_f)N[\rho-1]}{(eN)^\alpha - (1+t_f)wN} = 0 \qquad \text{(A.9)}$$

which, substituting Eq. (5) into the denominator of the right hand of (A.9), is equivalent to expression (9):

$$\beta \frac{(1-t)}{w(1-t)+c-rD} + (1-\beta)\frac{\alpha[\rho-1]}{(1-\alpha)w} = 0 \qquad \text{(A.10)}$$

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