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Effort, Taxation and Unemployment*

Torben M. Andersen[†] Bo Sandemann Rasmussen[‡]

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Abstract

The importance of the design of the income tax system for the incentive to supply effort is considered for both a situation where rms (efficiency wage model) or unions (monopoly union model) have the power to determine wages. A tax reform raising marginal taxes at all income levels and increasing (decreasing) average taxes at high (low) income levels may lead to higher wages, lower employment and higher unemployment under either wage determination regime.

Keywords: Progressive taxation, wage formation, unemployment, effort, trade unions.

JEL: J41, J51, H22.

1. Introduction

In economic policy debates it is often questioned whether tax reforms can contribute to improve labour market exibility and thereby lower unemployment (see e.g. Sørensen (1997)). Recent theoretical research on the incidence of income taxation has shown that the effects of progressive taxes may depend critically on the structure of the labour market, e.g. whether agents are wage-setters or wage-takers. In particular, the distinction between changes in average and marginal

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taxes has been emphasized and an increase in tax progression has typically been modelled as an increase in marginal taxes holding average taxes constant. In a perfectly competitive labour market where no single agent possesses market power such an increase in tax progression tends to reduce labour supply, whereby wages rise and employment falls (see, e.g. Andersen and Rasmussen (1993) and Bovenberg and van der Ploeg (1994)). On the other hand, when agents possess market power the degree of tax progression influences incentives quite differently, since a higher degree of tax progression, through the higher marginal tax rates, reduces the benefits of raising the wage due to a smaller increase in disposable income per unit increase in the pre-tax wage, making wage moderation a much more likely outcome (see, e.g. Hersoug (1984), Hoel (1990), Koskela and Kilmunen (1995), Lockwood and Manning (1993) and Bovenberg and van der Ploeg (1994) for examples in a number of different models with wage-setting agents).

The policy implications seem to be straightforward: If the labour markets are imperfectly competitive, and the level of employment as a consequence is too low from a social point of view, a high degree of tax progression is desirable. This stands in strong contrast to the idea underlying recent proposals to reforms in Europe as it is widely perceived that a lowering of marginal tax rates and a broadening of the tax base would contribute to improving labour market flexibility and thus lowering unemployment.

The purpose of the present paper is to challenge the seemingly strong result on the beneficial effects of progressive taxes in labour markets with wage-setting agents. In particular it may be critical that these analyses essentially assume a static environment in which adjustments problems are disregarded. In such a setting penalties on wages increases in the form of higher marginal tax rates may work. In a dynamic setting, however, there may be detrimental effects as higher marginal tax rates also reduce the return associated with activities which improve productivity either directly through effort or training or indirectly via different forms of mobility. We explore this issue by specifically considering the problem of inducing workers to supply effort and we explore the interrelationship between incentives and taxation.[1]

In the basic version of the model firms choose wages and employment, and it is assumed that the firm can perfectly observe which effort norm a particular worker fulfils. Subsequently, the model is extended in two directions. First, it is assumed that firms can only monitor the achievement of effort norms imperfectly, and secondly we let wage-setting unions organize workers.

The different versions of the model are all used to analyze how an increase in income tax progression affects the labour market. It is important to be care-

[1] Sandmo (1994) considers the role of taxes for effort in a model where promotion is dependent on effort, but he does not analyze the role of tax progression.

ful about how a change in tax progression is modelled. In the recent literature referred to above it is assumed that average and marginal taxes can be changed independently of one another at all income levels. This approach is, however, a problematic way to capture realistic tax reforms. First of all, since income is a continuous variable and the average tax basically is the integral of marginal taxes it is only possible to change average and marginal taxes independently of one another at a finite (or at least countable) number of income levels. Secondly, assuming that the tax authorities are able to manipulate average and marginal taxes for a number of different income levels amounts essentially to assuming that lump sum taxation is feasible, and while lump sum taxes may be a useful theoretical device they are hardly worth mentioning when actual tax reforms are to be implemented. Finally, it is quite easy to introduce aspects in the model, like informational problems, such that controlling both average and marginal taxes for individual workers becomes virtually impossible, e.g. because taxes essentially become specific to each individual. Therefore, an implementable increase in tax progression entails an increase in marginal tax rates at all income levels implying an increase in average taxes at high income levels relative to average taxes at lower income levels.

