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Flat tax reform: The Baltics 2000–2007

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ABSTRACT

The paper presents an endogenous growth economy with a representation of the tax rate system in the Baltic countries. Assuming that government spending is a given fraction of output, the paper shows how a flat tax system balanced between labor and corporate tax rates can be second best optimal. It then computes how actual Baltic tax reforms from 2000 to 2007 affect the growth rate and welfare, including transition dynamics. Comparing the actual reform effects to hypothetical tax experiments, it results that equal flat tax rates on personal and corporate income would have increased welfare in all three Baltic countries by more than the actual reforms. Experiments show that movement towards a more equal balance between labor and capital tax rates, through changing just one tax rate, achieve almost as high or higher utility gains as in actual law for all three countries.

1. Introduction

This paper focuses on how a balanced flat rate tax system, or movement towards this, can be optimal for the representative agent, as applied to tax reform in the Baltic economies from 2000 to 2007. Instead of the standard Ramsey optimum of a zero corporate income tax, the model economy has a Turnovsky (2000) optimum of equal flat tax rates on labor and capital income, with this rate set in turn to the output share of government spending. This results by assuming as in Barro (1990), Turnovsky (2000) and Funke and Strulik (2006) that government spending is a constant fraction of income, rather than exogenous and independent of income, and that there are zero benefits of non-transfer government spending. The model has a more comprehensive corporate sector than is typical and this allows for extension of the second-best optimum results, such that a composite labor tax rate including social security and VAT taxes is equal to the corporate income tax rate, and for more extensive tax experiments.

Applying this model to the Baltic countries, the optimum is derived and then the effects of actual tax reforms experienced from 2000 to 2007 are examined in light of the optimum. The Baltic tax reforms started in 1994 in Estonia, and by 2000 the average Baltic personal tax rates had fallen to 28% and average corporate tax rates to 16%. By 2007, the average Baltic tax rates had fallen further: to 25% for personal tax rates and to 10% for corporate tax rates. It emerges from the model results that this tax regime is not well-balanced in that it is sub-optimally weighted towards higher labor taxes. Intuitively, the

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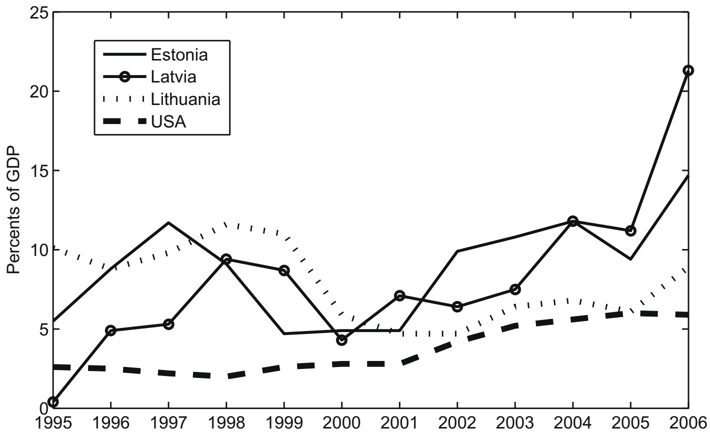

Fig. 1. Net foreign borrowing in the Baltics and the US.

economy has a central feature that the return on human capital is equal to the return on physical capital along the balanced growth path, and this in part gives rise to the desirability of balancing composite labor and corporate tax rates.

After setting up the economy (Section 2), the paper next presents the social planner problem (Section 3). It then calibrates a baseline model for each of the three Baltic countries (Section 4) and estimates the maximum possible utility gains from tax reform (Section 5.1) and the actual estimated utility gains from the 2000–2007 reforms (Section 5.2). For Latvia and Lithuania, it is shown that using only equal flat taxes, on personal and corporate income, to raise the same revenues as were raised under the 2007 tax law would have been better than the actual tax reforms instituted by 2007. And again raising the same amount of revenue as in 2007, but by changing just one tax, it is shown that lowering the personal income tax, or social security contributions, moves the countries towards more "balanced" tax rates and raises welfare by more than did the actual reforms in all three countries (Section 5.3). Also it is shown how the improvement in welfare from changing individual tax rates depends upon the initial set of tax rates; this helps explain how seemingly contradictory results from other studies for the ranking of tax reforms can be explained by different initial sets of tax rates (Section 6).

2. The endogenous growth economy

The economy is a closed economy model with endogenous growth so that tax changes can effect the balanced growth path equilibrium rate of output growth. This gives the advantage over an open economy model, which is specified with a given real interest rate and an exogenous output growth rate, in that welfare calculations in the closed economy include the effect on the growth rate. In addition, Fig. 1 shows that the US, which is typically analyzed as a closed economy, had in several years after 2000 nearly the same net foreign borrowing as Lithuania.[1] So while the Baltic countries are undoubtedly more open than the US, the analysis uses the closed economy as a first way to approximate such tax effects, as do Funke and Strulik (2006).[2]

The endogenous growth model shares common elements with Kim (1998) and Devereux and Love (1994). As in Kim (1998), the paper introduces a realistic tax system while the specification of preferences and technology resembles that of Devereux and Love (1994). A corporate sector, as the representative firm, is introduced following Turnovsky (1995, Chapters 10 and 11), so as to account for different types of corporate income and dividend tax treatment. We assume that there are no new equity issues, that investment is financed by retained earnings, and that the remaining income is distributed as dividends. Also, as in Kim (1998), we account for the added complexity of the difference between the actual depreciation rate and the accounting depreciation rate. The most closely related paper in terms of the study of tax reform in the Baltic countries is Funke and Strulik's (2006) interesting closed economy analysis of Estonia's 2000 tax reform, although that paper assumes exogenous growth while we use endogenous growth.

2.1. The consumer problem

The representative consumer's utility, with $\theta > 0, \epsilon \geqslant 0$ and $\beta \in (0,1)$, depends at time t on consumption C and leisure time l:

$$U = \sum_{t=0}^{\infty} \beta^t \frac{(C_t l_t^{\epsilon})^{1-\theta}}{1-\theta}. \tag{1}$$

[1] The data on the Baltic countries are from Eurostat's database, while the data on the USA are from the OECD database; Net Borrowing is the net resources that the given economy receives from the rest of the world.

[2] Our experiments with an open economy model with a given real interest rate found the same ranking of tax reforms as in the closed economy model presented here.

The consumer divides a time endowment of 1 between leisure, labour supplied for goods production u, and time spent producing human capital in a non-market sector z:

$$1 = l_t + u_t + z_t. \tag{2}$$

Following Lucas (1988), the consumer uses human capital indexed labour for goods and human capital production. With human capital denoted by H, its depreciation denoted by δ_h, and A_h a constant productivity parameter, its accumulation is governed by

$$H_{t+1} - H_t = A_h z_t H_t - \delta_h H_t. \tag{3}$$

The consumer derives income from the supply of labour to goods production at the real wage rate of w for effective, quality-indexed labour, the holding of government bonds B, and the holding of corporate equity shares E. Also the government provides a lump sum transfer T. The consumer spends the income on consumption goods and the acquisition of additional government bonds or corporate equity.

Taxes that the consumer faces are a personal income tax rate of τ^p that falls on wage income, a social security tax rate of τ^{sw} that also falls on wage income, value added tax (VAT) rate of τ^v that falls on goods purchases, a dividend tax rate of τ^d that falls on equity income, and a capital gains tax rate of τ^g that falls on net price gains on equity sales. Government bond income and government transfers are treated as tax exempt. With q_{t+1} the ex-dividend price on equities in period t with dividends paid starting in period $t+1$, with r_t^E the equity dividend yield, and with r_t the interest yield on government bonds, the budget constraint is

$$(1-\tau^p)(1-\tau^{sw})w_t u_t H_t + (1+r_t)B_t + \left(1-\tau^d\right)r_t^E q_t E_t + T_t = \tau^g\left(q_{t+1} - q_t\right)E_t + (1+\tau^v)C_t + B_{t+1} + q_{t+1}(E_{t+1} - E_t). \tag{4}$$

It will be convenient to denote by $D_t \equiv r_t^E q_t E_t$ the consumer's dividends that the corporate firm pays out.

Using the time constraint (2) to substitute in $l_t = 1 - u_t - z_t$ for leisure in the utility function, the consumer maximizes utility (1) subject to (3) and (4) with respect to $C_t, u_t, z_t, H_{t+1}, B_{t+1}$, and E_{t+1}, taking prices, taxes and the bond and dividend rates as given. Let λ_t and v_t be Lagrangian multipliers associated with the budget constraint (4) and human capital accumulation function (3), respectively. First order conditions are:

$$C_t^{-\theta} l_t^{\epsilon(1-\theta)} = \lambda_t(1+\tau^v); \tag{5}$$

$$C_t^{1-\theta} l_t^{\epsilon(1-\theta)-1}\epsilon = \lambda_t w_t (1-\tau^{sw})(1-\tau^p)H_t; \tag{6}$$

$$C_t^{1-\theta} l_t^{\epsilon(1-\theta)-1}\epsilon = v_t A_h H_t; \tag{7}$$

$$v_t = \beta[\lambda_{t+1} w_{t+1}(1-\tau^{sw})(1-\tau^p)u_{t+1} + v_{t+1}(A_h z_{t+1} + 1 - \delta_h)]; \tag{8}$$

$$\lambda_t = \beta\lambda_{t+1}(1 + r_{t+1}); \tag{9}$$

$$\lambda_t q_{t+1} = \beta\lambda_{t+1}\left[(1-\tau^d)r_{t+1}^E q_{t+1} - \tau^g(q_{t+2} - q_{t+1}) + q_{t+2}\right]. \tag{10}$$

Combining (9) and (10) gives the arbitrage condition between bond and equity returns:

$$r_t = (1-\tau^d)r_t^E + (1-\tau^g)\frac{q_{t+1} - q_t}{q_t}. \tag{11}$$

Thus return on government bonds must be equal to after tax return from dividend yield and capital gains.

