CARDIFF BUSINESS SCHOOL
WORKING PAPER SERIES

**Cardiff Economics
Working Papers**

Helmuts Āzacis and Max Gillman

# *Baltic Tax Reform*

E2008/6

Cardiff Business School
Cardiff University
Colum Drive
Cardiff CF10 3EU
United Kingdom
t: +44 (0)29 2087 4000
f: +44 (0)29 2087 4419
www.cardiff.ac.uk/carbs

ISSN 1749-6101
February 2008, updated October 2008

# Flat Tax Reform: The Baltics 2000 - 2007

Helmuts Āzacis
Cardiff Business School

Max Gillman
Cardiff Business School
EIHAS, Budapest

October 28, 2008

**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 24% more on average than the actual reforms. This shows how equal, balanced, flat rate taxes can be optimal in both theory and practice. Further, movement towards a more equal balance between labor and capital tax rates, through changing just one tax rate, achieved almost as high or higher utility gains as in actual law for all three countries under both open and closed economy cases. This shows benefits of moving towards the optimum.

*JEL*: E13, H20, O11, O14

*Keywords*: tax reform, endogenous growth, transitional dynamics, flat taxes

# 1 Introduction

The theoretically optimal capital tax in a second-best setting is to build up revenue by initially taxing capital at high rates and then decreasing the capital tax to zero in the long run (Ljungqvist and Sargent, 2000). But in practice, there is not an obvious international trend towards zero capital tax rates, and an initial build-up of taxes does not appear to have been documented. What we do see is that the level of tax rates on both capital and labor have trended down over time; and perhaps they have become more "balanced". For example in 1952 the US tax rate for the top-bracket of personal income was 92% and the top-bracket corporate income tax was 52% and now both of these are 35%.

However, evidence is more extensive for movements towards low flat taxes, which has been called "The Global Flat Tax Revolution" (Mitchell, 2007). A flat tax can refer to a single tax rate bracket on either personal or corporate income; there are many countries with a single tax bracket for each personal and corporate income tax rates; in some countries there are equal flat tax rates on both personal and corporate income (Romania- 16%; Serbia- 14%); and one at least even has equal rates on personal, corporate and on the value-added tax (Slovakia- 19%).

There are good reasons for these flat regimes in terms of the benefits of tax simplification for these systems, and for low tax rates in terms of decreasing the tax-induced disincentive to work, accumulate capital, and sell goods. It remains unclear however whether more balanced flat rate systems are better than more unbalanced ones. For example, the Baltic countries have low personal income tax rates but even lower corporate tax rates. And in contrast, Russia, Ukraine and Georgia have low flat corporate tax rates (24%) but even lower flat personal income tax rates (13%). One motivation for balanced personal and corporate rates is that tax evasion devices exist whereby the higher tax rate can be avoided in favor of the lower tax rate: for example the personal income tax rate can be evaded when company employees become self-employed consultants so that their labor income is subject to the corporate tax rate rather than the personal tax rate.

But putting aside the incentive to evade taxes, this paper focuses on even more basic reasons for balanced flat rate tax systems to be preferred in terms of the optimum welfare of the economy. In particular, an economy is presented in which the zero second-best optimal capital tax rate is replaced by a possible second-best optimum of balanced labor and capital tax rates. 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. The equal rate flat tax optimum combines the insight of Barro that a single flat tax income rate is equal to the government expenditure share and the extension in Turnovsky that with both labor and capital taxes, the equal flat rate on each tax is equal to the government expenditure share. This assumes zero benefits of non-transfer government spending. Applying this model to the Baltic countries, by developing a detailed model of the economy and its tax system, 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 details of the economy also allow for extension of the second-best optimum such that a "composite labor tax", which includes social security and VAT taxes, is equal to the corporate income tax rate and the government spending share.

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 that this tax regime is not well-balanced in that it is sub-optimally weighted towards higher labor taxes. Intuitively, the 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 initially-closed economy 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). Under open economy assumptions the ordering of the benefits from changing individual taxes is preserved, although the benefit of the reforms from 2000 to 2007 becomes smaller and actually turns negative for two of the Baltic countries (Section 6). 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 7).