The results reveal that the traditional finding in the recent literature of beneficial effects of income tax progression in imperfectly competitive labour markets is not robust. In particular, it is perfectly possible that increasing income tax progression may lead to higher wages, lower effort, lower employment and thus higher unemployment.

The paper proceeds as follows. In section 2 the basic model with wage-setting firms is presented. Section 3 considers the effects of a tax reform on the labour market while section 4 extends the analysis to incorporate imperfect monitoring of effort norms. Section 5 deals with tax reform when wages are set by unions instead of firms, and finally some concluding remarks are offered in section 6.

2. The Model

Consider a labour market where N workers may choose effort at two different levels, e_H or e_L, with $e_H > e_L$. The assumption of a limited number of possible effort levels is made to simplify the analysis but it may also be interpreted as reflecting a monitoring problem. In principle firms would like to pay workers according to productivity, but measuring individual productivity perfectly may be quite difficult (or costly). However, it may be much less demanding to observe whether a particular worker fulfils a specific effort norm specified (in a contract) by the firm. This aspect of costly monitoring is modelled through the existence of the two possible effort levels or effort norms.

The rm chooses wages (contingent on the effort provided) and employment and initially it is assumed that the rm can perfectly observe which effort norm a particular worker ful ls. (Subsequently, the model is extended in two directions. First, we assume that the rm can only monitor effort imperfectly, and secondly we assume that wage-setting unions organize the workers).

2.1. Households

All households are identical with preferences assumed to be linear in after-tax income, $\widehat{m}$, and effort, e,[2]

$$U = \widehat{m} - e, \tag{2.1}$$

where $\widehat{m} = m - T(m)$ is the post-tax income when pre-tax income is m, $T(m)$ being the income tax paid out of income m. Hence, we can de ne the tax rate (or the average tax) as $t(m) \equiv \frac{T(m)}{m}$, which in general will depend on the speci c income level, m, such that after-tax income can be written as $\widehat{m} = (1 - t(m))\, m$. The marginal tax rate, $T'(m)$, is the derivative of the tax function $T'(m) \equiv \frac{dT(m)}{dm}$.

Households are either employed as workers and earn a wage w_i, that is contingent on the effort level provided, $e_i \in \{e_L, e_H\}$, or they are unemployed and obtain unemployment bene ts b. The participation constraint reads

$$(1 - t(b))\, b \equiv \widehat{b} \leq (1 - t(w_i))\, w_i - e_i, \quad i = L, H. \tag{2.2}$$

The incentive compatibility constraints underlying the effort choice are

$$e = \begin{cases} e_H & for \quad (1 - t(w_L))\, w_L - e_L \leq (1 - t(w_H))\, w_H - e_H \\ e_L & otherwise. \end{cases} \tag{2.3}$$

Considering the wage level w_H needed to induce incentive to supply the high effort level e_H when the wage w_L can be obtained by supplying effort e_L, we have

$$w_H = w_L + \frac{e_H - e_L}{1 - t(w_H)} + \frac{t(w_H) - t(w_L)}{1 - t(w_H)} w_L. \tag{2.4}$$

Taxation is seen to have two effects. The rst is the tax-wedge (for $t(w_H) = t(w_L)$) implying that the gross wage premia must equal the effort difference $e_H - e_L$ times the tax-factor $(1 - t(w_H))^{-1} > 1$. Second we have that the wage premium is increased if the tax-system is progressive ($t(w_H) > t(w_L)$).

[2] The speci c separable and linear utility function is not critical to the results and at the cost of adding substantially to the complexity of the analysis it carries through with a general utility function $U(\widehat{m}, e)$ where $\frac{\partial U(\widehat{m},e)}{\partial \widehat{m}} > 0$ and $\frac{\partial^2 U(\widehat{m},e)}{\partial \widehat{m}^2} \leq 0$. If effort were a continuous variable, concavity of utility in income would be necessary to avoid corner solutions, cf. Pisauro (1991).

