CeGE-Discussion Paper

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GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

June 2004

ISSN 1439-2305

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June 2004

Abstract

This paper explores how revenue-neutral tax reforms impact employment and economic growth in a model of endogenous growth and search frictions on the labor market. We analyze how savings and the incentive to create new jobs are affected by tax swaps between wage income taxes, payroll taxes, capital income taxes and taxes levied on capital costs. In our framework, the payroll tax is found to be neutral. If this tax is used to finance a cut in the capital income tax, we will observe an increase in both growth and, via the capitalization effect, employment. Most other tax reforms, however, imply a trade-off between employment and growth.

JEL Classification: E6; H2; J6; O4

Keywords: search unemployment, growth, tax reform

*Revised version of a paper presented at the CeGE Research Workshop on May 27, 2004. We gratefully acknowledge helpful comments from Michael Bräuninger, Jörg Lingens, and Michael Pflüger, and from participants at research seminars in Hannover, Kassel, Mannheim and Regensburg.

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1 Introduction

The exploration of the employment effects of tax swaps has become an important issue in the academic and policy debate at least since the emergence of the European unemployment problem. The idea that one might be able to reduce equilibrium unemployment by shifting between different types of taxes is high on the research agenda (see, e.g., Sorensen 1997; Pissarides 1998). However, an almost neglected issue in this context is the impact of these reforms on economic growth. If there is a trade-off between employment and growth as put forward, for instance, by Aghion and Howitt (1992), and Eriksson (1997), an employment boosting tax reform will have a negative impact on economic growth. Taking the growth issue into account may lead to different policy conclusions concerning the recommendation or dismission of a specific tax reform. The contribution of this paper is to analyze the employment and growth effects of revenue-neutral tax reforms in a search equilibrium model à la Pissarides (2000) which we extent by introducing capital accumulation and economic growth. We integrate four taxes into the model, namely a wage income tax, a capital income tax, a payroll tax, and a tax on capital input.

Our analytical framework merges three strands of literature. First is the literature on employment-enhancing tax reforms. Starting with the contributions of Hersoug (1984) and Lockwood and Manning (1993), it has been established that an increasing degree of income-tax progression may be good for employment (e.g. Koskela and Vilmunen 1996). From the point of view of trade unions the trade-off between wage increases and employment becomes less attractive inducing a wage moderation. As our focus is on the interaction between employment and growth effects, we will confine the analysis to proportional-tax systems. Pissarides (1998) argues that the modelling of the labor market imperfections is of minor importance for the sign and size of the employment effect of a tax cut. Consequently, it is of second-order importance whether one assumes a union wage bargaining model, an efficiency wage model or a search equilibrium model (see also Boeters 2000). But since we have to take a stand, we assume a framework in the spirit of Pissarides (2000), where unemployment is the result of search frictions in the labor market.

The second strand of research is on the growth effects of tax policies. In the Solow model, in which (exogenous) labor-augmenting technical progress is the main determinant of the growth rate, tax policies have an impact only on the long-run per-capita income level (see, for instance, Carlberg 1988) but not on the long-run growth rate itself. To derive the possibility that the government influences the long-run growth rate, more recent models of endogenous growth are needed. Using an AK-based growth model Turnovsky (2000) discusses the role of income and consumption taxes in enhancing economic growth. Kim (1998) develops an endogenous growth model which allows for the assessment of the extent to which differences in the tax systems account for the difference in the actual growth rates across countries. He finds that about 30% of the difference of growth rates between the United States and a set of East Asian countries can be explained by differences in the tax systems. Bovenberg and de Mooij (1997) discuss how an environmental tax reform impacts economic growth, but they abstract from labor as an input factor. In a model with growth through R&D, Arnold (1999) discusses some reasons why we should not expect any simple and clear-cut (tax) policy recommendations as effective means of accelerating growth. Our framework follows Romer (1986) and introduces endogenous growth by assuming positive learning and knowledge spillover working through the economy's capital stock per worker.

The third strand of research we refer to is on the interaction between employment and growth. If growth comes through creative destruction (Aghion and Howitt 1992), the flow of workers into the pool of unemployed and thus the equilibrium unemployment rate is a positive function of the growth rate of the economy. A higher equilibrium growth rate, on the other hand, induces higher future revenues and thus rising vacancies that lead to more employment. For this reason current job creation and equilibrium employment is increasing in the growth rate (so-called capitalization effect, see Bean and Pissarides 1993). Overall, the relationship between employment and growth is difficult to sign (Aghion and Howitt 1994).

While the models just discussed have their focus on analyzing either taxes and equilibrium unemployment or taxes and growth, our model analyzes the issues of equilibrium unemployment, economic growth and different tax systems in a unified framework. The only work, at least to our knowledge, which uses a similar set up is Eriksson (1997), Daveri and Tabellini (2000), and Lingens (2004). Eriksson (1997) presents an endogenous growth model of the AK-type in which unemployment is caused by search frictions. He finds that an increase in the capital income tax reduces the incentive to save, which, in turn, reduces the equilibrium growth rate. Due to the capitalization effect labor market conditions worsen. Daveri and Tabellini (2000) develop an overlapping generations endogenous growth model where wages are set by monopolistic trade unions. They show that a higher labor income tax is met by a higher bargained wage forcing firms to cut employment. This in turn lowers the income of the young and thus savings and growth. A higher capital tax is claimed to be less costly in terms of growth than a higher labor tax. For a critical assessment of this model see Nickell and Layard (1999). In a model with expanding product varieties Lingens (2004) analyzes the employment and growth effects of a swap between payroll and income taxes. Unfortunately, even the sign of the effects is ambiguous and parameter dependent.