Under both closed and open economy assumptions and starting from the 2000 law, the paper concludes that moving towards more balanced flat taxes, in terms of the labor tax versus the corporate income tax, improves welfare in the Baltic countries. The puzzle of the international movement towards flat and equal taxes rather than zero corporate taxes is partly addressed by this type of result. But also, as the optimum allows for lower personal tax rates than corporate tax rates when there are other taxes on social security and goods purchases, this analysis better rationalizes the Russia-Ukraine-Georgia case than those countries with relatively low corporate tax rates (Section 8).

# 2 The Endogenous Growth Economy

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, we account for the added complexity of the difference between the actual depreciation rate and the accounting depreciate 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 analysis of Estonia's 2000 tax reform. Although that paper assumes exogenous growth, while we use endogenous growth, it includes the effect of transitional dynamics on welfare and includes a similar open economy analysis with a given world interest rate as in our economy extension in Section 7.

## 2.1 The Consumer Problem

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

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

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 $\delta_h$, 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 $\tau^p$ that falls on wage income, a social security tax rate of $\tau^{sw}$ that also falls on wage income, value added tax (VAT) rate of $\tau^v$ that falls on goods purchases, a dividend tax rate of $\tau^d$ that falls on equity income, and a capital gains tax rate of $\tau^g$ 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

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

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 rate as given. Let $\lambda_t$ and $\nu_t$ be Lagrangian multipliers associated with the budget constraint (4) and human capital accumulation function (3), respectively. First order conditions are:

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

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

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

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

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

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

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 $\delta$, which causes the economic and accounting capital to be unequal if the statutory depreciation rate differs from the economic one $\delta_k$. The accounting level of capital evolves according to

$$K^a_{t+1} = (1-\delta)K^a_t + I_t, \tag{12}$$

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 $\alpha \in (0,1)$

$$Y_t = AK^\alpha_t(u_tH_t)^{1-\alpha}. \tag{14}$$

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

$$\pi_t = AK^\alpha_t(u_tH_t)^{1-\alpha} - w_t(1+\tau^{se})u_tH_t. \tag{15}$$

With the corporate income tax given by $\tau^c$, 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 $\tau^s$ 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 $\tau^c\delta K^a_t$ to after-tax profit. The net profit is used to pay out dividends $D$ and to finance new investment

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

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

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

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, equation (19), becomes

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

Equation (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[1]

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

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 $\pi$ from equation (15) and for $I$ from equation (13), as

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

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

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

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

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

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

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

## 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 $\Gamma$, interest payments and redemption of bonds, and the lump sum transfer $T$. This implies the temporal government budget constraint:

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

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 $\Gamma_t$ exogenously grows at the rate of output growth $g_t$ for each $t$, so that $\Gamma_t / Y_t$ 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)–(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)-(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 equations (6)-(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. Equations (30)- (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 equations (5)-(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 equations (14) and (26), and substituting this into equation (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 equation (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 then solved as a function of $g$ alone by solving for $r$ as a function of $g$ from the Euler condition that results from equations (5) and (9):

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

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

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

Simplifying the the steady state the expression for $m$ in equation (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 equation (39) and substituting this into equation (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 $r$ :

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

Given that $\frac{\Gamma}{Y}$ is exogenous and equal to $\gamma$, substituting into equation (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 equation (36); the time allocation among sectors comes from equations (30) and (31); the capital-output ratio from equation (39), the investment-output ratio from equation (37), the consumption-output ratio from equation (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 equations (36) and (40), the dividend and equity values relative to the capital stock can be solved as well. From equation (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 equations (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 $\tau^*$ 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 equation (40). From equation (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.[2]

# 3 Social Planner Optimum

The social planner maximizes utility in equation (1), subject to time and goods constraints in equations (2) and (29), technology in equations (14) and (3), capital accumulation in equation (13) and the government spending condition in equation (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

[2]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, ch. 11) 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.

states one such second-best optimum, which is a special case of Turnovsky (2000).

**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 $\lambda_t$ 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 (equations (5) and (9)), then equations (45)-(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 equation (23). Comparing equations (34) and (44), and (25) and (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.[3]

More generally, as an extension of Turnovsky (2000), the optimum can be similarly characterized when the social security and VAT tax rates, $\tau^{sw}$, $\tau^{se}$ and $\tau^v$, 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 $\gamma$ to achieve the optimum. The importance of this is that corporate tax rates would be higher than personal income tax rates

[3] 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 $\tau^v=\tau^{sw}=\tau^{se}=0$. 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 $\gamma=\eta\frac{C}{Y}$.