2.2. Firms

Consider a firm producing output y, with a price given from the output market (and normalized to one) using labour as the only (variable) input,

$$y = f\left(e_i L_i\right), \quad f'(e_i L_i) > 0, \quad f''\left(e_i L_i\right) < 0, \tag{2.5}$$

where L_i is the number of employed workers when all employed workers supply the same level of effort, e_i. The representative firm chooses wages (w_L and $w_H > w_L$) and employment to maximize profits, $\Pi_i = f\left(e_i L_i\right) - w_i L_i$, subject to the participation constraint and the incentive compatibility constraints. For a given wage, employment is determined by the usual marginal productivity condition,

$$e_i f'\left(e_i L_i\right) = w_i, \tag{2.6}$$

which defines employment as an implicit function of w_i and e_i, $L_i = L\left(w_i, e_i\right)$. Substituting this employment function back into the expression for profits yields the profit function with w_i and L_i as arguments,

$$\Pi\left(w_i, e_i\right) = \max_{L_i} \left\{ f\left(e_i L_i\right) - w_i L_i \right\} = f\left(e_i L(w_i, e_i)\right) - w_i L\left(w_i, e_i\right), \tag{2.7}$$

and since profits must be decreasing in the wage (for a given level of effort) and increasing in effort (for a given wage), it follows that

$$\Pi\left(w_L, e\right) > \Pi\left(w_H, e\right) \quad \forall\, e \tag{2.8}$$

$$\Pi\left(w, e_L\right) < \Pi\left(w, e_H\right) \quad \forall\, w. \tag{2.9}$$

Let $\underline{w}_L$ denote the minimum wage needed to induce effort e_L:

$$\underline{w}_L = \left(1 - t(\underline{w}_L)\right)^{-1} \left(\widehat{b} + e_L\right) \tag{2.10}$$

while $\underline{w}_H$ is the minimum wage needed to induce the high effort level, e_H :

$$\underline{w}_H = \max\left\{ \left(1 - t(\underline{w}_H)\right)^{-1} \left(\left(1 - t(w_L)\right) w_L + e_H - e_L\right), \left(1 - t(\underline{w}_H)\right)^{-1} \left(\widehat{b} + e_H\right) \right\}, \tag{2.11}$$

from which follows that if $\underline{w}_L$ is actually offered by the firm, $\underline{w}_H$ is equal to

$$\underline{w}_H = \left(1 - t(\underline{w}_H)\right)^{-1} \left(\widehat{b} + e_H\right). \tag{2.12}$$

The analysis is con ned to the case where unemployment prevails at both wage levels, i.e.

$$L\left(\underline{w}_H, e_H\right) < N, \quad L\left(\underline{w}_L, e_L\right) < N. \tag{2.13}$$

Next, we de ne the critical wage, $\overline{w}$, as the maximum wage the rm will be willing to pay to induce the high effort level e_H:

$$\Pi\left(\overline{w}, e_H\right) = \Pi\left(\underline{w}_L, e_L\right). \tag{2.14}$$

The optimal wage policy of the rm will be

$$(w_L, w_H) = \begin{cases} (\underline{w}_L, \underline{w}_H) \quad if \quad \underline{w}_H \leq \overline{w} & : \quad e = e_{H,} \quad w = w_H \\ (\underline{w}_L, \overline{w}) \quad if \quad \overline{w} \leq \underline{w}_H & : \quad e = e_L, \quad w = w_L. \end{cases} \tag{2.15}$$

Thus, depending on the relative size of the exogenous parameters the outcome will either be one of low effort or high effort. In the present context it is particularly noteworthy that the degree of tax progression may affect which situation prevails. For a given $t(w_L)$ and $\widehat{b}$ an increase in $t(w_H)$ will make it more likely that the low effort outcome prevails in the sense that $\underline{w}_H$ increases. Similarly, if $t(w_L)$ is decreased for constant $t(w_H)$ and $\widehat{b}$, the low effort outcome is more likely to prevail since $\overline{w}$ falls through a fall in $t(w_L)$.