2.2. The corporate sector

The corporate firm problem follows Turnovsky, 1995, Chapters 10 and 11. Capital is stated in terms of the level of the usual economic capital K and in terms of the *accounting* level of the capital stock K^a. These different stock levels are necessary in order to introduce properly the statutory depreciation rate δ, which causes the economic and accounting capital to be unequal if the statutory depreciation rate differs from the economic one δ_k. The accounting level of capital evolves according to

$$K_{t+1}^a = (1-\delta)K_t^a + I_t, \tag{12}$$

while the economic capital is given by

$$K_{t+1} = (1-\delta_k)K_t + I_t. \tag{13}$$

Output Y is produced with Cobb–Douglas function in physical capital and effective labour; with $\alpha \in (0,1)$

$$Y_t = AK_t^\alpha (u_t H_t)^{1-\alpha}. \tag{14}$$

Given a social insurance tax paid by the firm on the wages, at the rate of τ^{se}, the gross profits π are defined as

$$\pi_t = AK_t^\alpha (u_t H_t)^{1-\alpha} - w_t(1+\tau^{se})u_t H_t. \tag{15}$$

With the corporate income tax given by τ^c, the profit net of taxes is $(1-\tau^c)\pi_t$.

Profits paid in taxes $\tau^c \pi_t$ can be decreased by two other factors. First, there may exist an investment subsidy τ^s that adds $\tau^s I$ to profit in proportion to the new investment (an "investment tax credit"). Second, taxable profits are decreased by the depreciated amount of capital that adds $\tau^c \delta K_t^a$ to after-tax profit. The net profit is used to pay out dividends D and to finance new investment

$$(1-\tau^c)\pi_t + \tau^s I_t + \tau^c \delta K_t^a = D_t + I_t. \tag{16}$$

The specification of (16) assumes that investment is financed only from profits of the firm, and not by the issue of new equities. The latter is justified by the under-developed nature of financial markets in the Baltics, making equity financing expensive. Only the initial equity issues are positive, and then held constant over time, so that

$$E_0 = \ldots = E_t = E_{t+1}. \tag{17}$$

This corresponds to the privatization programs and other forms of initial public offerings, whereby additional equity offerings cannot be supported in the market. The specification also rules out corporate bonds or bank credit.

Define the value V of equities at a given time as

$$V_t \equiv q_t E_t. \tag{18}$$

Given the assumption (17), the arbitrage condition (11) gives the difference equation in the value of equities as

$$V_{t+1} = V_t\left(1+\frac{r_t}{1-\tau^g}\right) - \left(\frac{1-\tau^d}{1-\tau^g}\right)D_t. \tag{19}$$

From (16) dividends equal

$$D_t = (1-\tau^c)\pi_t - (1-\tau^s)I_t + \tau^c \delta K_t^a \tag{20}$$

and the equation of motion for the value of the corporate firm, Eq. (19), becomes

$$V_{t+1} = V_t\left(1+\frac{r_t}{1-\tau^g}\right) - \left(\frac{1-\tau^d}{1-\tau^g}\right)\left[(1-\tau^c)\pi_t - (1-\tau^s)I_t + \tau^c \delta K_t^a\right]. \tag{21}$$

Eq. (21) gives the result, by the coefficient of V_t term, that the cost of capital is independent of the dividend yield and the tax rate on dividends. Solving the difference equation (21) gives that the current value of outstanding equities is equal to the present value of the discounted stream of future cash flows;

$$V_0 = \left(\frac{1-\tau^d}{1-\tau^g}\right)\sum_{t=0}^{\infty}\frac{(1-\tau^c)\pi_t - (1-\tau^s)I_t + \tau^c\delta K_t^a}{\prod_{j=0}^{t}\left(1+\frac{r_j}{1-\tau^g}\right)}. \tag{22}$$

However, expression (22) is in terms of K^a, the accounting capital, while the firm optimizes with respect to the economic capital K. Therefore K^a needs to be put in terms of K. Investment made at date t can be brought together from the terms in (22) to give that the present value of tax savings from future depreciation of date t investment (see Atkinson and Stiglitz, 1980, Lecture 5), as denoted by m, is equal to[3]

$$m_t = \tau^c \delta \sum_{j=1}^{\infty}\frac{(1-\delta)^{j-1}}{\prod_{i=1}^{j}\left(1+\frac{r_{t+i}}{1-\tau^g}\right)}, \tag{23}$$

which has the recursive form of

$$m_t = \frac{\tau^c \delta}{1+\frac{r_{t+1}}{1-\tau^g}} + \frac{1-\delta}{1+\frac{r_{t+1}}{1-\tau^g}} m_{t+1}.$$

Now the expression (22) can be rewritten, with substitution for π from Eq. (15) and for I from Eq. (13), as

$$\begin{aligned} V_0 = \left(\frac{1-\tau^d}{1-\tau^g}\right)\sum_{t=0}^{\infty}\prod_{j=0}^{t}\left(1+\frac{r_j}{1-\tau^g}\right)^{-1}\Big\{&(1-\tau^c)\left[AK_t^{\alpha}(u_tH_t)^{1-\alpha} - w_t(1+\tau^{se})u_tH_t\right] \\ &-(1-\tau^s-m_t)[K_{t+1}-K_t(1-\delta_k)] + \tau^c\delta K_0^a(1-\delta)^t\Big\}. \end{aligned} \tag{24}$$

The firm maximizes Eq. (24) with respect to capital K_{t+1} and effective labor u_t to yield the first-order conditions;

$$(1-\tau^s)\left(\frac{r_t}{1-\tau^g}+\delta_k\right) + m_t(\delta-\delta_k) - \tau^c\delta = (1-\tau^c)\alpha A\left(\frac{K_t}{u_tH_t}\right)^{\alpha-1}, \tag{25}$$

$$w_t(1+\tau^{se}) = (1-\alpha)A\left(\frac{K_t}{u_tH_t}\right)^{\alpha}. \tag{26}$$

[3] Kim (1998) derives m in continuous time and in later analysis treats it as a constant.

For example, with $\tau^g = \tau^s = \delta = 0$ the after tax input price ratio is

$$\frac{r_t + \delta_k}{w_t(1+\tau^{se})(1-\tau^c)} = \frac{a}{1-\alpha}\frac{u_t H_t}{K_t}.$$

2.3. Government sector

The government receives income from taxes on consumption goods, labour wage income to the consumer and labour wage payments by the firm, capital gains, dividend payments, profits, and new bond issues. Expenditures are for government spending Γ, interest payments and redemption of bonds, and the lump sum transfer T. This implies the government budget constraint:

$$\begin{aligned}(1+r_t)B_t + \Gamma_t + T_t = B_{t+1} + \tau^v C_t + [\tau^{sw} + (1-\tau^{sw})\tau^p + \tau^{se}]w_t u_t H_t + \tau^g(q_{t+1} - q_t)E_t + \tau^d r_t^E q_t E_t \\ + \tau^c[AK_t^\alpha (u_t H_t)^{1-\alpha} - (1+\tau^{se})w_t u_t H_t - \delta K_t^a] - \tau^s I_t. \end{aligned} \tag{27}$$

Transversality conditions also apply whereby as time tends to infinity the discounted value of each the bond and the equity holdings by agents, and the capital stock held by firms, approaches zero.

It is assumed that government runs a balanced budget every period and that there are no outstanding government bonds at date $t = 0$: $B_0 = 0$. Then the transfer each period is the difference between government revenue and expenditure. And it is assumed that government expenditure Γ_t exogenously grows at the rate of output growth g_t for each t, so that Γ_t/Y_t is a given constant $\gamma \in (0,1)$:

$$\Gamma_t = \gamma Y_t. \tag{28}$$

2.4. Balanced-growth path equilibrium

The balanced-growth path (BGP) equilibrium is derived from first order conditions (5)–(9) and (25) and (26), with the shares of time allocation for different activities being stationary while the variables Y, C, K, I, H all grow at common BGP growth rate, denoted by g. To solve for the equilibrium as a single implicit equation in terms of only g, the ratios $\frac{C}{Y}$ and $\frac{I}{Y}$ are solved and substituted into the social resource constraint

$$1 = \frac{C_t}{Y_t} + \frac{I_t}{Y_t} + \frac{\Gamma_t}{Y_t}. \tag{29}$$

Dropping time subscripts, the time allocation and human capital accumulation equations (2) and (3) imply that the growth rate is the following function of leisure l and work u:

$$g = A_h(1 - l - u) - \delta_h. \tag{30}$$

Using Eqs. (5)–(9), the interest rate in terms of l is

$$r = A_h(1-l) - \delta_h, \tag{31}$$

stating that the net return on physical capital equals the net return on human capital. Eqs. (30) and (31) imply a leisure to work ratio of

$$\frac{l}{u} = \frac{A_h - \delta_h - r}{r - g}, \tag{32}$$

which is used now to solve for $\frac{C}{Y}$. The marginal rate of substitution between goods and leisure, from Eqs. (5) and (6), is

$$\frac{\epsilon C}{l} = \frac{(1-\tau^{sw})(1-\tau^p)wH}{1+\tau^v}. \tag{33}$$

Solving for the wage rate from the output production function and the marginal product of labor condition, in Eqs. (14) and (26), and substituting this into Eq. (33) gives the ratio $\frac{C}{Y}$ in terms of $\frac{l}{u}$:

$$\frac{C}{Y} = \frac{(1-\tau^{sw})(1-\tau^p)}{(1+\tau^{se})(1+\tau^v)}\frac{(1-\alpha)}{\epsilon}\frac{l}{u} \tag{34}$$

and using the $\frac{l}{u}$ ratio of Eq. (32), $\frac{C}{Y}$ is then a function of g and r:

$$\frac{C}{Y} = \frac{(1-\tau^{sw})(1-\tau^p)}{(1+\tau^{se})(1+\tau^v)}\left[\frac{(1-\alpha)}{\epsilon}\right]\left(\frac{A_h - \delta_h - r}{r-g}\right). \tag{35}$$