The model we set up in the next section frames a closed economy comprised of infinitely-lived consumers and firms producing a homogeneous good with the help of capital and labor. Growth is made possible by positive externalities of the economy's capital stock. Our model can be reduced to two equilibrium conditions, the efficient factor allocation function showing equilibrium in the factor markets for labor and capital, and the capital accumulation function depicting the equilibrium growth path. The intersection of these curves determines the steady state values of labor market tightness (employment) and the equilibrium growth rate. We will show that (i) a cut in the capital income tax financed by an increase in the payroll tax will increase both equilibrium employment and the growth rate, that (ii) a cut in the capital input tax combined with a higher payroll tax boosts growth but has an ambiguous effect on employment, that (iii) a higher payroll tax combined with a cut in the wage tax is neutral for growth and good for employment, and that (iv) a switch from capital income to capital input taxes is good in terms of both growth and employment.

The rest of paper is organized as follows. Section 2 and 3 present the model and the analysis of the steady state solution, respectively. The tax reform analysis is performed in Section 4, Section 5 concludes.

2 The Model

2.1 Flows in the Labor Market

The labor market is characterized by search frictions with firms seeking for new workers and unemployed workers seeking for a job. Matching jobs and workers is a time-consuming and costly activity. The results of this process are described by a constant-returns-to-scale matching function[1]:

$$M = V^{1-\beta} U^{\beta}, \quad 0 < \beta < 1 \tag{1}$$

where M, V and U denote the number of matches per unit of time, the number of vacancies, and the number of unemployed workers, respectively. Let $\theta := V/U$ serve as a measure of the tightness of the labor market. Then, the probability of a vacant job becoming filled is $q(\theta) := M/V = \theta^{-\beta}$ and the probability of an unemployed worker finding a job is $M/U = \theta q(\theta) = \theta^{1-\beta}$.

The change in aggregate employment is determined by the difference between the inflows into and the outflows out of unemployment. The outflows are given by the newly formed job-matches M. The inflows, on the other hand, are given by νE, where ν is the exogenous separation rate, and E is the number of employed workers. We neglect population growth, so that there are no inflows from a growing labor force. Equilibrium in the labor market requires that the flows into and out of unemployment equal each

[1] See Petrongolo and Pissarides (2001) for further details on matching functions.

other, that is $\dot{E} = M - \nu E = 0$. In the θ-notation the flow equilibrium reads

$$\theta^{-\beta} V = \nu E. \tag{2}$$

Denoting the exogenous labor force by L, it is easy to show that the equilibrium unemployment rate, $u := U/L$, is determined by the transition rates in and out of unemployment:

$$u = \frac{\nu}{\nu + \theta^{1-\beta}}. \tag{3}$$

In equilibrium, the unemployment rate rises with the separation rate ν and falls with the tightness of the labor market θ. To derive the employment effects of tax reforms all we need to know is the change in θ. Equation (3) then gives the change in the unemployment rate and from $E/L = 1 - u$ we know the change in the employment rate.

2.2 Firms

Each firm i uses capital K_i and labor E_i to produce a homogenous good X_i. Following Romer (1986) we introduce endogenous growth by assuming positive learning and knowledge spillover working through the economy's capital stock per worker, $k = K/E$. The production function for firm i is of the Cobb-Douglas type,

$$X_i = F(k, K_i, E_i) := k^{\delta} K_i^{\alpha} E_i^{1-\alpha}, \tag{4}$$

where $\alpha + \delta = 1$. In per capita terms we get $x_i = k^{\delta} k_i^{\alpha}$, which simplifies to

$$x = k \tag{5}$$

in a symmetric equilibrium, where $k_i = k$ for all i. At the firm level, the technology exhibits constant returns to scale in the private inputs, K_i and E_i. At the aggregate level, however, there are constant returns in capital. The private marginal products are $F_K = \alpha x_i / k_i$ and $F_E = (1-\alpha) x_i$ with F_j denoting the partial derivative of $F(\cdot)$ with respect to $j = K, E$. In a symmetric equilibrium the private marginal product of capital corresponds to the capital share parameter: $F_K = \alpha$.

Firm i maximizes the present-discounted value of expected profits with respect to the capital stock K_i and the creation of job vacancies V_i. Each vacancy induces gross hiring costs, which, following Bovenberg and van der Ploeg (1998), are assumed to be a fixed proportion, η, of the producer wage: $\eta\,(1 + t_{pw})\,w$, where w is the wage rate, and t_{pw} is the payroll tax. The current flow of profits amounts to output minus gross factor payments minus gross search expenditures. The factor payments consists of capital costs $(1+t_k^F) r K_i$ and labor costs $(1 + t_{pw}) w E_i$, where r is the interest rate and t_k^F is the tax on capital in production. The superscript F indicates that firms have to pay this tax. Taking these aspects into consideration, firm i chooses its capital stock K_i and the number of vacancies V_i to maximize

$$\int_0^\infty \{F(k, K_i, E_i) - (1 + t_k^F)rK_i - (1 + t_{pw})\, wE_i - \eta\,(1 + t_{pw})\, wV_i\}e^{-rt}dt$$

subject to the employment constraint $\dot{E}_i = \theta^{-\beta} V_i - \nu E_i$. In a steady state where labor market tightness θ is constant and wages grow at the (endogenous) rate g, the first-order conditions become:

$$F_K = (1 + t_k^F)r \qquad (6)$$

$$F_E = (1 + t_{pw})\, w \left[1 + \eta\,(r + \nu - g)\, \theta^\beta\right]. \qquad (7)$$

As usual the optimization conditions entail equality between the marginal products and marginal costs. The last term in the squared bracket in equation (7) represents the present value of expected net hiring costs. A higher separation rate ν and a higher interest rate r means that the expected present value of a successful matching falls. An increase in g means an increase in the growth rate of wages and profits leading to more job creation (capitalization effect). Moreover, the tighter the labor market (higher θ), the lower is the probability of filling the firm's vacancies and the higher are the expected hiring costs.