3. Tax Reform

Since it is well known that the incidence of average and marginal taxes may differ substantially in imperfectly competitive labour markets it has become standard to treat tax reforms as changes in either average or marginal taxes. Malcomson and Sartor (1987) worked with the general tax function $T(w, z)$ where z represents parameters of the tax system. This formulation of the tax system allows average and marginal taxes to be changed independently of one another. The average tax rate is $T(w, z)/w$ such that a tax reform that keeps the average tax rate constant at some wage level w corresponds to $T_2(w, z) \equiv \frac{\partial T(w,z)}{\partial z} = 0$. The marginal tax rate is $T_1 \equiv \frac{\partial T(w,z)}{\partial w}$ such that a tax reform that holds the marginal tax rate constant at some wage level w requires that $T_{12} \equiv \frac{\partial T_1(w,z)}{\partial z} = 0$. Thus, simply by assuming that the set of tax parameters is sufficiently rich any combination of changes in average and marginal tax rates at any wage levels can be considered. Even though this way of modelling tax reforms has some analytic advantages (e.g. by making it possible to separate changes in average and marginal taxes from one another) it may be misleading when it comes to implementation of tax reforms in actual economies.

As a commonly used example, consider an increase in tax progression created by an increase in marginal tax rates keeping average taxes constant. Since the average tax basically is the integral of marginal taxes when the tax function is continuous such a tax reform must make the tax function discontinuous. If the average tax rate is to be kept constant at a single wage level only (or at any countable number of wage levels) this is perfectly possible, but if this should hold at *all* wage levels (the wage being a continuous variable) such a tax reform is simply not possible. This problem does not come to the surface in analyses assuming a homogeneous labour market implying that only one wage level prevails in equilibrium as is the case both in the standard efficiency wage model and the wage bargaining model.

Therefore, even if it is theoretically possible to increase tax progression by increasing marginal tax rates while holding average taxes constant, we dismiss such tax reforms being of little practical relevance and assume instead that average and marginal taxes change simultaneously when an increase in tax progression is implemented.

To be speci c, we consider tax reforms that make taxes more progressive[3] by increasing marginal taxes at all income levels while increasing average taxes at high income levels and decreasing average taxes at low income levels, such that the average tax rate in some sense may be kept constant. Throughout the exercise it is assumed that the after-tax value of unemployment bene ts is kept constant (which could be accomplished by changing pre-tax bene ts if the tax rate on bene ts is affected by the tax reform).

To evaluate the effects on wages, effort and employment we need to consider how the various critical wage levels are affected by the tax reform. Such a change in taxes leads to a fall in $\underline{w}_L$ while $\underline{w}_H$ rises and, as a consequence of the fall in $\underline{w}_L$, $\overline{w}$ falls (see equations 2.10, 2.11 and 2.14). This implies that the increased tax progression can lead to three qualitatively different outcomes, depending on the initial situation in the rm.

Case 1: $dw > 0$, $dL < 0$, $de = 0$.

This is the outcome when $\underline{w}_H < \overline{w}$ both before and after the tax reform, i.e. when the high effort situation prevails both before and after the change in taxes. In this case the tax increase for the high wage level forces the rm to raise wages to prevent workers from reducing effort to the low level (which, by assumption, would result in lower pro ts). Notice, that this is the opposite of the usual effects of higher tax progression in models with wage-setting agents.

[3] Christiansen (1988) considers some of the same aspects of increasing tax progressivity, especially by analyzing how a change in taxation affects economic efficiency through the effect on workers choice of occupation. In his model, however, labour markets are perfectly competitive leaving no role for wage-setting agents and equilibrium unemployment.

Case 2: $dw < 0$, $dL > 0$, $de = 0$.

If the initial situation is characterized by $\underline{w}_H > \overline{w}$, such that the low effort outcome prevails, we get the usual tax incidence in non-competitive models of the labour market. Intuitively, the lower tax rate at the low wage level allows the rm to reduce wage offers at the low effort level.

Case 3: $dw < 0$, dL ambiguous, $de < 0$.

This happens when $\underline{w}_H \leq \overline{w}$ before the tax reform while $\underline{w}_H > \overline{w}$ after the tax reform such that there is a shift from high effort to low effort. As a consequence wages drop substantially, but since effort also falls employment may go either up or down.