The ratio $\frac{C}{Y}$ is solved as a function of g alone by solving for r as a function of g from the Euler condition (Eqs. (5) and (9)):

$$(1+g)^\theta = \beta(1+r). \tag{36}$$

Next the ratio $\frac{I}{Y}$ is solved by first dividing the investment Eq. (13) by Y:

$$\frac{I}{Y} = (g + \delta_k)\frac{K}{Y}. \tag{37}$$

Simplifying the the steady state the expression for m in Eq. (23) to

$$m = \frac{\tau^c \delta}{\frac{r}{1-\tau^g} + \delta}, \tag{38}$$

the capital to output ratio $\frac{K}{Y}$ is given by combining the output production function and the marginal product of capital equations, (14) and (25):

$$(1 - \tau^c)\alpha \frac{Y}{K} = \left(1 - \tau^s - \frac{\tau^c \delta}{\frac{r}{1-\tau^g} + \delta}\right)\left(\frac{r}{1 - \tau^g} + \delta_k\right). \tag{39}$$

Solving for $\frac{K}{Y}$ from Eq. (39) and substituting this into Eq. (37) gives the solution for I/Y in terms of r and g. Substituting this solution for I/Y into the social resource constraint (29), gives the implicit solution for g in terms of only r:

$$1 - \frac{\Gamma}{Y} = \frac{(1-\tau^{sw})(1-\tau^p)}{(1+\tau^{se})(1+\tau^v)}\left[\frac{1-\alpha}{\epsilon}\right]\left[\frac{A_h - \delta_h - r}{r - g}\right] + \left[\frac{(g+\delta_k)(1-\tau^c)(1-\tau^g)\alpha}{(1-\tau^s)r + (1-\tau^s-\tau^c)(1-\tau^g)\delta}\right]\left[\frac{r + (1-\tau^g)\delta}{r + (1-\tau^g)\delta_k}\right]. \tag{40}$$

Given that $\frac{\Gamma}{Y}$ is exogenous and equal to γ, substituting into (40) for r from the Euler equation (36) gives an implicit equation only in g and allows all other BGP variables to be solved.

For example, the bond interest rate follows from Eq. (36); the time allocation among sectors comes from Eqs. (30) and (31); the capital-output ratio from Eq. (39), the investment-output ratio from Eq. (37), the consumption-output ratio from Eq. (34); and the first-order conditions for the firm give the effective labour to physical capital ratio and the wage rate. The share of profits in total output is obtained from (15).

Given Eqs. (36) and (40), the dividend and equity values relative to the capital stock can be solved as well. From Eq. (12) the balanced-growth path ratio K^a/Y is

$$\frac{K^a}{Y} = \frac{1}{g+\delta}\frac{I}{Y} = \frac{g+\delta_k}{g+\delta}\frac{K}{Y}, \tag{41}$$

giving that the steady state dividends to physical capital ratio D/K, from Eqs. (15), (20), (25), (26) and (41), is

$$\frac{D}{K} = (1 - \tau^s - \tau^*)\left(\frac{r}{1-\tau^g} - g\right), \tag{42}$$

where τ^* is

$$\tau^* = \frac{\tau^c \delta(\delta - \delta_k)}{\left(\frac{r}{(1-\tau^g)} + \delta\right)(g + \delta)}$$

and where it is noted that g is independent of the tax rate on dividends, by Eq. (40). From Eq. (19), the steady state equity value to physical capital is given by

$$\frac{V}{K} = \frac{(1-\tau^d)}{(1-\tau^g)}(1 - \tau^s - \tau^*). \tag{43}$$

McGrattan and Prescott (2005) derive a similar expression for the value of the firm; similar to their Propositions 2 and 5, it can be shown that if changes in the tax on dividends are offset by changes in lump-sum transfers, then the equilibrium path is unchanged.[4]

3. Social planner optimum

The social planner maximizes utility in Eq. (1), subject to time and goods constraints in Eqs. (2) and (29), technology in Eqs. (14) and (3), capital accumulation in Eq. (13) and the government spending condition in Eq. (28). The competitive equilibrium conditions that replicate the social planner first-order conditions achieve the second-best optimum given positive government expenditure; zero taxes and zero government expenditure are the first-best optimum. The following proposition states one such second-best optimum, which is a special case of Turnovsky (2000).

[4] Note that in Turnovsky (1995, Chapters 10 and 11)), the personal income tax falls on income from wages, interest income and dividends, while in our paper each of these income sources has a different tax rate according to the tax structure of the Baltics; here interest income from the government bonds is not taxed. This results in the dividend tax not having a growth effect. And although Turnovsky (1995) also finds that the personal income tax does not affect the cost of capital when investment is financed through retained earnings, the personal income tax still affects the interest rate and hence the growth rate in Turnovsky and here.

Proposition 1. *Given $\tau^{sw} = \tau^{se} = \tau^v = \tau^g = \tau^s = \delta = 0$, equal flat rate taxes on personal and corporate income are second-best optimal.*

Proof. The first order conditions of the social planner's problem are similar to the ones obtained from the consumer and firm problems. But now, instead of (34) in the representative agent problem, by which $\frac{C_t}{Y_t} = \left[\frac{(1-\tau^{sw})(1-\tau^p)}{(1+\tau^{se})(1+\tau^v)}\right] \frac{(1-\alpha)}{\epsilon} \frac{l_t}{u_t}$, the social planner consumption ratio is

$$\frac{C_t}{Y_t} = [1-\gamma] \frac{(1-\alpha)}{\epsilon} \frac{l_t}{u_t} \tag{44}$$

and in the social planner's problem the first order conditions with respect to C_t and K_{t+1} are

$$C_t^{-\theta} l_t^{\varepsilon(1-\theta)} = \lambda_t$$

and

$$\lambda_t = \beta \lambda_{t+1} \left[(1-\gamma)\alpha A \left(\frac{K_{t+1}}{u_{t+1} H_{t+1}} \right)^{\alpha-1} + 1 - \delta_k \right],$$

where λ_t is the Lagrange multiplier of the social resource constraint. This implies that the Euler equation is

$$C_t^{-\theta} l_t^{\varepsilon(1-\theta)} = \beta C_{t+1}^{-\theta} l_{t+1}^{\varepsilon(1-\theta)} \left[(1-\gamma)\alpha A \left(\frac{K_{t+1}}{u_{t+1} H_{t+1}} \right)^{\alpha 1} + 1 - \delta_k \right]. \tag{45}$$

Defining the interest rate r_t as

$$r_t \equiv \frac{1}{\beta} \left(\frac{C_{t-1}}{C_t} \right)^{-\theta} \left(\frac{l_{t-1}}{l_t} \right)^{\varepsilon(1-\theta)} - 1, \tag{46}$$

which is equal to r_t in the competitive equilibrium (Eqs. (5) and (9)), then Eqs. (45) and (46) imply that

$$r_t + \delta_k = (1-\gamma)\alpha A \left(\frac{K_t}{u_t H_t} \right)^{\alpha-1}. \tag{47}$$

In the competitive equilibrium problem, the comparable equation is (25), by which $(1-\tau^s)\left(\frac{r_t}{1-\tau^g} + \delta_k\right) + m_t(\delta - \delta_k) - \tau^c \delta = (1-\tau^c)\alpha A \left(\frac{K_t}{u_t H_t}\right)^{\alpha-1}$, where $m_t = \tau^c \delta \sum_{j=1}^{\infty} \frac{(1-\delta)^{j-1}}{\prod_{i=1}^{j}\left(1+\frac{r_{t+i}}{1-\tau^g}\right)}$ from Eq. (23). Comparing Eq. (34) with (44), and Eq. (25) with (47), it can be seen that one way to implement this optimum is to set equal tax rates on personal and corporate income, at a level equal to the share of government expenditure in output: $\tau^p = \tau^c = \gamma$, with all other tax and subsidy rates set to zero ($\tau^{sw} = \tau^{se} = \tau^v = \tau^g = \tau^s = \delta = 0$). □

The equal flat tax rate optimum holds both along the transition path towards and at the BGP equilibrium. And the balanced tax optimum of $\tau^p = \tau^c = \gamma$ is found also in Turnovsky (2000), using his equations (19a) and (19b) under the assumptions that $\tau^v = 0$ and that government spending has zero utility or productive effect, as in our economy. More generally, Turnovsky derives results with positive effects of government spending.[5]

More generally, as an extension of Turnovsky (2000), the optimum can be similarly characterized when the social security and VAT tax rates, τ^{sw}, τ^{se} and τ^v, are not restricted to be zero.