By combining $F_K = \alpha$ and the first-order condition (6) we immediately get $(1+t_k^F)r = \alpha$. In the steady state the user costs of capital are uniquely determined by the capital share parameter. A higher capital tax induces a proportional decrease in the interest rate, so that the user costs of capital do not depend on the capital tax.

2.3 Wage Determination[2]

The wage rate for a job is bargained between the firm and the worker after they meet. They share the rent of a realized job match, i.e. the sum of the expected search costs for the firm and the worker. Let V_{Ji} denote the expected present value of the successful job match (an occupied job) in firm $i$and V_V the expected present value of a vacant job. Then the asset values satisfy:

$$rV_{Ji} = x_i - (1 + t_{pw})w_i - (1 + t_k^F)rk_i - \nu(V_{Ji} - V_V) \qquad (8)$$

$$rV_V = -\eta(1 + t_{pw})w + q(\theta) \cdot (V_J - V_V) \qquad (9)$$

Equation (8) simply prices the option or the asset of an occupied job by requiring that the opportunity costs of holding it, the left hand side, is equal to the worker's real output minus labor and capital costs and minus the loss from the destruction of the job. Following

[2] See also Zanchi (2000) and Ellingsen and Rosén (2003) for a recent discussion of the wage determination in search models.

Pissarides (2000) we assume that there are no quasi-rents from a fixed capital stock, i.e. in the case of a job destruction capital can be sold at the second-hand market. As can be seen from (9) the opportunity costs of having a vacant job or pricing the vacant job is the gain $V_J - V_V$ received with probability $q(\theta)$ minus hiring costs. Note that rV_V is uniquely determined by economy-wide parameters and thus given at the firm-level. With free entry of new vacancies, $V_V = 0$, equation (9) shows that in equilibrium, the expected profits from a filled job have to cover the hiring costs: $q(\theta) \cdot V_J = \eta(1 + t_{pw})w$.

The worker's expected returns are given by

$$rV_{Ei} = (1 - t_w)w_i - \nu(V_{Ei} - V_U) \tag{10}$$

$$rV_U = B + \theta q(\theta) \cdot (V_E - V_U) \tag{11}$$

where V_E, V_{Ei} and V_U denote the expected present value of being employed, employed in firm i , and unemployed, respectively. The permanent income of an individual employed in firm i is the net wage $(1 - t_w)w_i$ minus the loss associated with a transition to unemployment. Finally, the expected return from unemployment amounts to the (indefinitely available) unemployment benefits, B, plus the gain in income if a job is found.

The firm and the worker choose the wage w_i that maximizes the Nash product $(V_{Ei} - V_U)^{\phi} \cdot (V_{Ji} - V_V)^{1-\phi}$, where ϕ stands for the bargaining power of the worker. This wage is given by:

$$w_i = \frac{1-\phi}{1-t_w} rV_U + \frac{\phi}{1+t_{pw}}[x_i - (1 + t_k^F)rk_i]. \tag{12}$$

A higher wage tax t_w lowers the net wage and thus the worker's rent of a job match. The worker bargains more aggressively and demands a higher wage. Analogously, a higher payroll tax t_{pw} corresponds to a decline in the firm's profits and thus to a decline in the firm's rent of the job match, now the firm bargains more aggressively. The decrease in the bargained wage w_i, however, does not outweigh the increase in t_{pw}, so that, at the firm level, the producer real wage $(1 + t_{pw})w_i$ is increasing in the payroll tax. A higher capital input tax t_k^F reduces the firm's rent of an occupied job leading to a lower wage w_i.

Equation (12) describes the wage-setting process at the firm level, where the permanent income of the unemployed and the interest rate are exogenous. At the aggregate level, however, rV_U and r are endogenous, and it is well-known that due to repercussions the partial equilibrium results do not necessarily carry over to the general equilibrium context. We restrict the analysis to a symmetric equilibrium in which all firms and workers are identical: $w_i = w$, $x_i = x$ and $k_i = k$ for all i. In order to generate a balanced growth path we shall assume a constant gross replacement ratio: $h \equiv B/w$. Any change in the wage rate w leads to a proportionate adjustment of the level of benefits. By making use of the first-order condition for capital, $(1 + t_k^F)r = \alpha$, the free entry condition, $V_V = 0$, and the asset equations, we get the bargained real wage at the aggregate level

$$w = \frac{1}{1+t_{pw}} \cdot \frac{\phi(1-t_w)}{(1-t_w)(1-\phi\eta\theta)-(1-\phi)\,h} F_E \tag{13}$$

as a share of the marginal product of labor. This share depends on the model parameters in a familiar way: the higher the workers' bargaining strength ϕ and the replacement ratio h, the higher is the share and thus the real wage. Because of a higher rent from a job match, the wage is increasing in the hiring costs captured by η. A tighter labor market (higher θ) improves the chance of an unemployed to find a job and lowers the chance of a firm to fill a vacancy. This raises the bargaining position of the worker and thus the real wage. Concerning the tax rates, we can state that, firstly, the negative wage effect of a higher capital input tax t_k^F at the firm level vanishes at the aggregate level. The reason is the decline in the interest rate r, so that the user costs of capital $(1+t_k^F)r$ and thus the rent of a job match do not depend on t_k^F. Secondly, an increase in the wage tax t_w leads to a higher wage w, but the net wage $(1-t_w)w$ falls. Compared to being unemployed, the relative attractiveness of being employed declines. The employed have to accept a worsening status, since unemployment benefits are indexed to the wage, any change in w implies a one-to-one change in B.[3] And thirdly, at the aggregate level a higher payroll tax t_{pw} is neutral for the producer real wage $(1+t_{pw})w$. The decline in the wage at the firm level will be reinforced by lower unemployment benefits leading to an even weaker bargaining position of workers.