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 $\tau^s$ 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 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 instead $\tau^g = \tau^s = \delta = 0$ 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 Summary of 2000, 2007 Tax Systems

Information about the tax rates in the year 2000 of the Baltic states is contained in IMF country reports (1998; 1999a; 1999b; 2000a; 2000b; 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. Further descriptions of the tax structures of each of the Baltic countries is found in Appendix A.1. In summary, 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. The tax rate changes from the baseline of 2000 to the new rates in 2007 are studied in the next section.

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 | $\tau^v$ | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| Personal income tax | $\tau^p$ | 0.26 | 0.25 | 0.33 | 0.22 | 0.25 | 0.27 |
| Social security contribution | | | | | | | |
| by workers | $\tau^{sw}$ | 0.00 | 0.09 | 0.01 | 0.00 | 0.09 | 0.03 |
| by employers | $\tau^{se}$ | 0.33 | 0.28 | 0.30 | 0.33 | 0.2409 | 0.31 |
| Corporate income tax | $\tau^c$ | 0.00 | 0.25 | 0.24 | 0.00 | 0.15 | 0.15 |
| Tax on dividends | $\tau^d$ | 0.26 | 0.00 | 0.29 | 0.22 | 0.00 | 0.15 |
| Tax on capital gains | $\tau^g$ | 0.26 | 0.00 | 0.15 | 0.22 | 0.00 | 0.15 |
| Investment subsidy | $\tau^s$ | 0.00 | 0.00 | 0.24 | 0.00 | 0.00 | 0.00 |
| Statutory tax depreciations | $\delta$ | 0.00 | 0.40 | 0.00 | 0.00 | 0.40 | 0.20 |

## 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 $\alpha$ and the 'true' depreciation rates of physical and human capital $\delta_k$ and $\delta_h$. Preferences parameters are the coefficient of relative risk aversion $\theta$, the leisure weight $\epsilon$ and the discount factor $\beta$.

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: $\gamma$ is set equal to the average share of government consumption in domestic demand, that is, GDP less net export, while the parameters $\alpha$ and $A_h$ are chosen to match the average shares of investment and consumption in domestic demand, respectively, using equations (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 $\gamma$ is approximately 0.2, which is also used in Funke and Strulik's (2006) study of Estonian tax change.

Table 2 reports the parameter values and the implied steady state values for each country. The values of $\alpha$ 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 stead state value of the firm is equal to the capital stock according to (43) since $\tau^d = \tau^g$ and $\tau^s = \tau^* = 0$.[4] 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 U.S. and was 1.96 for U.K. during 1990-2001, while the value of equity to output ratio, respectively, was 1.576 and 1.845 during 1998-2001. The allocation of time is similar across the countries, with the share of time devoted to both goods and human capital production being the highest in Estonia and the lowest in Lithuania.

The rest of the parameters are set equal across the three Baltic states. The coefficient of relative risk aversion is set at $\theta = 1.5$; the discount factor is $\beta = 0.99$; and the utility weight for leisure weight $\epsilon$ is selected to ensure that approximately 21% of time is spent on work (1840 annual hours of work). The long run growth rate is common for all three countries and is set at 2%. Finally, the scale parameter $A$ affects the ratio of physical to human capital in the economy and this is normalized to $A = 1$. 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, Manuelli and Siu (2005) who discuss the different estimates of $\delta_h$ at length. 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. Given that $r = 4.1\%$ and $g = 2\%$, plus choosing leisure near to 50% and labour time near to 20% gives values for $A_h$ and $\delta_h$ from equations (30) and (31).

[4] 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 | | | | | | | | |
| $\theta$ | $\epsilon$ | $\beta$ | $\alpha$ | $A$ | $A_h$ | $\delta_k$ | $\delta_h$ | $\gamma$ |
| 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 | | | | | | | | |
| $\theta$ | $\epsilon$ | $\beta$ | $\alpha$ | $A$ | $A_h$ | $\delta_k$ | $\delta_h$ | $\gamma$ |
| 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 | | | | | | | | |
| $\theta$ | $\epsilon$ | $\beta$ | $\alpha$ | $A$ | $A_h$ | $\delta_k$ | $\delta_h$ | $\gamma$ |
| 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 |