Corollary 2. *Given $\tau^g = \tau^s = \delta = 0$, rather than equal personal and corporate income tax rates, a balanced tax rate optimum is now an equalization of the composite labor tax rate, defined as $1 - \frac{(1-\tau^{sw})(1-\tau^p)}{(1+\tau^{se})(1+\tau^v)}$, and the corporate tax rate:*

$$1 - \frac{(1-\tau^{sw})(1-\tau^p)}{(1+\tau^{se})(1+\tau^v)} = \tau^c = \gamma.$$

This corollary's more realistic setting implies that with positive social security and VAT taxes, $\tau^{sw} > 0, \tau^{se} > 0$ and $\tau^v > 0$, the personal income tax rate must be less than γ to achieve the optimum. The importance of this is that corporate tax rates would be higher than personal income tax rates in the optimum, even while the composite labor tax rate and corporate tax rate remained equal.

In the actual calibration of the model, given in the next section, the assumptions in the corollary are not too far amiss. For example, $\tau^s = 0$ is assumed in the corollary while the investment subsidy τ^s was zero only in Latvia and Estonia, and was 24% in Lithuania in 2000 (and zero in all countries in 2007). With $\tau^s > 0$, an optimum would result if the balance of tax rates were

[5] If government consumption is utility-enhancing as in Turnovsky (2000), then $U = \sum_{t=0}^{\infty} \beta^t \frac{(C_t l_t^{\epsilon} \Gamma_t^{\eta})^{1-\theta}}{1-\theta}$, and the condition for the second best optimum in Proposition 1 becomes $\tau^p = \tau^c = \gamma - \eta \frac{C}{Y}$ with other taxes equal to zero. Since, in general, C_t/Y_t is not constant along the transition path, the second best cannot be attained with constant tax rates, but it can still hold in the steady state. In the first best the share of government consumption is then given by $\gamma = \eta \frac{C}{Y}$.

modified from that given in the corollary to $1 - \frac{(1-\tau^{sw})(1-\tau^{p})}{(1+\tau^{se})(1+\tau^{v})} = \frac{\tau^{c}-\tau^{s}}{1-\tau^{s}} = \gamma$. In effect, the corporate tax rate would need to be even higher than in the corollary.

Or, alternatively, if $\delta = \delta_k$ and $\tau_s = \tau_g = -\gamma$, instead of $\tau^g = \tau^s = \delta = 0$ as in the corollary, then the economic and accounting depreciation rate would be the same and a positive investment tax would be combined with a subsidy to capital gains. In this case, the exact same balance of tax rates results as stated in the corollary.

4. Calibration of the baseline model for 2000

4.1. Baltic tax systems

Information about the Baltic tax rates in 2000 is contained in country reports of the IMF (1998–2001), while information on the 2007 tax rates can be found on the web-sites of the Ministries of Finance of all three countries. Table 1 summarizes the tax rates that are found in law and that are used in the baseline calibration of the 2000 Baltic tax regimes. While there are differences in tax rates across the Baltics, the similarities in the major taxes that form most of the government tax revenue show a high degree of harmonization in both 2000 and 2007.

4.1.1. Summary

Table 1 shows that the Baltic countries have opted over time for a reduction in the income taxes and, especially, in corporate income taxes. The corporate income tax fell by 2007 to 15% both in Latvia and Lithuania, while in Estonia tax rates on all sources of income was lowered to 22%. Additionally, tax on dividends was reduced to 15% and personal income tax to 27% in Lithuania. Other changes include the elimination of the investment subsidy in Lithuania with taxable income now being decreased by the value of the capital depreciation, with depreciation rates varying from 5% to 33%. In the calibration of the model the depreciation rate is set at 20%. Social security contributions paid by the employee is 3% and by the employer 27%, additionally the employer pays 3% for health insurance and 1% for accidents; it is similar in Latvia. In all Baltic states the base rate for the VAT has been 18%, which is set to the consumption tax rate, ignoring other miscellaneous excise taxes.

Statutory taxes are used in the calibration below. Note that calibrated tax rates often are estimated rather than those of the statutes. For example, Mendoza et al. (1994) calculates the effective tax rate as the ratio of tax revenues of the consolidated government to the tax base as calculated from national accounts; this is a type of average tax rate that the representative agent faces. However in the paper here, statutory taxes are used given that the tax rates in the Baltic countries are flat rate taxes that do not depend on the income level or the status of the enterprise. In addition, the tax bases of all taxes were widened over time so as to eliminate most of the exemptions. Deductions that allow for a decrease in taxable income are mainly of a lump-sum nature, with out affecting margins. An average tax rate on the basis of total tax revenue in the Baltic case may therefore be misleading in terms of the effect on margins and on growth, suggesting the modeling of the marginal tax rates by the statutory rates, which is how we proceed.

4.1.2. Details of Baltic tax laws

Taxation of capital gains and dividends is determined by either the law on personal income or the law on corporate income. Usually, in order to avoid double taxation, income that is already taxed as corporate income is not taxed again as personal income. All personal income that is derived from the ownership of enterprises through capital gains or dividends is not taxed in Latvia.

From January 1, 2000, Estonia introduced a tax law that abolishes taxation of profits but introduces taxes on distributed profits at the rate of 26/74. Thus as long as profits are retained by the company they are not subject to taxes. Enterprises pay on the behalf of owners taxes on dividends equal to 26/74 of the amount of paid dividends. This is the same as if the individual pays tax of 26% on dividends received. In order to simplify notation the model specifies that the tax on dividends is paid by the shareholder.

Table 1
Tax rates in Baltic countries for calibration.

Tax rate values		Estonia 2000	Latvia 2000	Lithuania 2000	Estonia 2007	Latvia 2007	Lithuania 2007
Consumption tax	τ^v	0.18	0.18	0.18	0.18	0.18	0.18
Personal income tax	τ^p	0.26	0.25	0.33	0.22	0.25	0.27
Social security contribution							
By workers	τ^{sw}	0.00	0.09	0.01	0.00	0.09	0.03
By employers	τ^{se}	0.33	0.28	0.30	0.33	0.2409	0.31
Corporate income tax	τ^c	0.00	0.25	0.24	0.00	0.15	0.15
Tax on dividends	τ^d	0.26	0.00	0.29	0.22	0.00	0.15
Tax on capital gains	τ^g	0.26	0.00	0.15	0.22	0.00	0.15
Investment subsidy	τ^s	0.00	0.00	0.24	0.00	0.00	0.00
Statutory tax depreciations	δ	0.00	0.40	0.00	0.00	0.40	0.20

In Lithuania the tax rate on enterprise income applied to legal persons was also decreased from January 1, 2000, to 24%, the rate applied previously to partnerships. Thus, starting in 2000, all enterprises were subject to the same tax rate. Lithuanian law on corporate income allows deductions from taxable income of either retained earnings or the amount of investment in long term assets; these cases coincide in the model. This implies setting the investment subsidy at a 24% rate. Such tax treatment of corporate profits is very close to the Estonian case because under the present specification of the model non-distributed profits are equal to investment.

Lithuanian law taxes capital gains only if they are not reinvested back into securities; the rate of taxation for such gains is 15%. However, in the model it is assumed that equities are neither sold nor bought, making for zero capital gains. On other hand, the model specifies that taxes are paid whenever the price of an equity increases so that the tax on capital gains occurs implicitly, on the accrued but yet unrealized capital gains; and taxes are reimbursed when the price of an equity decreases, again on an accrued basis. So to the extent that capital gains are reinvested in Lithuania and untaxed, the model overstates the effect of the tax.

Another way to promote investment is through a faster depreciation of capital since taxable income is also decreased by the amount of depreciation. Latvia especially uses depreciation as a tool for promoting investment by allowing a decrease in taxable income by double the depreciated amount of capital stock. In terms of this model it means that if statutory depreciation rate is δ, then in the model we must use the rate 2δ. Since official depreciation rate varies across different forms of equipment—from 10% on buildings to 35% on high-tech—a middle rate is chosen of 20%, which when doubled to 2δ is 40%.

4.2. Baseline calibration at Year 2000

Technological parameters are comprised by scale parameters of the human capital production function A_h, and the market good production function A, the share of physical capital income in output α and the 'true' depreciation rates of physical and human capital δ_k and δ_h. Preferences parameters are the coefficient of relative risk aversion θ, the leisure weight ϵ and the discount factor β.

Assuming that the economies are in the steady state before the tax rate changes, three of these parameters are estimated separately for each country using annual GDP data for 1995–2000: γ is set equal to the average share of government consumption in domestic demand, that is, GDP less net export, while the parameters α and ϵ are chosen to match the average shares of investment and consumption in domestic demand, respectively, using Eqs. (35), (37) and (39). These parameter estimates are based on GDP statistics by the expenditure approach at current prices, obtained from the online databases of national statistical offices (Statistics Estonia, Central Statistical Bureau of Latvia, Statistics Lithuania). Note that the resulting value of γ is approximately 0.2, which is also used in Funke and Strulik (2006) for Estonia.