Note that the wage equations (12) and (13) do not make economic sense in the cases where a party dominates the bargain. If the firms set the wage ($\phi = 0$), the take home pay (net wage) of a worker in firm i just equals the permanent income of an unemployed worker. At the aggregate level, however, the wage is driven down to zero, since we do not assume any income or utility from leisure activities. If the workers set the wage ($\phi = 1$), the producer real wage will be greater than the marginal product of labor. In this case, however, firms do not cover their hiring costs, they will make losses. When the firms anticipate such a scenario, they will not engage in any job creation. In other words, to fulfill the firms' participation constraint, i.e. the (expected) zero-profit condition, the bargaining strength ϕ must not be too large.

2.4 Government Budget and Savings

The government controls five policy parameters: a wage income tax t_w, a payroll tax t_{pw}, a capital input tax t_k^F levied on the firms' capital costs, a capital tax levied on the

[3] Birk and Michaelis (2002) assume a constant net replacement ratio, $B/(1-t_w)w = const.$, but in this case a change in the labor income tax t_w has no impact on the relative attractiveness of being employed compared to being unemployed shutting off an important channel for employment effects of tax reforms.

capital income of households t_k^H, and unemployment benefits B. The tax revenues are completely spent for paying the unemployment benefits, BU. Therefore, the government budget constraint reads $BU = t_w wE + t_{pw} wE + t_{pw} \eta wV + t_k^F rK + t_k^H rK$. The tax base of the payroll tax is larger than that on wage income because it covers also hiring costs. By observing the flow equilibrium $V/E = \nu\theta^\beta$ and the policy assumption $B = hw$ the government budget constraint can be written in per worker terms as

$$wh\nu\theta^{\beta-1} = t_w w + t_{pw} w(1 + \eta\nu\theta^\beta) + t_k^F rk + t_k^H rk. \tag{14}$$

Now turn to the optimizing behavior of households. The infinitely-lived household j is assumed to maximize utility

$$\int_0^\infty e^{-\rho t} \cdot \frac{(c_j)^{1-\sigma} - 1}{1-\sigma} dt, \tag{15}$$

subject to the constraint $\dot{k}_j = (1 - t_k^H) r k_j + \pi_j + I_j - c_j$, where π_j is j's share of aggregate profits, I_j is j's net wage if employed and unemployment benefits if unemployed, ρ is the rate of time preference, and σ is the elasticity of marginal utility of consumption. Focusing on a symmetric equilibrium, the optimal growth rate of consumption can be derived as

$$g \equiv \frac{\dot{c}}{c} = \frac{1}{\sigma}\left[(1 - t_k^H) r - \rho\right]. \tag{16}$$

In a steady state, capital per worker, output per worker, and the wage rate also grow at the (endogenous) rate g. A higher capital income tax t_k^H leads to a fall in the net interest rate $(1 - t_k^H)r$ and thus to a fall in the rate of return to savings. Households shift less consumption to the future, they accumulate less capital leading to a lower growth rate of capital, output and consumption. The sensitivity of consumption growth to changes in the gap between the net interest rate and ρ is given by the elasticity of intertemporal substitution $(1/\sigma)$. Analogously, a higher tax on capital input t_k^F leads to a decline in the interest rate $r = \alpha/(1 + t_k^F)$ and via lower savings to a reduction in the growth rate. Note that the growth rate does not depend on labor market tightness. In the (g, θ)-space (see Fig. 1 below), equation (16) describes the capital accumulation function CA. This function is a horizontal with t_k^H and t_k^F as shift parameters.

3 Steady-State Solution

The overall steady-state of our economy is determined by the interaction of the firms' job creation (employment) decision (7), the wage bargain between firms and workers (13), capital accumulation (16), and the government budget constraint (14). The model can be solved for (the change in) four endogenous variables: labor market tightness θ, the equilibrium growth rate g, the wedge between the marginal product of labor and the real wage, and a tax rate.

Due to non-linearities, we log-linearize our model denoting relative changes by a tilde. Observing $F_E = (1-\alpha)x$ the log-linearized version of the model reads

$$\tilde{x} - \tilde{w} = \tilde{t}_{pw} + [a_1\tilde{\theta} - a_2\tilde{g} - a_3\tilde{t}_k^F] \tag{17}$$

$$\tilde{w} - \tilde{x} = -\tilde{t}_{pw} + a_4\tilde{\theta} + a_5(\tilde{t}_w + \tilde{h}) \tag{18}$$

$$\tilde{g} = -a_6(\tilde{t}_k^H + \tilde{t}_k^F) \tag{19}$$

$$\tilde{h} = a_7\tilde{t}_w + a_8\tilde{t}_{pw} + a_9\tilde{t}_k^H + a_{10}\tilde{t}_k^F \tag{20}$$

where a_i $(i = 1, ..., 10)$ are positive constants defined in the Appendix. Equation (17) is the first-order condition for labor showing that the wedge between the marginal product of labor and the real wage, $\tilde{x} - \tilde{w}$, has to cover the payroll tax and hiring costs. Equation (18) describes the wage bargain. The fraction of F_E that has to be allocated to the worker is declining in t_{pw} because of a more aggressive bargain of the firm. Furthermore, this fraction is increasing in the wage tax, the replacement ratio and labor market tightness since these parameters lower the worker's rent of a match implying a more aggressive bargain by the worker. As explained in the previous section, the growth rate (19) is a negative function of the capital taxes t_k^H and t_k^F. Concerning the government budget constraint (20), we impose the condition of ex-ante revenue-neutrality. In accordance with Creedy and McDonald (1992), or Goerke (1996, 2002), just to name a few, tax reforms are assumed to be budget neutral at the initial equilibrium. The issue of ex-post neutrality, where the budget is assumed to be neutral after all adjustments in the economy have taken place is explored in Pflüger (1997) and Michaelis and Pflüger (2000).