### 4.3 Sensitivity Analysis

Tables 3-5 show one table for each Baltic country in which modified results are obtained by varying one parameter at a time with all other parameters staying at the benchmark values. It results that for all three countries, when a parameter is changed, the affected variables move in the same direction. The largest variations in the growth rate $g$ come from changes in utility parameters and parameters affecting human capital accumulation. The discount factor and elasticity of relative risk aversion affect $g$ through (36) while $\epsilon$ affects $g$ through the leisure time and equation (31). The parameters of human capital accumulation affect growth rate through equations (30) and (31). The growth rate is stable to changes in the share of physical capital $\alpha$ and the depreciation rate of physical capital $\delta_k$. So is time allocated to different activities. Changes in the utility parameters that lead to higher growth also lead to a larger share of time devoted to human capital accumulation $z$. It is accompanied with a bigger variation in time devoted to leisure than to market activity. An increase in government consumption raises the growth rate but decreases one-for-one the consumption to output ratio $C/Y$. The

$C/Y$ ratio also falls with the increase in the share of capital income in output $\alpha$ but otherwise this ratio is relatively insensitive to parameter changes. The changes in value of equities to output ratio $V/Y$ are positively correlated with the changes in the capital to output ratio $K/Y$, and the biggest changes in both ratios come from varying parameters of the market good production technology $\alpha$ and $\delta_k$ and the scale parameter of the human capital production function $A_h$.

Table 3: Alternative Parameter Values and the Latvian Calibration

| | $g$ | $r$ | $l$ | $u$ | $z$ | $K/H$ | $C/Y$ | $K/Y$ | $V/Y$ |
|---|---|---|---|---|---|---|---|---|---|
| $\theta = 1.20$ | 0.032 | 0.050 | 0.405 | 0.174 | 0.421 | 0.314 | 0.589 | 1.561 | 1.320 |
| $\theta = 1.80$ | 0.014 | 0.037 | 0.531 | 0.225 | 0.244 | 0.460 | 0.598 | 1.719 | 1.434 |
| $\epsilon = 1.00$ | 0.025 | 0.049 | 0.413 | 0.237 | 0.350 | 0.429 | 0.598 | 1.571 | 1.324 |
| $\epsilon = 1.70$ | 0.016 | 0.035 | 0.553 | 0.188 | 0.259 | 0.394 | 0.592 | 1.750 | 1.460 |
| $\beta = 0.985$ | 0.014 | 0.037 | 0.534 | 0.226 | 0.240 | 0.464 | 0.598 | 1.723 | 1.437 |
| $\beta = 0.995$ | 0.027 | 0.046 | 0.442 | 0.189 | 0.369 | 0.354 | 0.591 | 1.605 | 1.352 |
| $\alpha = 0.20$ | 0.020 | 0.041 | 0.492 | 0.209 | 0.299 | 0.312 | 0.630 | 1.377 | 1.154 |
| $\alpha = 0.30$ | 0.020 | 0.041 | 0.490 | 0.210 | 0.300 | 0.590 | 0.547 | 2.062 | 1.728 |
| $A_h = 0.07$ | 0.009 | 0.025 | 0.506 | 0.219 | 0.275 | 0.514 | 0.587 | 1.908 | 1.579 |
| $A_h = 0.13$ | 0.030 | 0.057 | 0.485 | 0.204 | 0.311 | 0.343 | 0.602 | 1.482 | 1.256 |
| $\delta_k = 0.07$ | 0.020 | 0.041 | 0.496 | 0.208 | 0.296 | 0.563 | 0.604 | 2.126 | 1.746 |
| $\delta_k = 0.13$ | 0.020 | 0.041 | 0.489 | 0.210 | 0.301 | 0.319 | 0.589 | 1.372 | 1.172 |
| $\delta_h = 0.00$ | 0.024 | 0.046 | 0.537 | 0.228 | 0.235 | 0.424 | 0.597 | 1.600 | 1.346 |
| $\delta_h = 0.02$ | 0.016 | 0.036 | 0.446 | 0.191 | 0.364 | 0.396 | 0.592 | 1.740 | 1.452 |
| $\gamma = 0.15$ | 0.018 | 0.039 | 0.515 | 0.201 | 0.284 | 0.405 | 0.649 | 1.698 | 1.420 |
| $\gamma = 0.25$ | 0.021 | 0.043 | 0.471 | 0.217 | 0.313 | 0.416 | 0.551 | 1.640 | 1.377 |