The preceding analysis considered the effect in a single rm and this would only yield insight on the aggregate effects if all rms are identical. Clearly, this is an extreme situation, and it is therefore of interest to consider the more general case with heterogeneity among rms or sectors. This can easily be introduced by assuming that the critical wage level is rm or sector speci c. This simply re ects that the effort problem is different for different rms or sector. Speci cally, assume that we have J rms (sectors) indexed by $j = 1, 2, ..., J$ where $\overline{w}_j$ is the maximum wage rm j would be willing to pay to induced workers to supply the high effort level. Since the incentive problem in inducing effort is similar for all rms, it follows that rms for which[4]

$$\overline{w}_j \geq \underline{w}_H, \tag{3.1}$$

will offer the wage $\underline{w}_H$ and its workers will supply the high effort level (e_H), whereas for rms where

$$\overline{w}_j < \underline{w}_H, \tag{3.2}$$

the wage $\underline{w}_L$ will be offered and workers will supply low effort (e_L).

Consider now the effects of a tax reform.[5] Total employment is

$$L = L_L + L_H, \tag{3.3}$$

where L_L (L_H) is employment in rms offering the wage $\underline{w}_L$ $(\underline{w}_H)$. The effect for those rms offering the high wage will be to increase the wage to maintain incen-

[4] Notice that rms with a high willingness to pay (a high $\overline{w}_j$) earn a rent. In section 5 the rent accrues to the workers.

[5] In principle, what we would like to consider is a revenue-neutral (or balanced-budget) tax reform. Due to the discontinuities in the model we cannot, however, use standard calculus to derive exact expressions for the various tax changes in a revenue-neutral tax reform. However, since the proposed tax reform implies higher average taxes at high income levels and lower average taxes at low income levels, it should in principle pose no problem to design a revenue-neutral tax reform.

tives for workers to supply the high effort and employment (L_H) will be lowered (case 1 above). For the low wage rms, the wage will be lowered and the employment (L_L) increased (case 2 above). For marginal rms, i.e. rms initially having $\overline{w}_j = \underline{w}_H + \epsilon$, ϵ being a small positive number, the tax reform will transform them from high wage rms to low wage rms, having an ambiguous effect on employment (case 3 above). The net effect of the tax reform on unemployment is thus in general ambiguous as employment goes down in high wage rms, goes up in low wage rms while the employment effect is ambiguous in the marginal rms . However, there will be fewer high wage jobs and more low wage jobs so the composition of employment is critically affected. Moreover, there will be more dispersion in gross wages but less dispersion in after tax wages.

4. Imperfect Monitoring of Effort Norms

So far the rm has been able to monitor perfectly whether individual workers ful l the effort norms speci ed in the contract offered by the rm. Imperfect monitoring of effort will imply that the rm must specify how shirkers are punished. In our model where there are only two possible effort levels, only shirking from the high effort level is potentially desirable for workers. We assume that workers who have signed a contract (w_H, e_H) and are caught providing the low effort level, e_L, are paid according to their observed effort, i.e. they are paid w_L.

Let $1-q$ denote the (exogenous)[6] probability that workers are monitored and if they do not ful l the required effort norm they are paid the low wage, w_L. A worker will choose not to shirk if the expected utility from doing so is less than the utility when providing the high effort level:

$$(1-t(w_H))\,w_H - e_H \geq q\,(1-t(w_H))\,w_H + (1-q)\,(1-t(w_L))\,w_L - e_L. \quad (4.1)$$

If we let w_H^{NSC} denote the minimum wage that ful ls the non-shirking condition it follows straightforwardly that

$$\left(1-t(w_H^{NSC})\right)w_H^{NSC} = (1-t(w_L))\,w_L + \frac{e_H - e_L}{1-q}, \quad (4.2)$$

from which follows that $w_H^{NSC} \geq \underline{w}_H$, implying that the existence of imperfect monitoring requires the rm to pay higher wages to induce the high effort level than with perfect monitoring. Hence, the optimal wage policy of the rm can be expressed as

[6] In the appendix q is made endogenous by introducing a cost of monitoring to rms. Given ful llment of some regularity requirements the qualitative results of the tax reform are unchanged.