The rest of the parameters are set equal across the three Baltic states. The parameters are chosen such that the long run growth rate is common for all three countries and is set at 2%. The steady state interest rate in each country is set equal to the world interest rate of 4.1% used in McGrattan and Prescott (2000), Tables 4 and 5 that approximately corresponds to the risk-free rate on 30-year inflation-protected US Treasury bonds in the 1st quarter of 2000. Assuming the coefficient of relative risk aversion equal to $\theta = 1.5$, the discount factor is $\beta = 0.99$ according to Eq. (36). We assume that physical capital becomes obsolete at a faster rate than human capital, setting $\delta_k = 0.1$ and $\delta_h = 0.01$ in all three countries, similar to Jones et al. (2005) who discuss the different estimates of δ_h at length. The parameter A_h is chosen such that approximately 50% of time are spent on leisure and 20% on work (which corresponds to 1840 annual hours of work) according to Eqs. (30) and (31). Finally, the scale parameter A affects the ratio of physical to human capital in the economy and this is normalized to $A = 1$.

Table 2 reports the parameter values and the implied steady state values for each country. The values of α differ substantially due to considerable differences in the average ratios of investment to domestic demand across the Baltic states. The lowest ratio is 20% for Latvia, while the highest is 26.9% for Estonia. And, consequently, Latvia has the highest and Estonia the lowest C/Y ratio since the shares of government consumption are approximately the same. This, in turn, results in the highest steady state K/H and K/Y ratios for Estonia and the lowest ratios for Latvia. In the case of Estonia, the steady state value of the firm is equal to the capital stock according to (43) since $\tau^d = \tau^g$ and $\tau^s = \tau^* = 0$.[6] While for Lithuania the market value of a unit of the firm's capital V/K is the lowest. No data appear to be available on the capital to output ratio K/Y and the value of equity to output ratio V/Y for the Baltic countries; but for comparison to Table 2 note that McGrattan and Prescott (2005), Tables 4 and 5 report that the (sum of tangible and intangible) capital to output ratio was 1.68 for the US and was 1.96 for UK during 1990–2001, while the value of equity to output ratio, respectively, was 1.576 and 1.845 during 1998–2001.

4.3. Sensitivity analysis

Table 3 shows for Latvia variations in the equilibrium variables when one parameter is increased, with all other parameters staying at the benchmark values. The largest variations in the growth rate g come from changes in utility parameters and parameters affecting human capital accumulation. Results for the other two countries are similar and not shown.

[6] By substituting (26) and (25) into (24), one can verify that under Estonian tax system, $V_t = K_t$ also holds outside the steady state.

Table 2
Baseline calibration: 2000.

Latvia								
θ	ϵ	β	α	A	A_h	δ_k	δ_h	γ
1.5	1.35	0.990	0.242	1	0.100	0.1	0.01	0.205
g	r	l	u	z	K/H	C/Y	K/Y	V/Y
0.020	0.041	0.491	0.209	0.299	0.411	0.595	1.667	1.397
Estonia								
θ	ϵ	β	α	A	A_h	δ_k	δ_h	γ
1.5	1.35	0.990	0.348	1	0.100	0.1	0.01	0.203
g	r	l	u	z	K/H	C/Y	K/Y	V/Y
0.020	0.041	0.489	0.211	0.301	0.726	0.528	2.241	2.241
Lithuania								
θ	ϵ	β	α	A	A_h	δ_k	δ_h	γ
1.5	1.35	0.990	0.259	1	0.103	0.1	0.01	0.205
g	r	l	u	z	K/H	C/Y	K/Y	V/Y
0.020	0.041	0.504	0.204	0.292	0.435	0.585	1.750	1.111

Table 3
Alternative parameter values and the Latvian calibration.

	g	r	l	u	z	K/H	C/Y	K/Y	V/Y
$\theta = 1.80$	0.014	0.037	0.531	0.225	0.244	0.460	0.598	1.719	1.434
$\epsilon = 1.70$	0.016	0.035	0.553	0.188	0.259	0.394	0.592	1.750	1.460
$\beta = 0.995$	0.027	0.046	0.442	0.189	0.369	0.354	0.591	1.605	1.352
$\alpha = 0.30$	0.020	0.041	0.490	0.210	0.300	0.590	0.547	2.062	1.728
$A_h = 0.13$	0.030	0.057	0.485	0.204	0.311	0.343	0.602	1.482	1.256
$\delta_k = 0.13$	0.020	0.041	0.489	0.210	0.301	0.319	0.589	1.372	1.172
$\delta_h = 0.02$	0.016	0.036	0.446	0.191	0.364	0.396	0.592	1.740	1.452
$\gamma = 0.25$	0.021	0.043	0.471	0.217	0.313	0.416	0.551	1.640	1.377

4.4. Transition dynamics

To solve for the welfare effects of tax changes, transition dynamics to the new steady state need to be taken into account. In particular, the paths of consumption and leisure after a tax reform, and the subsequent utility changes, must be calculated. To do this we define the policy functions as the time t optimal value of each variable given the state of the system, where the state variable is $k_t = K_t/H_t$, and where these functions are given implicitly by the following dynamic system of equilibrium conditions; variables growing in the long run are normalized by human capital, with the notation $k_t = K_t/H_t, c_t = C_t/H_t$ and $y_t = Y_t/H_t$:

$$c_t^{-\theta} l_t^{\epsilon(1-\theta)} = c_{t+1}^{-\theta}(A_h z_t + 1 - \delta_h)^{-\theta} l_{t+1}^{\epsilon(1-\theta)} \beta(1 + r_{t+1}), \tag{48}$$

$$w_t(1 + r_{t+1}) = w_{t+1}[A_h(1 - l_{t+1}) + 1 - \delta_h], \tag{49}$$

$$c_t = \frac{(1 - \tau^{sw})(1 - \tau^p)}{(1 + \tau^v)\epsilon} w_t l_t, \tag{50}$$

$$w_t(1 + \tau^{se}) = (1 - \alpha) A k_t^{\alpha} u_t^{-\alpha}, \tag{51}$$

$$(1 - \tau^s)\left(\frac{r_t}{1 - \tau^g} + \delta_k\right) + m_t(\delta - \delta_k) - \tau^c \delta = (1 - \tau^c)\alpha A k_t^{\alpha-1} u_t^{1-\alpha}, \tag{52}$$

$$y_t = A k_t^{\alpha} u_t^{1-\alpha}, \tag{53}$$

$$l_t + u_t + z_t = 1, \tag{54}$$

$$(1 - \gamma) y_t = c_t + k_{t+1}(A_h z_t + 1 - \delta_h) - (1 - \delta_k) k_t, \tag{55}$$

$$(1 - \tau^g + r_{t+1}) m_t = (1 - \tau^g)\tau^c \delta + (1 - \tau^g)(1 - \delta) m_{t+1}. \tag{56}$$

Following Judd (1992), we use a projection method to approximate the policy functions for consumption c and the time allocated to work u, and variable m as functions of capital:

$$c(k) = \sum_{i=1}^{n} \varphi_i(k) a_i^c, \quad u(k) = \sum_{i=1}^{n} \varphi_i(k) a_i^u, \quad m(k) = \sum_{i=1}^{n} \varphi_i(k) a_i^m$$

where φ_i are Chebyshev polynomials and the coefficients a_i^c, a_i^u, and a_i^m are found using the orthogonal collocation method: the coefficients are chosen so that the system of Eqs. (48)–(56) is satisfied exactly for n different values of k; $(k_t)_{t=1}^{n}$ are chosen to satisfy $\sum_{t=1}^{n} \varphi_i(k_t)\varphi_j(k_t) = 0$ for $i \neq j$. Throughout we set $n = 9$ and choose the domain of approximation $[\frac{2}{3}k^{ss}, \frac{4}{3}k^{ss}]$,