Table 4: Alternative Parameter Values and the Estonian Calibration

| | $g$ | $r$ | $l$ | $u$ | $z$ | $K/H$ | $C/Y$ | $K/Y$ | $V/Y$ |
|---|---|---|---|---|---|---|---|---|---|
| $\theta = 1.20$ | 0.032 | 0.050 | 0.402 | 0.175 | 0.423 | 0.541 | 0.522 | 2.084 | 2.084 |
| $\theta = 1.80$ | 0.015 | 0.037 | 0.528 | 0.226 | 0.246 | 0.823 | 0.531 | 2.320 | 2.320 |
| $\epsilon = 1.00$ | 0.025 | 0.049 | 0.412 | 0.237 | 0.351 | 0.741 | 0.534 | 2.102 | 2.102 |
| $\epsilon = 1.70$ | 0.016 | 0.035 | 0.549 | 0.190 | 0.262 | 0.711 | 0.523 | 2.364 | 2.364 |
| $\beta = 0.985$ | 0.014 | 0.037 | 0.531 | 0.227 | 0.242 | 0.831 | 0.532 | 2.326 | 2.326 |
| $\beta = 0.995$ | 0.027 | 0.046 | 0.439 | 0.190 | 0.371 | 0.616 | 0.524 | 2.148 | 2.148 |
| $\alpha = 0.30$ | 0.020 | 0.041 | 0.488 | 0.211 | 0.301 | 0.539 | 0.565 | 1.928 | 1.928 |
| $\alpha = 0.40$ | 0.020 | 0.041 | 0.490 | 0.210 | 0.300 | 1.017 | 0.488 | 2.575 | 2.575 |
| $A_h = 0.07$ | 0.010 | 0.025 | 0.499 | 0.222 | 0.280 | 0.961 | 0.512 | 2.601 | 2.601 |
| $A_h = 0.13$ | 0.030 | 0.057 | 0.485 | 0.204 | 0.311 | 0.578 | 0.540 | 1.969 | 1.969 |
| $\delta_k = 0.07$ | 0.019 | 0.040 | 0.498 | 0.207 | 0.295 | 1.009 | 0.546 | 2.804 | 2.804 |
| $\delta_k = 0.13$ | 0.020 | 0.042 | 0.482 | 0.213 | 0.305 | 0.556 | 0.516 | 1.870 | 1.870 |
| $\delta_h = 0.00$ | 0.023 | 0.046 | 0.536 | 0.229 | 0.235 | 0.737 | 0.532 | 2.142 | 2.142 |
| $\delta_h = 0.02$ | 0.017 | 0.036 | 0.442 | 0.192 | 0.366 | 0.713 | 0.523 | 2.349 | 2.349 |
| $\gamma = 0.15$ | 0.018 | 0.039 | 0.514 | 0.202 | 0.285 | 0.720 | 0.579 | 2.290 | 2.290 |
| $\gamma = 0.25$ | 0.022 | 0.043 | 0.465 | 0.219 | 0.317 | 0.731 | 0.483 | 2.195 | 2.195 |