$$(w_L, w_H) = \begin{cases} \left(\underline{w}_L, w_H^{NSC}\right) \quad if \quad w_H^{NSC} \leq \overline{w} & : \quad e = e_H, \quad w = w_H \\ \left(\underline{w}_L, \underline{w}_L\right) \quad if \quad \overline{w} < w_H^{NSC} & : \quad e = e_L, \quad w = w_L. \end{cases} \tag{4.3}$$

Notice that when it is not pro table for the rm to induce the high effort level (i.e. when $w_H^{NSC} > \overline{w}$) the rm should never pay a wage higher than $\underline{w}_L$ since a higher wage would induce all workers to sign up for the high effort contract and subsequently shirk. Since an increase in the tax rate qualitatively has the same effects on w_H^{NSC} as on $\underline{w}_H$, a tax reform that raises the tax rate at w_H^{NSC} and lowers the tax rate at $\underline{w}_L$ has the same qualitative effects as with perfect monitoring.

5. Wage-Setting by Unions

Another variation of the basic model is to delegate wage-setting to trade unions instead of the rm. (For simplicity, we assume that monitoring of effort norms is perfect as in section 2. We only consider the effects for the representative rm, leaving the analysis of the aggregate effects as an exercise for the reader). Let unions be utilitarian such that union preferences can be described as

$$V = L\left(\left(1 - t(w_i)\right) w_i - e_i - \widehat{b}\right). \tag{5.1}$$

Unions maximize this utility function with respect to w_i subject to the labour demand function, $L = L\left(w_i, e_i\right)$ and the participation and incentive compatibility constraints, equations 2.2 and 2.3. If we for simplicity assume that the labour demand function has a constant elasticity, η ,

$$\eta \equiv -\frac{\partial L\left(w, e\right)}{\partial w}\frac{w}{L} > 0, \tag{5.2}$$

we can state the optimal wage policy of the union for a given e

$$w_i^* \left(1 - t(w_i^*)\right) = \frac{\eta}{\eta - s\left(w_i^*\right)}\left(e_i + \widehat{b}\right), \tag{5.3}$$

where

$$s\left(w_i\right) \equiv \frac{1 - T'\left(w_i\right)}{1 - t\left(w_i\right)}, \tag{5.4}$$

is the coefficient of residual income progression (see Musgrave and Musgrave (1973)). De ning $\phi_i \equiv \frac{\eta}{\eta - s(w_i)}$ we can rewrite the optimal wage as

$$w_i^* \left(1 - t(w_i^*)\right) = \phi_i^* \left(e_i + \widehat{b}\right). \tag{5.5}$$

Notice, that for a non-regressive tax schedule, i.e. for $s(w_i) \leq 1$ we have $\phi_i^* > 1$. The incentive constraint for the individual worker to choose the high effort level is

$$(1 - t(w_L))\, w_L - e_L \leq (1 - t(w_H))\, w_H - e_H, \tag{5.6}$$

which is ful lled when wages are set according to 5.5 as long as $\phi_H^* \geq \phi_L^*$ (a suf- cient condition corresponding to $s(w_H^*) \leq s(w_L^*)$). Thus, the individual worker will always prefer the high effort equilibrium.

The union must, however, take into account that employment may be lower at the high wage, w_H^* , than at the low wage, w_L^*. Since employment is falling in the wage for a given effort level, we can calculate a critical wage $\widetilde{w}$ being the maximum w_H the union will prefer to w_L^* . Formally, if we by $V(w_i, e_i)$ denote the union utility function, $\widetilde{w}$ is de ned implicitly as $V(\widetilde{w}, e_H) = V(w_L^*, e_L)$ or

$$\widetilde{w} \quad : \quad L(\widetilde{w}, e_H) = L(w_L^*, e_L) \frac{(\phi_L^* - 1)\left(e_L + \widehat{b}\right)}{\left(\widetilde{\phi} - 1\right)\left(e_H + \widehat{b}\right)} \tag{5.7}$$

Thus, for $w_H^* \leq \widetilde{w}$ the union should set wages $(w_L,\ w_H)$ such that individual workers choose $e = e_H$. For $w_H^* > \widetilde{w}$ the union should set wages $(w_L,\ w_H)$ such that individual workers choose $e = e_L$. The optimal wage policy is then (for $\varepsilon > 0$)

$$(w_L, w_H) = \begin{cases} (w_L^*, w_H^*) \quad if \quad w_H^* \leq \widetilde{w} \quad : \quad e = e_{H,} \quad w = w_H \\ (w_L^*, \underline{w}_H - \varepsilon) \quad if \quad \widetilde{w} < w_H^* \quad : \quad e = e_L, \quad w = w_L. \end{cases} \tag{5.8}$$

(The wage $w_H = \underline{w}_H - \varepsilon$ is required for the individual workers not to choose $e = e_H$ when the low effort equilibrium is optimal for the union).