By combining (17) and (18) we yield the efficient factor allocation function

$$\tilde{\theta} = \frac{a_2}{a_1 + a_4}\tilde{g} + \frac{a_3}{a_1 + a_4}\tilde{t}_k^F - \frac{a_5}{a_1 + a_4}(\tilde{t}_w + \tilde{h}). \tag{21}$$

It represents all combinations of the growth rate and labor market tightness where factor markets are in equilibrium. In particular, real income claims of workers are consistent with those of firms, and the capital stock is at the profit-maximizing level. The efficient factor allocation function (FA) is positively sloped in the (g, θ)-space (see Fig. 1). A higher g corresponds to a higher growth rate of expected profits from a successful match making job creation more profitable, labor market tightness θ goes up. A rise in the tax on capital input t_k^F causes a decline in the interest rate (hiring costs) and drives up the equilibrium value of θ. On the other hand, a higher wage tax t_w and a higher replacement ratio h shifts the efficient factor allocation locus inwards, since a higher wage makes job creation less profitable. A higher payroll tax t_{pw} leaves the efficient factor allocation unaffected reflecting the fact that the bargained wage w declines one-to-one in t_{pw}, so the producer wage $(1+t_{pw})w$ and thus labor costs are independent of t_{pw}. Also, the capital income tax t_k^H does not affect the efficient factor allocation.

The efficient factor allocation function (21), the capital accumulation function (19) and the government budget constraint (20) can now be used to discuss the growth and employment effects of various budgetary reforms.

4 Tax Reforms

4.1 Switch from Capital Income Taxes to Payroll Taxes

The first tax reform we are interested in is a cut in the capital income tax, t_k^H, financed by a higher payroll tax, t_{pw}. Ex-ante revenue neutrality requires $\tilde{t}_{pw} = -(a_9/a_8)\tilde{t}_k^H$ from (20). The employment and growth effects are described in

Proposition 1 *An ex-ante revenue-neutral shift from capital income to payroll taxes unambiguously raises both labor market tightness and the equilibrium growth rate.*

Proof. By combining (19) and (21) we get $\tilde{g} = -a_6 t_k^H > 0$ and $\tilde{\theta} = -\frac{a_2 a_6}{a_1+a_4}\tilde{t}_k^H > 0$. ■

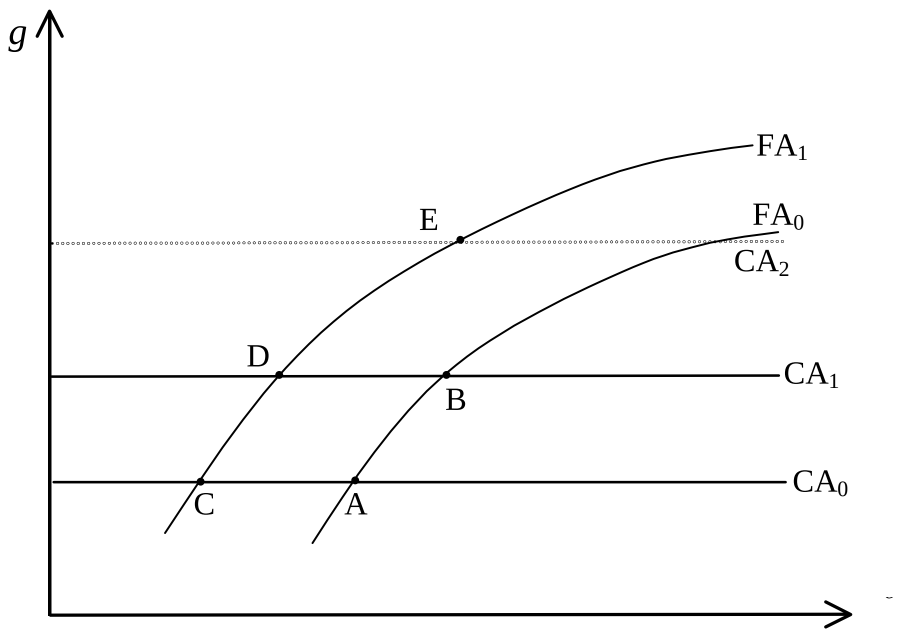

Figure 1: Tax Reforms I

As already pointed out by Eriksson (1997), the cut in the capital income tax increases the incentive to save pushing up the growth rate. And due to the capitalization effect firms find it more attractive to hire worker, the performance of the labor market improves. The increase in the payroll tax, necessary to finance the cut in the capital income tax, has no repercussions since neither wage nor hiring costs depend on t_{pw}.

Figure 1 visualizes the tax swap under consideration. The initial equilibrium is given by point A. The reduction in the capital income tax shifts the capital accumulation function from CA_0 to CA_1, whereas the increase in t_{pw} has no impact on these loci. As indicated by point B, the equilibrium values of g and θ move up.

4.2 Switch from Capital Input Taxes to Payroll Taxes

The employment and growth effects of such a tax swap are described in

Proposition 2 *An ex-ante revenue neutral shift from capital input taxes to payroll taxes boosts growth. If the elasticity of marginal utility of consumption, σ, is lower than $1-t_k^H$, then labor market tightness θ increases too. For $\sigma > 1 - t_k^H$, labor market tightness declines.*[4]

Proof. The growth effect is given by $\tilde{g} = -a_6 t_k^F > 0$ from (19). Inserting this in (21) delivers $\tilde{\theta} = \frac{a_3 - a_2 a_6}{a_1 + a_4} \tilde{t}_k^F$. Labor market tightness increases, if $a_3 - a_2 a_6 < 0$, or equivalently, if $\frac{\eta \theta^\beta (1+t_{pw}) w}{(1-\alpha)x}(r - \frac{\sigma g + \rho}{\sigma}) < 0$. By observing $\sigma g + \rho = (1 - t_k^H) r$ this boils down to the condition $\sigma < 1 - t_k^H$. If this condition is not met, θ decreases. ■