Table 5: Alternative Parameter Values and the Lithuanian Calibration

| | $g$ | $r$ | $l$ | $u$ | $z$ | $K/H$ | $C/Y$ | $K/Y$ | $V/Y$ |
|---|---|---|---|---|---|---|---|---|---|
| $\theta = 1.20$ | 0.032 | 0.050 | 0.417 | 0.171 | 0.413 | 0.331 | 0.579 | 1.634 | 1.037 |
| $\theta = 1.80$ | 0.014 | 0.037 | 0.543 | 0.219 | 0.238 | 0.487 | 0.588 | 1.808 | 1.148 |
| $\epsilon = 1.00$ | 0.025 | 0.049 | 0.426 | 0.231 | 0.343 | 0.453 | 0.589 | 1.645 | 1.044 |
| $\epsilon = 1.70$ | 0.016 | 0.035 | 0.565 | 0.183 | 0.252 | 0.418 | 0.582 | 1.842 | 1.169 |
| $\beta = 0.985$ | 0.014 | 0.037 | 0.546 | 0.220 | 0.234 | 0.492 | 0.588 | 1.813 | 1.151 |
| $\beta = 0.995$ | 0.027 | 0.046 | 0.454 | 0.185 | 0.361 | 0.374 | 0.581 | 1.682 | 1.068 |
| $\alpha = 0.20$ | 0.020 | 0.041 | 0.504 | 0.204 | 0.292 | 0.297 | 0.633 | 1.350 | 0.857 |
| $\alpha = 0.30$ | 0.020 | 0.041 | 0.503 | 0.204 | 0.292 | 0.559 | 0.552 | 2.023 | 1.284 |
| $A_h = 0.07$ | 0.009 | 0.024 | 0.519 | 0.214 | 0.266 | 0.558 | 0.575 | 2.030 | 1.288 |
| $A_h = 0.13$ | 0.029 | 0.055 | 0.498 | 0.200 | 0.302 | 0.368 | 0.592 | 1.572 | 0.998 |
| $\delta_k = 0.07$ | 0.020 | 0.040 | 0.509 | 0.202 | 0.288 | 0.589 | 0.597 | 2.207 | 1.401 |
| $\delta_k = 0.13$ | 0.020 | 0.041 | 0.500 | 0.206 | 0.294 | 0.340 | 0.577 | 1.452 | 0.922 |
| $\delta_h = 0.00$ | 0.023 | 0.046 | 0.550 | 0.222 | 0.228 | 0.447 | 0.588 | 1.680 | 1.067 |
| $\delta_h = 0.02$ | 0.017 | 0.036 | 0.458 | 0.187 | 0.356 | 0.421 | 0.582 | 1.826 | 1.159 |
| $\gamma = 0.15$ | 0.018 | 0.039 | 0.528 | 0.196 | 0.276 | 0.429 | 0.639 | 1.785 | 1.133 |
| $\gamma = 0.25$ | 0.021 | 0.043 | 0.483 | 0.212 | 0.306 | 0.440 | 0.541 | 1.720 | 1.092 |

# 5 Tax Reform Effects from 2000-2007

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 to 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 in 2007, when only the one tax is changed; this provides a comparison of the different taxes in the sense of which are 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.

With tax reform, the initial post-reform state of the economy is not at its steady state equilibrium. Therefore, to calculate welfare gains from a tax reform, the transition dynamics to the new steady state must be taken into account. For that, we first solve for the policy functions relating different economic variables to the state variables, as described in Appendix A.2.

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 $\xi C_t$ at each date $t$. When the tax system changes from a set of initial rates, say $\tau_{old}$, to a new set of rates, say $\tau_{new}$, the percent of consumption goods that compensate utility for the new tax system $\tau_{new}$ is equal to the $\xi$ that equates utility in the new regime to the utility of the old regime (when $\xi = 0$), as given by the following standard equation:

$$W(\xi, \tau_{old}) = W(0, \tau_{new}). \tag{48}$$

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 6 reports values of variables in the steady state of the second best optimum; Table 7 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 7 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 $\tau^{sw} = \tau^{se} = 0$, equations (34) and (44) imply that a necessary condition for optimality is $\dfrac{1-\tau^p}{1+\tau^v} = 1-\gamma$. Given that this condition holds and using equation (33), the sum of consumption and personal income tax revenues is

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

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 $\tau^v$ 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 8 summarizes the results of the marginal growth rate increases changes and the more significant consumption-equivalent utility gains for the actual 2000 to 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

Table 6: 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 7: Second Best Optimal Changes in Utility, Growth and Revenue

| | | Second Best Optimum | | |
|---|---|---|---|---|
| | | Latvia | Estonia | Lithuania |
| $\xi\%$ | | 13.747 | 11.182 | 16.270 |
| $\Delta g$ | | 0.0085 | 0.0077 | 0.0095 |
| $PVR$ | 2000 | 5.791 | 6.686 | 6.088 |
| | new | 2.395 | 3.090 | 2.401 |
| $\Delta PVR$ | | -3.397 | -3.596 | -3.687 |
| $\gamma$ | 2000 | 0.205 | 0.203 | 0.205 |
| | new | 0.205 | 0.203 | 0.205 |
| $PVT/PVY$ | 2000 | 0.269 | 0.213 | 0.289 |
| | new | 0 | 0 | 0 |
| $PVR/PVY$ | 2000 | 0.474 | 0.416 | 0.494 |
| | new | 0.205 | 0.203 | 0.205 |

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 $\hat{\xi}$ is from going straight to the 2007 steady state, from the 2000 steady state; the results in this case would be that $\hat{\xi} = 1.693$ for Latvia, 2.619% for Estonia and 2.366% for Lithuania. Estonia now would end up with the biggest gain. This change in rankings occurs because the transition dynamics cause Latvia and Estonia to have a lower gain, and Lithuania to have a bigger gain. As Appendix A.3 further details, the transition dynamics for Lithuania are different because the capital stock in the 2007 steady state after the 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.