The tax reform implies, as before, that the tax rate at w_H is increased, $dt(w_H) > 0$, and that the tax rate at w_L is decreased, $dt(w_L) < 0$. Moreover, the degree of progression is either constant or increased at any income level, such that $s(w_i)$ is either constant or lowered for all w_i. Totally differentiating the wage-setting rule, equation 5.5, reveals that

$$dw_i^* = \frac{w_i^*}{1 - t(w_i^*)} \left\{ \frac{1 - t(w_i^*)}{\eta - s(w_i^*)} ds(w_i^*) + dt(w_i^*) \right\}, \quad i = L, H. \tag{5.9}$$

Inspection of 5.9 reveals that $dw_L^* < 0$ while the sign of dw_H^* is ambiguous. Furthermore, if we assume that the degree of tax progression is increased by the same relative amount at all income levels it can be shown that $\widetilde{w}$ decreases along with w_L^*. Again we can distinguish between three qualitatively different cases.

Case 1: $dw > 0$, $dL < 0$, $de = 0$.

This requires rst of all that the high effort equilibrium prevails both before and after the tax change, i.e. $w_H^* < \widetilde{w}$. Furthermore, the increase in the degree of tax progression must not be too large compared to the change in the tax rate at the high wage, w_H^*. More precisely,

$$dw_H^* > 0 \quad for \quad \left| \frac{ds\left(w_H^*\right)}{\eta - s\left(w_H^*\right)} \right| < \frac{dt\left(w_H^*\right)}{1 - t\left(w_H^*\right)}. \tag{5.10}$$

Thus, if the degree of tax progression is kept constant by changing average and marginal taxes by the same relative amounts this condition is automatically satis ed. Otherwise, when the degree of progression is changed a wage increase and a fall in employment is *less* likely when unions set wages than when the rm sets wages, the reason being that unions take into account that a higher marginal tax rate makes the bene ts of a higher pre-tax wage smaller such that the wage pushing effects from the higher average tax rate are moderated. When the rm sets wages it only cares about creating the right incentives for the workers to choose the high effort level, implying that the change in marginal taxes does not affect wage formation. With union wage-setting the results become a mix of the incentive effects with respect to the effort decision and the traditional trade union effect of a higher marginal tax rate.

Case 2: $dw < 0$, $dL > 0$, $de = 0$.

Both equilibria may now lead to this outcome. If the initial equilibrium is a low effort equilibrium, i.e. if $w_H^* > \widetilde{w}$ the wage will always fall and employment will rise. Moreover, if the high effort equilibrium initially prevails and the tax progression effect dominates the tax rate effect, i.e. if

$$\left| \frac{ds\left(w_H^*\right)}{\eta - s\left(w_H^*\right)} \right| > \frac{dt\left(w_H^*\right)}{1 - t\left(w_H^*\right)}, \tag{5.11}$$

we also get lower wages and higher employment.

Case 3: $dw < 0$, dL ambiguous, $de < 0$.

This corresponds to case 3 in section 3, i.e. when the equilibrium jumps from a high effort equilibrium to a low effort equilibrium. As a consequence wages drop substantially, but since effort also falls employment may go either up or down and the direction of the change in unemployment is also undetermined.

6. Concluding Remarks

The role of the design of the income tax system has been considered in the case where wages serve to provide incentives for agents to supply effort. Wages, effort and employment depend in general on characteristics of the tax-system. In particular, it is worth pointing out that in the speci c context analyzed here both the possibility of the high effort state to prevail in employment as well as the employment of high effort workers depend negatively on the progression of the income tax-system. This holds irrespective of whether wages are determined by rms or unions.