The maintenance of budget balance requires a higher payroll tax, but as argued above, this is neutral for both factor allocation and capital accumulation. For the employment and growth effects only the cut in the capital input tax matters. In contrast to the capital income tax, the cut in t_k^F causes a rise in the interest rate r and thus a rise in hiring costs. Creating new vacancies is less profitable, labor market tightness falls ceteris paribus. In Figure 1 the factor allocation function shifts to the left from FA_0 to FA_1 (point C). But, of course, point C is not the end of the story, since due to the higher interest rate households have an incentive to save more pushing up the growth rate with positive repercussions on labor market tightness via the capitalization effect. The net effect on θ very much depends on the elasticity of intertemporal substitution, the parameter capturing the sensitivity of savings with respect to the increase in the interest rate. If the elasticity of intertemporal substitution $(1/\sigma)$ is low, households have strong preferences for a uniform pattern of consumption over time, their willingness to substitute intertemporally in response to a higher interest rate is low. Consequently, the higher σ, the lower the increase in savings, and the lower is the positive impact on the growth rate and labor market tightness (small upward shift of the capital accumulation function in Figure 1). Similarly, if the capital

[4] In a model with exogenous growth, Eriksson (1997) derives the same condition for the sign of the employment effect of a higher growth rate.

income tax t_k^H is large, the increase in the interest rate is very much taxed away, so that there is only a small increase in the net interest rate $(1-t_k^H)r$, a small increase in the gap between $(1-t_k^H)r$ and ρ and thus only a small response of savings and the growth rate (see (16)).

As stated in Proposition 2, for $\sigma > 1 - t_k^H$, the positive capitalization effect does not offset the rise in the interest rate, overall hiring costs increase, labor market tightness θ (employment) goes down. In Figure 1 this scenario is indicated by point D, which lies to the left of point A. For $\sigma < 1 - t_k^H$, however, the effect on the growth rate is strong, the capitalization effect now dominates, the labor market gets tighter. In Figure 1 we observe point E lying to the right of point A. From an empirical point of view, the former parameter constellation seems most plausible. Hall (1988) has argued that consumption growth is insensitive to changes in the interest rate and, hence, the elasticity of substitution $(1/\sigma)$ is close to zero. The subsequent literature, see for instance Patterson and Pesaran (1992) and the more recent study by Yogo (2004), confirms this result and reports a σ in the range between 5 and 10. Given these estimates, we conclude that a cut in the capital input tax financed by a higher payroll tax is good for growth but bad for employment.

4.3 Switch from Wage Taxes to Payroll Taxes

The third tax swap under consideration is a cut in the wage tax financed by a higher payroll tax. The employment and growth effects are described in

Proposition 3 *An ex-ante revenue neutral shift from wage taxes to payroll wage leaves growth unaffected, labor market tightness unambiguously improves.*

Proof. Inspection of (19) and (21) shows that $\tilde{g} = 0$ and $\tilde{\theta} = -\frac{a_5}{a_1+a_4}\tilde{t}_w > 0$. ■

Since the increase in the payroll tax is neutral, it is the decline in the wage tax that matters. As argued above, a reduction in t_w means that workers get a higher rent from the match shifting relative bargaining power to firms. The bargained wage w and thus hiring costs decline generating an incentive for the creation of new jobs. Market tightness rises, whereas growth is unaffected. In Figure 2 (see below) the factor allocation function shifts to the right (not depicted), the new equilibrium is point B.

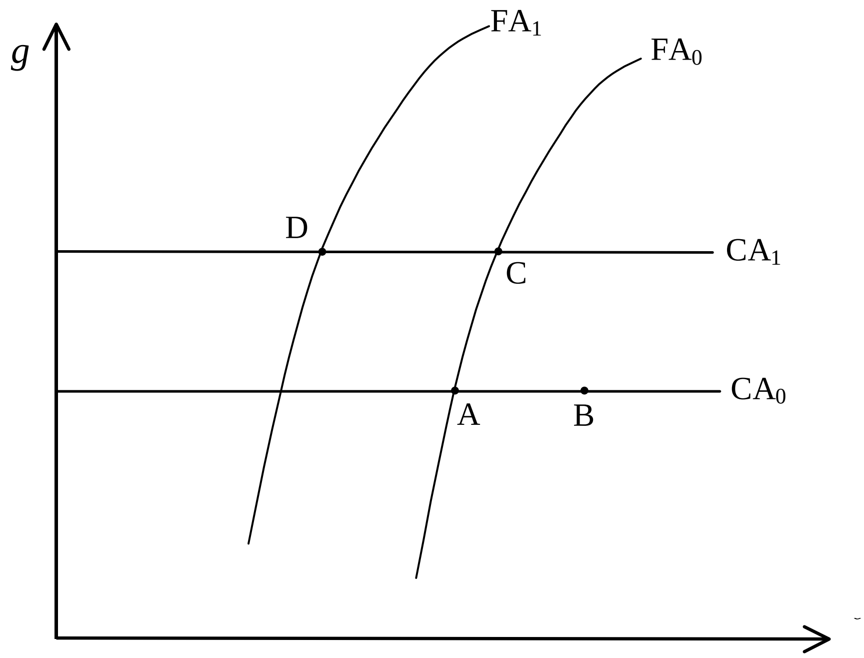

Figure 2: Tax Reforms II

4.4 Switch from Capital Taxes to Wage Taxes

The employment and growth effects of a cut in capital taxes financed by a higher wage tax are described in Propositions 4 and 5.