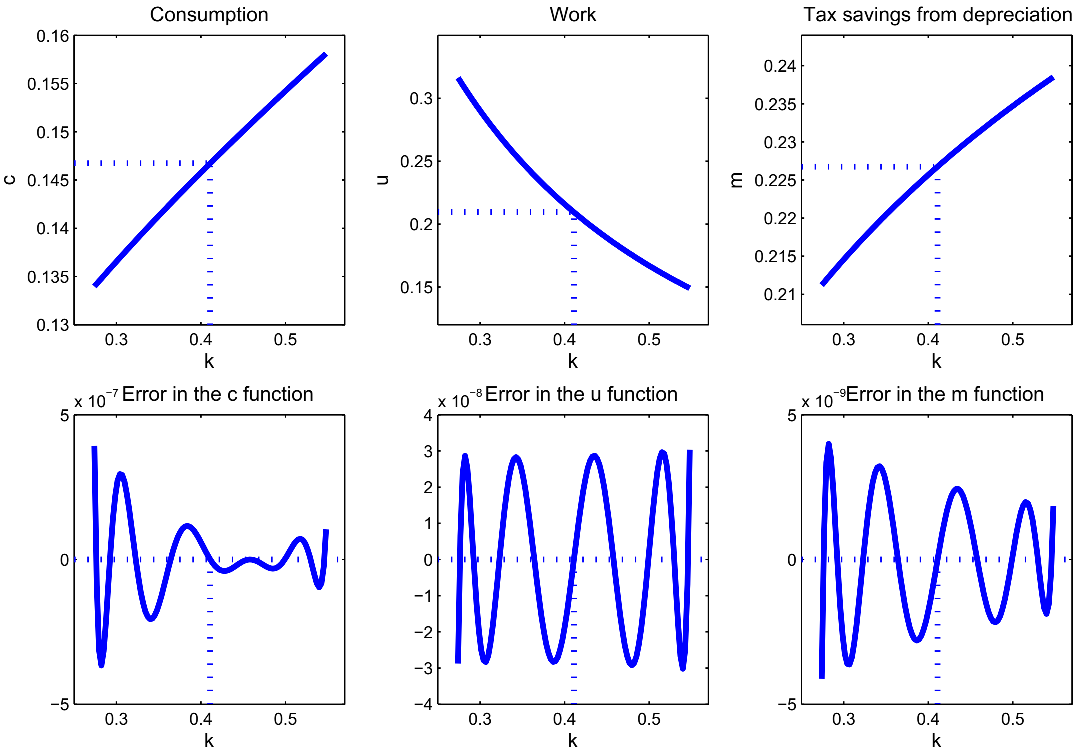

Fig. 2a. Policy functions and errors of approximation.

where k^{ss} is the steady state K/H ratio. The choice of domain also ensures that one of Chebyshev nodes coincides with the steady state value, $k_t = k^{ss}$.

Using tax rates of Latvia in 2000, the consumption c, the time allocated to work u, and the tax savings from depreciation, m, are given as functions of capital k in Fig. 2a. The wage rate w, the time allocated to leisure l and to human capital production sector z, the interest rate r, investment i and output y are given similarly in Fig. 2b. Fig. 2a also shows the approximation error for the policy functions c, u and m. With the physical to human capital ratio above its steady state level, more of the output is consumed and less is invested. Human capital accumulation is accelerated by devoting more time to this sector in order to bring the economy to the steady state. It not only decreases the time allocated to work but also to leisure. The latter is compensated with increased consumption. A higher capital stock and less time devoted to work imply that the wage is above while the interest rate is below their respective steady state values. Since m is inversely related to the interest rate, m exceeds its steady state value. Note that the decrease in the work time more than offsets the higher-than-steady-state value of the capital stock, leading to a lower output to human capital ratio.[7]

When a tax change occurs, the economy is pushed out of the steady state and must re-adjust back to a new steady state. The policy functions give the values of each variable given the state variable at each time period, and these values change over time as the state variable gradually re-adjusts to its new balanced growth path equilibrium value. The results for Latvia are given in Fig. 3 (the dotted line indicates the old steady state values). This illustrates the transition of different variables to the new steady state using the policy function computed above and assuming that the economy was initially in the steady state corresponding to the year 2000 tax rates. It results that in order to move to the new steady state, the agent accumulates additional physical capital. Time allocated to work u is above the steady state level, leading to higher-than-steady-state output y, lower consumption c, and, consequently, higher investment. The accumulation of human capital slows down due to a decrease in z, while lower consumption is compensated by higher-than-steady-state leisure l. Note that, except for period $t = 0$ when the tax rates change, during the transition period the economy exhibits a lower growth rate of output Y_{t+1}/Y_t compared with the new steady state rate. Since the accounting capital stock is a fraction of the physical capital stock, the increase in investment during transition causes the accounting capital to overshoot its steady state ratio. As a result, the value of the company and dividends to human capital also slightly overshoot their long run ratios. Results for Estonia are very similar and not shown.

For Lithuanian transition dynamics, unlike the Latvia and Estonia, the new steady state capital stock of 0.418 is below the old steady state level of 0.435. Therefore, the Lithuanian transition pattern (not shown) is the opposite of those for the other two Baltic countries. The accumulation of physical capital is decelerated while the accumulation of human capital is accel-

[7] When considering the other two countries and performing tax experiments, we must again solve for the policy functions using new tax rates. Since the functions slope the same way as the corresponding functions in Figs. 2a and 2b, we do not present them again. The magnitudes of the error of approximation are also similar to those shown in Fig. 2a. Note, however, when $\delta = 0, m = 0$ according to (23) and we only need to solve for $c(k)$ and $u(k)$.

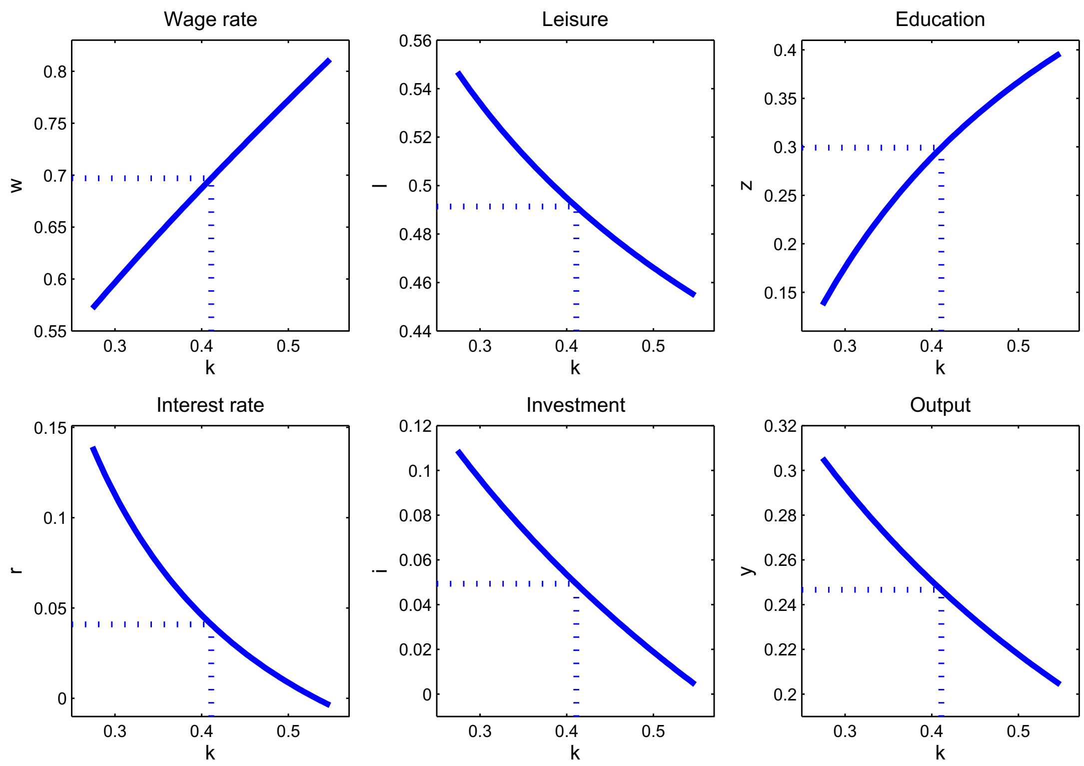

Fig. 2b. Policy functions.

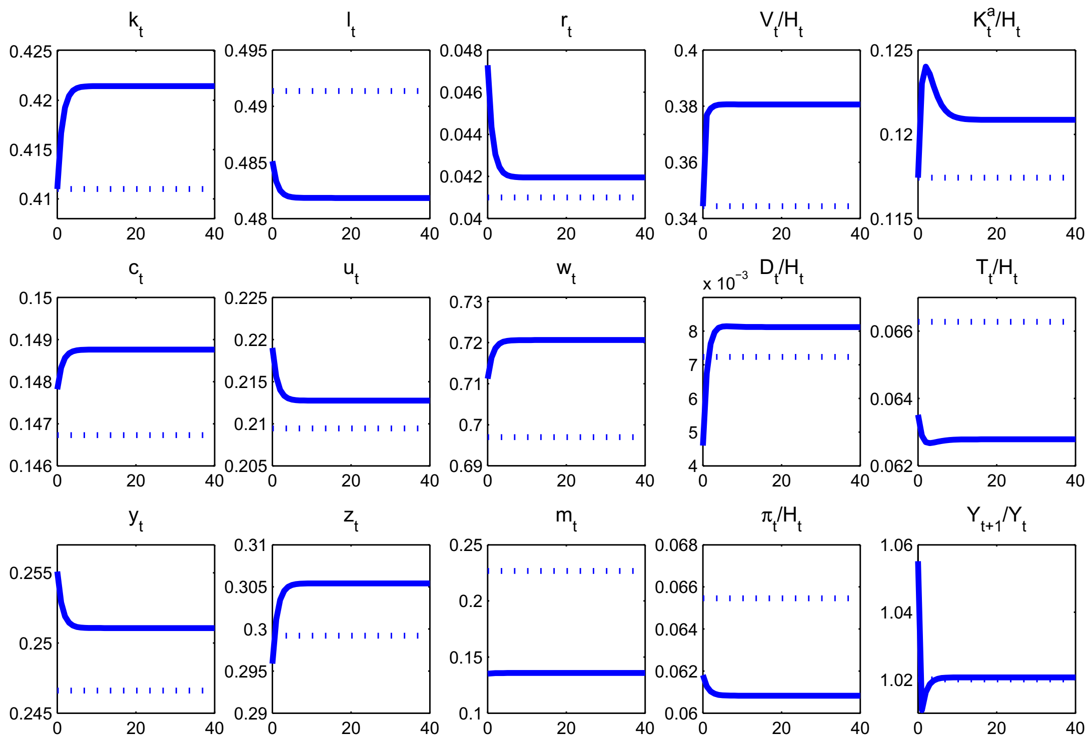

Fig. 3. Transitional dynamics for Latvia.

erated by devoting less time to work u and more time to human capital production z than in their new steady state levels. This leads to higher-than-steady-state consumption but lower output and investment. Higher consumption compensates for a lower-than-steady-state value of leisure l.