Table 8: Actual Reform Changes in Utility, Growth and Revenue

| 2000-2007 | | Actual Tax Changes | | |
|---|---|---|---|---|
| | | Latvia | Estonia | Lithuania |
| $\xi\%$ | | 1.536 | 2.286 | 2.635 |
| $\Delta g$ | | 0.0006 | 0.0011 | 0.0008 |
| $PVR$ | 2000 | 5.791 | 6.686 | 6.088 |
| | 2007 | 5.551 | 6.232 | 5.782 |
| $\Delta PVR$ | | -0.240 | -0.454 | -0.306 |
| $\gamma$ | 2000 | 0.205 | 0.203 | 0.205 |
| | 2007 | 0.205 | 0.203 | 0.205 |
| $PVT/PVY$ | 2000 | 0.269 | 0.213 | 0.289 |
| | 2007 | 0.250 | 0.188 | 0.267 |
| $PVR/PVY$ | 2000 | 0.474 | 0.416 | 0.494 |
| | 2007 | 0.455 | 0.391 | 0.472 |

In terms of tax revenue, and assuming here that the government share of output remains at $\gamma$, Table 8 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 9, which compare to the baseline in Table 2.

Table 9: 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 |

## 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 10 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.[5]

Table 10: Revenue Equivalent Changes of Each Tax

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

Table 11 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 8 for the three countries under the actual reforms, for 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 10 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 10 which is better than the 2.56% gain from the flat tax policy in Table 11. In sum, the experiments show that equal flat rate taxes are very attractive, but also that just balancing out the system better in terms of reducing the composite labor tax can be the best reform.

[5] We do not report revenue equivalent changes in the depreciation rate $\delta$. 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 $\delta$ cannot be found that generates $PVR = 5.551$ without leading to an explosive path of $k_t^a$. For Lithuania, $\xi = 0.6203\%$ when $\delta = 0.0190$, assuming $k^a = 0.2372$ which is described at the end of Appendix A.3.

Table 11: 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 |
| $\Delta g$ | | 0.0012 | 0.0017 | 0.0016 |
| $PVR$ | 2000 | 5.791 | 6.686 | 6.088 |
| | new | 5.551 | 6.232 | 5.782 |
| $\Delta PVR$ | | -0.240 | -0.454 | -0.306 |
| $\gamma$ | 2000 | 0.205 | 0.203 | 0.205 |
| | new | 0.205 | 0.203 | 0.205 |
| $PVT/PVY$ | 2000 | 0.269 | 0.213 | 0.289 |
| | new | 0.242 | 0.191 | 0.251 |
| $PVR/PVY$ | 2000 | 0.474 | 0.416 | 0.494 |
| | new | 0.447 | 0.394 | 0.456 |

# 6 Open Economy Case

The results of the tax reform analysis also hold in the open economy case, which is the case assumed in Funke and Strulik (2006). Now allowing the Baltics to borrow capital on the international market, then $B_t$ in consumer's budget constraint is defined as net foreign assets, rather than government bonds. Eliminating $B_t$ from the government budget constraint, it is assumed that the government runs a balanced budget every period. Consumer and firm problems are the same as in the case of a closed economy model, and consequently the same first order conditions together with the budget constraints still describe the equilibrium solution. However, in addition it is assumed that the world interest rate is constant and equal to $r = 0.041$ as in the baseline calibration. These assumptions imply zero net trade before the tax reform, and it is assumed that initially the consumer has zero foreign assets, so that $B_0 = 0$.

Table 12 states the new steady state values corresponding to the 2007 tax rates; the table also reports net exports $X_t/Y_t$ and net foreign assets $B_t/Y_t$ normalized by output. Given a constant interest rate, the growth rate and time allocation are independent of tax rates according to (30)-(31). In the steady state, all three countries run a trade deficit of 2-3% of output. The welfare gain from the tax changes for Latvia, Estonia and Lithuania, respectively are $\xi = -0.054\%$, $\xi = -0.095\%$ and $\xi = 0.391\%$, which are lower compared to the closed economy model (Table 8), but of the same ranking. And only Lithuania experiences a gain from the 2000-2007 tax reform while Latvia and Estonia experience losses.