Proposition 4 *An ex-ante revenue neutral shift from capital income taxes to wage taxes unambiguously boosts growth. Labor market tightness and employment increases (decreases), if hiring costs are sufficiently high (low), that is, if $\eta > \bar{\eta}$ ($\eta < \bar{\eta}$) with $\bar{\eta} = \frac{(1-\phi)h}{\phi(1-t_w)^2}\frac{\sigma x}{\theta^\beta w}$.*

Proof. The growth effect is given by $\tilde{g} = -a_6 \tilde{t}_k^H > 0$ from (19). By inserting this and $\tilde{t}_w = -\frac{a_9}{a_7}\tilde{t}_k^H > 0$ from (20) into (21), we get $\tilde{\theta} = \frac{1}{a_1+a_4}\left(\frac{a_5 a_9}{a_7} - a_2 a_6\right)\tilde{t}_k^H$. The performance of the labor market improves (higher θ), if the bracketed term is negative, or equivalently, if $\eta > \bar{\eta} = \frac{(1-\phi)h}{\phi(1-t_w)^2}\frac{\sigma x}{\theta^\beta w}$. The result reverses for $\eta < \bar{\eta}$. ■

The decline in the capital income tax induces households to save more, which gives a positive effect on growth. As argued above, this effect is the stronger, the larger is the intertemporal elasticity of consumption ($1/\sigma$), or equivalently, the parameter a_6. In Figure 2 the parameter a_6 determines the size of the upward-shift of the capital accumulation function from CA_0 to CA_1. Starting at the initial equilibrium A, the economy moves along the factor allocation function FA_0 to the north-east. How large is the θ-effect of a higher g (capitalization effect)? Graphically, this depends on the slope of FA_0, analytically, the decisive parameter is a_2, and economically, it is the proportion of hiring costs to the producer wage, η, which matters most. That is, the more substantial the hiring costs are relative to the producer wage (higher η), the higher is the number of new jobs caused by the decline in these costs. Figure 2 depicts the scenario of a low η (steep FA-curve) with a small θ-effect (point C).

An ex-ante revenue neutral shift from capital income taxes to wage taxes unambiguously boosts growth. Labor market tightness and employment increases (decreases), if hiring costs are sufficiently high (low), that is, if $\eta > \bar{\eta}$ ($\eta < \bar{\eta}$) with $\bar{\eta} = \frac{(1-\phi)h}{\phi(1-t_w)^2}\frac{\sigma x}{\theta^\beta w}$.

The increase in the wage tax necessary to keep the budget balanced is given by $\tilde{t}_w = -(a_9/a_7)\tilde{t}_k^H$. Workers demand a higher wage, and with higher wages firms create fewer jobs. The factor allocation function shifts from FA_0 to FA_1 leading to point D as new equilibrium. Labor market tightness is negatively affected, and if hiring costs as proportion of the producer wage fall short off the critical level $\bar{\eta}$ given in Proposition 4, this effect offsets the positive impact of the decline in the capital income tax. In this case, point D lies to the left of point A. For $\eta > \bar{\eta}$, point D lies to the right of A. As noted above, the empirical literature indicates low values for the intertemporal elasticity of consumption, so that the upward shift of the CA-function and thus the initial growth and θ-effect (movement from A to C) seems to be quite low. Thus, the most likely outcome of a cut in the capital income tax financed by a higher wage tax is a trade-off between growth and employment, the (small) increase in the growth rate comes at the cost of lower employment.

Proposition 5 *An ex-ante revenue neutral shift from capital input taxes to wage taxes unambiguously boosts growth. A sufficient (but not necessary) condition for a decline in labor market tightness is* $\sigma > 1 - t_k^H$.

Proof. By combining (19), (20) and (21) we get $\tilde{g} = -a_6\tilde{t}_k^F > 0$ and $\tilde{\theta} = \frac{1}{a_1+a_4}(a_3 - a_2a_6 + \frac{a_5a_{10}}{a_7})\tilde{t}_k^F$. As shown in the proof of Proposition 2, from $\sigma > 1 - t_k^H$ follows $a_3 - a_2a_6 > 0$, which in turn is sufficient for $\tilde{\theta} < 0$. ■

Since this tax swap is a mixture of two already analyzed tax instruments, the intuition of Proposition 5 should be clear. The cut in the capital input tax raises the interest rate and therefore stimulates saving. Higher savings translate into a higher growth rate, and, due to the capitalization effect, improves the performance of the labor market (movement along the positively sloped factor allocation function). But a higher interest rate also means that future revenues of a job are discounted more heavily, fewer jobs are created. Proposition 2 states that, concerning market tightness, the latter effect dominates for $\sigma > 1 - t_k^H$. Since this constellation seems empirically warranted, the decline in the capital input tax worsens labor market tightness. The increase in the wage tax necessary to balance the budget reinforces the negative θ-effect of this tax swap.

4.5 Switch from Capital Income to Capital Input Taxes

Despite an identical tax base, a swap between a capital income tax and a capital input tax is not neutral for growth and employment.

Proposition 6 *An ex-ante revenue neutral shift from capital income to capital input taxes is unambiguously good for both growth and employment.*

Proof. To fulfill the budget constraint (20), the capital input tax has to rise by $\tilde{t}_k^F = -\frac{1-t_k^H}{1+t_k^F}\tilde{t}_k^H$. Inserting this into (19) leads to $\tilde{g} = -\frac{a_6(t_k^H+t_k^F)}{1+t_k^F}\tilde{t}_k^H > 0$ proofing the first part of Proposition 6. From the factor allocation function (21) we can derive the change in labor market tightness as $\tilde{\theta} = -\frac{1}{a_1+a_4}[a_2a_6(t_k^H + t_k^F) + a_3(1 - t_k^H)]\tilde{t}_k^H > 0$. ■

The decisive factor for the growth effect is the impact of the tax swap on the net interest rate $(1 - t_k^H)r$. There are two countervailing effects, which, however, do not offset each other. On the one hand, the decline in the capital income tax t_k^H increases the net interest rate causing a positive growth effect. On the other hand, because of $r = \alpha/(1 + t_k^F)$, the interest rate r falls in response to the increase in the capital input tax t_k^F. As Proposition 6 indicates, the former effect always dominates, so that households have an incentive to shift additional resources into the future. Concerning labor market tightness, both the increase in the growth rate and the decline in the interest rate means a decline in hiring costs leading to more vacancies.