5. Tax reform effects from 2000 to 2007

After setting out the compensating utility measure, Section 5.1 establishes the maximum possible gains from tax reforms, starting with the 2000 baseline system and moving to the (second-best) optimum of flat rate taxes as in Proposition 1. Section 5.2 presents the actual growth rate and utility changes of the 2000–2007 reforms. And Section 5.3 shows the contribution of each type of tax to growth and welfare under the assumption that the same tax revenue is raised as under the 2007 tax law, when only one tax is changed; this provides a comparison of the different taxes in the sense of which are the best ones to use to raise revenue. Note that all comparisons of actual and experimental reforms are conducted using the long run steady state and always include the transition dynamics; in other words, we calculate the welfare gains accruing from the date of reform to infinity.

The compensating consumption measure is constructed by following Lucas (1990) and defining the indirect utility function $W(\xi,\tau)$ as

$$W(\xi,\tau)=\sum_{t=0}^{\infty}\beta^t\frac{((1+\xi)C_t l_t^{\epsilon})^{1-\theta}}{1-\theta}.$$

This is the utility the consumer obtains under the tax system $\tau=(\tau^c,\tau^p,\tau^{sw},\tau^{se},\tau^v,\tau^d,\tau^g,\tau^s,\delta)$ when in addition there is a consumption supplement of ξC_t at each date t. When the tax system changes from a set of initial rates, say τ_{old}, to a new set of rates, say τ_{new}, the percent of consumption goods that compensate utility for the new tax system τ_{new} is equal to the ξ that equates utility in the new regime to the utility of the old regime (when $\xi=0$), as given by the following standard equation:

$$W(\xi,\tau_{old})=W(0,\tau_{new}). \tag{57}$$

Assuming the economy is in the steady state under the old tax system, then $C_t=C_0(1+g)^t$ while l_t is constant and $W(\xi,\tau_{old})$ is equal to

$$W(\xi,\tau_{old})=\frac{((1+\xi)C_0 l^{\epsilon})^{1-\theta}}{1-\theta}\frac{1}{1-\beta(1+g)^{1-\theta}},$$

where C_0, l and g are steady state values corresponding to the baseline calibration. Here human capital is normalized at date $t=0$ to $H_0=1$. The representation of $W(0,\tau_{new})$ is more complex in that it includes consumption and leisure both along transition path and in the new steady state; this is computed numerically.

5.1. Maximum possible gain from tax reform

In this economy, the gain from moving to the second-best optimum of equal flat rate taxes on personal and corporate income provides an upper bound to the potential welfare gains from tax reform. The implementation of the second-best optimum assumes that the Baltic economies start in steady state in 2000, and move to the new second-best optimum. Table 4 reports values of variables in the steady state of the second best optimum; Table 5 summarizes the total welfare gains including transition dynamics and the impact on the government budget as a result of going to the second best optimum. The total utility gains, in consumption terms, for Latvia, Estonia and Lithuania, respectively, are $\xi=13.75\%$, $\xi=11.18\%$ and $\xi=16.27\%$. The steady state growth rate increases by almost one percentage point in all three economies.

Table 5 also shows the impact of the tax changes on revenues, where notationally, *PVR* is the present value of government revenues, *PVT* the present value of government transfers and *PVY* the present value of output. The table indicates that a result of such a flat rate policy is that the present discounted value of all future tax revenue falls; for example, in the case of Latvia the decline is from 5.791 to 2.395. However the model does allow implementation of the second best outcome with the same revenue as in 2000 by using in addition the VAT tax, if there are no restrictions on the signs of tax rates. With

Table 4
The second best outcome.

Latvia								
g	r	l	u	z	K/H	C/Y	K/Y	V/Y
0.0285	0.054	0.362	0.255	0.384	0.342	0.634	1.251	1.251
Estonia								
g	r	l	u	z	K/H	C/Y	K/Y	V/Y
0.0277	0.053	0.370	0.252	0.378	0.629	0.565	1.816	1.816
Lithuania								
g	r	l	u	z	K/H	C/Y	K/Y	V/Y
0.0295	0.056	0.362	0.254	0.384	0.371	0.623	1.326	1.326

Table 5
Second best optimal changes in utility, growth and revenue.

		Second best optimum		
		Latvia	Estonia	Lithuania
$\xi\%$		13.747	11.182	16.270
Δg		0.0085	0.0077	0.0095
PVR	2000	5.791	6.686	6.088
	Post-reform	2.395	3.090	2.401
ΔPVR		−3.397	−3.596	−3.687
γ	2000	0.205	0.203	0.205
	Post-reform	0.205	0.203	0.205
PVT/PVY	2000	0.269	0.213	0.289
	Post-reform	0	0	0
PVR/PVY	2000	0.474	0.416	0.494
	Post-reform	0.205	0.203	0.205

$\tau^{sw} = \tau^{se} = 0$, Eqs. (34) and (44) imply that a necessary condition for optimality is $\frac{1-\tau^p}{1+\tau^v} = 1-\gamma$. Given that this condition holds and using Eq. (33), the sum of consumption and personal income tax revenues is

$$\tau^v C_t + \tau^p w_t u_t H_t = \frac{\tau^v (1-\tau^p) w_t l_t H_t}{(1+\tau^v)\epsilon} + \tau^p w_t u_t H_t = \left\{ \tau^v (1-\gamma)\left(\frac{l_t}{\epsilon} - u_t\right) + \gamma u_t \right\} w_t H_t$$

In case of Latvia, when moving from the tax system of 2000 to this second best tax regime, all along the transition path the term $[(l_t/\epsilon) - u_t]$ is positive. This means that government revenue is maximized if τ^v is set as high as possible, and employment is subsidized, $\tau^p < 0$. The government can raise $PVR = 5.791$ as in the Latvian 2000 tax system, although not realistically, with $\tau^c = 0.205, \tau^v = 8.1453, \tau^p = -6.2705$ and the rest of taxes set equal to zero.

5.2. Actual utility gain from tax reform

Table 6 summarizes the results of the marginal growth rate increases and the more significant consumption-equivalent utility gains for the actual 2000–2007 tax changes in each of the Baltic countries, including transition dynamics. The utility gains are around 2%, with $\xi = 1.54\%$, 2.29%, and 2.64% for Latvia, Estonia and Lithuania. Estonia and Lithuania each reduced the personal income tax rate while Latvia did not, which may explain the bigger gains in these two countries. And Lithuania, with the highest gain, in addition reduced the corporate tax rate, while Estonia did not. Reform benefits of each tax is explored next in Section 5.3.

Note that the importance of including the transition dynamics is that without including them the ranking of the gains from reform changes somewhat, although the magnitude of the gains only changes by about 10%. If the effect of the transition dynamics is not included, the utility gain from going straight to the 2007 steady state would be 1.693% for Latvia, 2.619% for Estonia and 2.366% for Lithuania. Estonia now would end up with the biggest gain. This change in ranking occurs because the transition dynamics cause Latvia and Estonia to have a lower gain, and Lithuania to have a bigger gain. As Section 4.4 describes, the transition dynamics for Lithuania are different because the capital stock in the 2007 steady state after the

Table 6
Actual reform changes in utility, growth and revenue.

		Actual tax changes		
		Latvia	Estonia	Lithuania
$\xi\%$		1.536	2.286	2.635
Δg		0.0006	0.0011	0.0008
PVR	2000	5.791	6.686	6.088
	Post-reform	5.551	6.232	5.782
ΔPVR		−0.240	−0.454	−0.306
γ	2000	0.205	0.203	0.205
	Post-reform	0.205	0.203	0.205
PVT/PVY	2000	0.269	0.213	0.289
	Post-reform	0.250	0.188	0.267
PVR/PVY	2000	0.474	0.416	0.494
	Post-reform	0.455	0.391	0.472

Table 7
2007 Baltic tax system.

Latvia								
g	r	l	u	z	K/H	C/Y	K/Y	V/Y
0.021	0.042	0.482	0.213	0.305	0.421	0.593	1.679	1.516
Estonia								
g	r	l	u	z	K/H	C/Y	K/Y	V/Y
0.021	0.043	0.472	0.216	0.311	0.751	0.524	2.252	2.252
Lithuania								
g	r	l	u	z	K/H	C/Y	K/Y	V/Y
0.021	0.042	0.492	0.208	0.300	0.418	0.593	1.674	1.583

Table 8
Revenue equivalent changes of each tax.