In a second best context changes in the design of the tax-system may contribute to a lowering of structural unemployment. The present analysis shows that the result obtained in homogeneous labour market models that tax progression is good for employment is not robust. There is a need for further analysis of the incentive effects of tax progression in imperfectly competitive labour markets, as well as more empirical analysis, before rm policy conclusions can be drawn.

A. Endogenous Monitoring

Let $c = c(1-q)$ be the cost of monitoring when monitoring efforts of the rm lead to a probability of detection of $1-q$. Of course, $c(0) = 0$, $c'(1-q) \equiv \frac{dc(1-q)}{d(1-q)} > 0$, while $c''(1-q) \equiv \frac{d^2c(1-q)}{d(1-q)^2} \gtrless 0$ may generally be assumed (we return to this below). Notice that a low wage rm will always choose $q = 1$, since none of its workers will ever shirk. The pro ts of a high wage rm are $\widetilde{\Pi} = \Pi(w_H, e_H) - c(1-q)$ where w_H is given by

$$w_H = (1 - t(w_H))^{-1} \left[\widehat{b} + e_L + \frac{e_H - e_L}{1-q}\right], \tag{A.1}$$

and $\Pi(w_H, e_H)$ is given by

$$\Pi(w_H, e_H) = f(e_H L(w_H, e_H)) - w_H L(w_H, e_H). \tag{A.2}$$

The rst-order condition for $1-q$ reads

$$\frac{\partial \widetilde{\Pi}}{\partial (1-q)} = \frac{\partial \Pi(w_H, e_H)}{\partial w_H} \frac{\partial w_H}{\partial (1-q)} - c'(1-q) = 0, \tag{A.3}$$

such that, using A.1 and A.2 we get

$$\frac{L(w_H, e_H)(e_H - e_L)}{(1 - t(w_H))(1-q)^2} - c'(1-q) = 0. \tag{A.4}$$

The second-order condition for pro t maximization reads

$$\frac{\partial^2 \widetilde{\Pi}}{\partial (1-q)^2} = -\frac{(e_H - e_L)\left[\frac{\partial L(w_H, e_H)}{\partial w_H} \frac{(e_H - e_L)}{(1-t(w_H))(1-q)} + 2L(w_H, e_H)\right]}{(1 - t(w_H))(1-q)^3} - c''(1-q) < 0, \tag{A.5}$$

and since the sum of the two terms inside the brackets may be either positive or negative, convexity of the cost function $c(1-q)$ is neither necessary nor sufficient for an interior solution to be a pro t maximum. In the following we assume that the second-order condition is satis ed. We now have two equations, A.1 and A.4 to determine the endogenous variables w_H and $1-q$ both of which will be functions of the tax rate, $t(w_H)$. We can nd the effect on w_H of a change in $t(w_H)$ by implicitly differentiating A.1 and A.4 and solving for $\frac{\partial w_H}{\partial t(w_H)}$. Solving that tedious but straightforward exercise reveals that

$$\frac{\partial w_H}{\partial t(w_H)}=\frac{\frac{(e_H-e_L)L(w_H,e_H)}{(1-t(w_H))(1-q)^3}\left[w_H+\frac{\hat{b}+e_L}{(1-t(w_H))}\right]+w_H\left(1-t(w_H)\right)c''(1-q)}{\frac{(e_H-e_L)}{(1-t(w_H))(1-q)^3}\left[\frac{\partial L(w_H,e_H)}{\partial w_H}\frac{(e_H-e_L)}{(1-t(w_H))(1-q)}+2L(w_H,e_H)\right]+c''(1-q)}, \tag{A.6}$$

where the denominator is positive, given the ful llment of the second-order condition. The numerator is also positive if, as a sufficient condition, the cost function is convex, $c''(1-q)\geq 0$. (Since convexity is a sufficient, but not a necessary condition for $\frac{\partial w_H}{\partial t(w_H)}>0$, non-convexities of the monitoring technology could be present without changing the sign of the effect on wages). Thus, we have established that the wage effect, and hence the effect on unemployment, of the tax reform is qualitatively the same as in the model with an exogenous detection rate.

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