4.6 Switch from Income Taxes to Capital Input Taxes

Up to now we have assumed that the tax rate households have to pay depends of the source of income, a wage tax on wage income and a capital income tax on capital income. If we give up this distinction, the taxation of households collapses (or simplifies) to an income tax t_I with $t_I = t_w = t_k^H$. With such a modification we get

Proposition 7 *An ex-ante revenue neutral shift from income taxes to capital input taxes is bad for growth, if the after-tax income of households is higher than firms' capital costs. A sufficient (but not necessary) condition for an increase in labor market tightness is* $\sigma > 1 - t_I$.

Proof. Solving the government budget for the change in the capital input tax necessary to finance the cut in the income tax yields $\tilde{t}_k^F = -\frac{a_7+a_9}{a_{10}}\tilde{t}_I$ (note that $\tilde{t}_w = \tilde{t}_k^H = \tilde{t}_I$). Using this we get $\tilde{g} = \frac{a_6}{a_{10}}(a_7 + a_9 - a_{10})\tilde{t}_I$ from (19). For $a_7 + a_9 - a_{10} > 0$, or equivalently, for $(w+rk)(1-t_I)-rk(1+t_k^F) > 0$, the growth rate declines. Inserting these terms into the factor allocation function (21) leads to $\tilde{\theta} = \frac{1}{a_{10}(a_1+a_4)}[(a_7+a_9)(a_2a_6-a_3)-a_{10}(a_2a_6+a_5)]\tilde{t}_I$. From $\sigma > 1 - t_I$ follows $a_2a_6 - a_3 < 0$, which in turn is sufficient for $\tilde{\theta} > 0$. ■

The analysis of this tax swap is very similar to the tax swap considered in the previous section. Since capital income is part of the tax base of the income tax, the cut in t_I corresponds to a higher net interest rate on savings. The upward shift of the capital accumulation function and thus the positive impact on growth is the same as in the case of a cut in the capital income tax. However, due to the increase in the capital input tax the gross interest rate $r = \alpha/(1 + t_k^F)$ declines causing a negative growth effect. Which effect dominates? In the previous section the net effect on growth was positive. Now, however, the net effect is most likely to be negative. Since the income tax has a broader tax base than the capital income tax, a given cut in t_I generates a higher deficit than the same cut in t_k^H. To keep the budget balanced a higher increase in the capital input tax is required. If the after-tax income $(w + rk)(1 - t_I)$ exceeds the firms' capital costs $rk(1 + t_k^F)$, the increase in the capital input tax (and thus the decline in the interest rate r) is larger than the decline in the income tax resulting, overall, in a decline of the net interest rate and growth rate. However, we observe a positive employment effect. The reason is that a lower interest rate leads to lower hiring costs, which, in turn, induces the creation of more jobs.

5 Conclusions

In this paper we have analyzed the employment and growth effects of different revenue-neutral tax reforms. The main results are stated in both the abstract and the introduction, so there is no need to repeat them here. Our analysis suggests that there is a "first-best tax reform" in terms of higher employment and growth: cut the capital income tax and - in order to fulfill the budget constraint - increase the payroll tax. It is interesting to note that this policy recommendation is a turn-around to the recommendation given by Daveri and Tabellini (2000), who state that a cut in labor taxes financed by higher capital taxes is good for growth and employment. The reason for these conflicting results remains open, since the models differ in too many respects, e.g. the assumed driving force of growth, the modeling of labor market imperfections and the saving decision of households. Further research is needed in order to identify the crucial assumptions and critical parameters, which determine not only the magnitude but even the sign of the employment and growth effects of tax reforms.

Lastly, let us mention two limitations of our framework. We do not have a criterion which allows us to analyze meaningfully the welfare implications of alternative policies. In particular, if the employment and growth effects show different signs, an unambiguous ranking of the tax instruments is not possible and thus the policy conclusions are only vague. A related point is concerned with our focus on analytical results. The method of log-linearization restricts us to small changes in the policy parameters. In order to evaluate large policy shocks and/or to get a numerical assessment of the employment and growth effects, a calibration of the model would be necessary.

Appendix

Parameter definitions

$$a_1 := \beta\eta\theta^\beta(r+\nu-g)\frac{(1+t_{pw})w}{(1-\alpha)x} \qquad a_2 := \frac{\eta\theta^\beta g(1+t_{pw})w}{(1-\alpha)x}$$

$$a_3 := \frac{\eta\theta^\beta r(1+t_{pw})w}{(1-\alpha)x} \qquad a_4 := \frac{\eta\phi\theta(1+t_{pw})w}{\phi(1-\alpha)x}$$

$$a_5 := \frac{(1-\phi)(1+t_{pw})hw}{\phi(1-\alpha)(1-t_w)x} \qquad a_6 := \frac{\sigma g+\rho}{\sigma g}$$

$$a_7 := \frac{(1-t_w)w}{w\nu\theta^{\beta-1}h} \qquad a_8 := \frac{(1+t_{pw})(1+\eta\nu\theta^\beta)w}{w\nu\theta^{\beta-1}h}$$

$$a_9 := \frac{rk(1-t_k^H)}{w\nu\theta^{\beta-1}h} \qquad a_{10} := \frac{rk(1+t_k^F)}{w\nu\theta^{\beta-1}h}$$

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