	Latvia			Estonia			Lithuania		
	Tax rate	g	$\xi\%$	Tax Rate	g	$\xi\%$	Tax rate	g	$\xi\%$
τ^p	0.2157	0.0208	2.0777	0.2065	0.0212	2.8098	0.2891	0.0211	2.9844
τ^{sw}	0.0484	0.0208	2.0777	−0.0723	0.0212	2.8098	−0.0505	0.0211	2.9844
τ^{se}	0.2241	0.0208	2.0777	0.2404	0.0212	2.8098	0.2252	0.0211	2.9844
τ^v	0.1482	0.0205	1.2883	0.1290	0.0208	1.8218	0.1394	0.0206	1.7954
τ^c	−0.1238	0.0202	0.2309	−0.0763	0.0207	0.4913	0.1711	0.0206	0.5972
τ^d	−0.6701	0.0200	0	−0.3324	0.0200	0	−0.5928	0.0200	0
τ^g	−0.6496	0.0209	0.4580	−0.0007	0.0210	0.5558	−0.2671	0.0208	0.7153
τ^s	0.0603	0.0205	0.3800	0.0774	0.0208	0.5143	0.3074	0.0206	0.6256

tax reform is lower than in the 2000 steady state, while for Latvia and Estonia the post-reform capital stock is higher. And in short, increasing the capital stock requires lower consumption on the transition, while decreasing the capital stock leads to higher consumption on the transition.

In terms of tax revenue, and assuming here that the government share of output remains at γ, Table 6 also shows that the *PVR* and the ratios of *PVT*/*PVY* and *PVR*/*PVY* of each country dropped modestly after the reform. Other equilibrium values for each of the countries are given in Table 7, which compare to the baseline in Table 2.

5.3. Experimental tax reform

There are better ways in which tax rates could have been changed compared to the actual tax reforms, while keeping discounted tax revenues constant at the same lower level as was found post-reform (with *PVR* at 5.551, 6.232, and 5.782 for Latvia, Estonia and Lithuania). A simple way to show this is to consider decreasing just one tax so as to generate the entire revenue decrease of 2007, starting from the 2000 baseline, and to compare this result across all of the taxes, and for each country. Table 8 gives the new compensated utility gains from such experiments, with transition dynamics always included. Since some initial tax rates are zero or close to zero, almost half of the new rates end up being negative, which is not realistic. But still this experiment shows the welfare ranking of each tax, and it can be seen that the ranking is the same for all three economies. The highest gain is from lowering the personal income tax or social security contributions, followed by the VAT; the corporate income tax generates the lowest welfare gain (except for the 0 effect of the non-distortionary dividend tax). This is consistent with Lithuania and Estonia having higher gains from the 2000–2007 changes than did Latvia, in that Latvia did not decrease the personal income tax while the other two nations did.[8]

Table 9 shows that using higher but equal flat tax rates on personal and corporate income, with all other taxes set to zero as in the optimum of Proposition 1 and with the same revenue as is found for 2007, also leads to bigger welfare gains than the actual reforms for all countries. The gains are 2.214, 2.556 and 3.032 for Latvia, Estonia and Lithuania, as compared to 1.536, 2.286 and 2.635 in Table 6 for the three countries under the actual reforms; this gives a simple average of 24% higher gains in the Baltics.

And the flat tax gains are bigger than the gains seen in all of the previous experiments in Table 8 for Latvia and Lithuania. For Estonia, the first three tax reductions in the personal and social security taxes yield a gain of 2.81% in Table 8 which is better than the 2.56% gain from the flat tax policy in Table 9. In sum, the experiments show that equal flat rate taxes are very

[8] We do not report revenue equivalent changes in the depreciation rate δ. First, in the case of Estonia, variations in the depreciation rate do not affect tax revenues because $\tau^c = 0$. Second, in the case of Latvia a value of δ cannot be found that generates $PVR = 5.551$ without leading to an explosive path of k^a_t. For Lithuania, $\xi = 0.6203\%$ when $\delta = 0.0190$, assuming $k^a = 0.2372$ which is obtained by setting $\delta = 0.2$ in Eq. (41).

Table 9
Revenue equivalent tax changes with flat tax.

		$\tau^c = \tau^p$		
		Latvia	Estonia	Lithuania
$\tau^c = \tau^p$		0.447	0.394	0.456
$\xi\%$		2.214	2.556	3.032
Δg		0.0012	0.0017	0.0016
PVR	2000	5.791	6.686	6.088
	Post-reform	5.551	6.232	5.782
ΔPVR		−0.240	-0.454	−0.306
γ	2000	0.205	0.203	0.205
	Post-reform	0.205	0.203	0.205
PVT/PVY	2000	0.269	0.213	0.289
	Post-reform	0.242	0.191	0.251
PVR/PVY	2000	0.474	0.416	0.494
	Post-reform	0.447	0.394	0.456

attractive, but also that just balancing out the system better in terms of reducing the composite labor tax can be the best reform.

6. Discussion

The tax reform results are limited to the set of assumed taxes. For example, Stokey and Rebelo (1995) allow human capital production to be taxed, which allows for a higher impact of tax rates on growth. And extending the Section 2 model to allow for both equity and debt finance allows for the dividend tax to be distortionary as in Kim (1998), where labor taxes also directly effect the real interest rate. But also important, in finding the effect of reforms, is what is the initial set of tax rates.

For example, in contrast to Section 5's results, Devereux and Love (1994) find that the consumption tax dominates the personal income tax, which in turn dominates the corporate income tax, with this ranking holding for both growth rates and utility. Yet what emerges is that not that the models are inherently at odds. Rather such a difference can occur because of different initial distributions of the tax rates. In support of how the ranking of reforms depends on the initial tax system, Table 10 replicates the Devereux and Love (1994) ranking under one set of initial tax rates but replicates the ranking of Section 5 under a different initial set of tax rates.

Using a hypothetical initial set of tax rates (rather than the baseline calibration), Table 10 sets the government consumption of taxes to zero, so that $\gamma = 0$, and all tax revenues raised are returned lump sum to the consumer. Then initial tax rates are also all set to zero, in the first experiment, so that with $\gamma = 0$ the economy is at its (first-best) optimum; second, initial taxes on personal income and consumption goods are set at 0.25, so that in this case the economy is not at its optimum, with components of the composite labor tax being over-taxed.

The rest of parameters are set as in baseline calibration for Latvia. The left-hand side of Table 10 shows the growth and utility changes starting from 0 initial tax rates and then raising a set amount of tax revenue ($PVT = 0.25$) from just a single tax increase, for each of four different taxes. This shows that raising the revenue using the VAT is best, followed closely by raising the personal income tax rate, while raising the revenue with the corporate tax leads to a much bigger loss of utility; this is the same ranking as in Devereux and Love (1994). But now consider the right-hand side columns of the Table 10. With the initial tax rates for both personal income and the VAT now assumed to be equal to 25%, instead of 0, and all other tax rates equal zero, the initial tax revenue is $PVT = 4.79$. The same experiment is run of increasing tax revenue by the same amount of $PVT = 0.25$, from $PVT = 4.79$ to $PVT = 5.04$, with just one tax. With composite labor taxes over-taxed through already high taxes on personal income and consumption, this results in a re-ordering of the utility ranking to that of Section 5: raising the additional revenue through the corporate tax rate is now much better for utility than raising the revenue with the personal income tax, while the VAT is marginally worse than the corporate income tax.

Table 10
Raising revenue from different initial tax distributions.

	Tax revenue: $0 \rightarrow 0.25$				Tax revenue: $4.79 \rightarrow 5.04$			
	Tax rate		g	$\xi\%$	Tax rate		g	$\xi\%$
	Initial	New			Initial	New		
τ^p	0	0.0271	0.0280	−0.0338	0.25	0.2755	0.0193	−1.7305
τ^v	0	0.0258	0.0281	−0.0289	0.25	0.2748	0.0196	−0.9746
τ^c	0	0.0856	0.0281	−0.1676	0	0.0742	0.0196	−0.9737
τ^d	0	0.5124	0.0285	0	0	0.5618	0.0199	0

7. Conclusions

The model includes a comprehensive corporate sector within a Lucas (1988) human capital economy, with transition dynamics as in Lucas (1990), and with a second-best optimum of flat taxes on corporate and labor income resulting when government spending is constrained to be a fraction of output. Moving to the flat tax optimum from the 2000 tax rate law, welfare improvements were 11–16% of consumption, as compared to a utility gain from the actual 2000–2007 tax reforms ranging from 1.5% to 2.6%, with Lithuania having the highest gain. Experiments show that a personal income tax reduction alone, or going to equal flat tax rates on personal and corporate income, each give utility gains higher than actual reforms. Given initial Baltic tax rates, results suggest an imbalance of taxes causing welfare to be lower than it necessary.

The social security taxes would differ in effect from the personal income tax if benefits of pension were modeled, which would be a useful albeit difficult extension. Similarly the general public benefits of government expenditure are not modelled here although public capital has benefits that could affect the optimal balance of the tax system. Inclusion of the inflation tax would appear to increase the composite labor tax and suggest a somewhat greater reliance on capital rather than labor taxes as being optimal. Similarly, including evasion of taxes would seem to go in the direction of making balanced labor and capital taxes desirable.

These extensions may strengthen the intuition that large imbalances between the effective, or composite, capital and labor tax rates may not create the best tax system. This leaves the analysis with government expenditure as a constant fraction of output as one answer for why adoption of zero capital tax rates may not be widespread in practice. And it demonstrates that the Baltic countries, and other similarly configured countries, might be better off with more balanced effective labor versus capital tax rates.

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