Transitional dynamics for the open economy model are similar and given in Figures (6)-(8) of Appendix A.3. Note that these figures indicate that dividends are negative in period 0, which can be viewed as unrealistic. However, avoiding this result by allowing for new equity issue gives the same solution for the firm problem given that $\tau^d = \tau^g$, which is true in all but one case of 2000 and 2007 tax law for the Baltic countries (Table 1).To see this, consider that the firm finances its investment through retained earnings and distributes the rest in dividends. Since the period 0 investment demand exceeds the retained earnings supply of capital, the resulting dividends are negative. Extending the economy to allow the firm to issue new equity, negative dividends can be avoided. In this case, equation (16) becomes

$$(1-\tau^c)\pi_t + \tau^s I_t + \tau^c \delta K_t^a + q_{t+1}(E_{t+1} - E_t) = D_t + I_t.$$

Combining it with the arbitrage condition (11), leads to the equation of motion for the value of the firm

$$V_{t+1} = V_t \left(1 + \frac{r_t + \left(\tau^d - \tau^g\right) r_t^E}{1-\tau^g}\right) - [(1-\tau^c)\pi_t - (1-\tau^s)I_t + \tau^c \delta K_t^a]. \quad (49)$$

The maximization of firm's value implies the minimization of the cost of capital $1 + \frac{r_t + \left(\tau^d - \tau^g\right) r_t^E}{1-\tau^g}$ with a consequent dividend payout rate $r_t^E = D_t/V_t$. With the same tax rate for dividends and capital gains, the dividend payout rate $r_t^E$ does not matter, in that equations (21) and (49), and the equilibria, are the same.

Table 13 reports the necessary changes in tax rates and resulting welfare gains that correspond to the same experiments as in Table 10. The welfare ranking of taxes is the same as in the closed economy model; the magnitudes of the utility gains are smaller, and are negative for the corporate income tax.

Table 12: Open Economy Steady State Values for Tax System in 2007

| $g$ | $r$ | $l$ | $u$ | $z$ | $K/H$ | $C/Y$ | $K/Y$ | $V/Y$ | $X/Y$ | $B/Y$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Latvia | | | | | | | | | | |
| 0.020 | 0.041 | 0.491 | 0.209 | 0.299 | 0.419 | 0.614 | 1.691 | 1.526 | -0.022 | 1.029 |
| Estonia | | | | | | | | | | |
| 0.020 | 0.041 | 0.489 | 0.211 | 0.301 | 0.747 | 0.557 | 2.282 | 2.282 | -0.034 | 1.597 |
| Lithuania | | | | | | | | | | |
| 0.020 | 0.041 | 0.504 | 0.204 | 0.292 | 0.416 | 0.620 | 1.692 | 1.599 | -0.028 | 1.323 |

Table 13: Open Economy Revenue Equivalent Tax Changes

| | Latvia | | Estonia | | Lithuania | |
|---|---|---|---|---|---|---|
| | Tax Rate | $\xi\%$ | Tax Rate | $\xi\%$ | Tax Rate | $\xi\%$ |
| $\tau^p$ | 0.2183 | 0.094 | 0.2137 | 0.121 | 0.2789 | 0.182 |
| $\tau^{sw}$ | 0.0516 | 0.094 | -0.0625 | 0.121 | -0.0655 | 0.182 |
| $\tau^{se}$ | 0.2282 | 0.094 | 0.2518 | 0.121 | 0.2079 | 0.182 |
| $\tau^v$ | 0.1521 | 0.056 | 0.1382 | 0.074 | 0.1323 | 0.106 |
| $\tau^c$ | -0.1954 | -0.443 | -0.1255 | -1.899 | 0.0944 | -2.446 |
| $\tau^d$ | -0.5419 | 0 | -0.1842 | 0 | -0.6585 | 0 |
| $\tau^s$ | 0.0958 | -1.625 | 0.1287 | -2.371 | 0.3731 | -2.809 |

# 7 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 14 replicates the Devereux and Love (1994) ranking under one set of initial tax rates but replicates the ranking of Sections 5 and 6 under a different initial set of tax rates.

Using a hypothetical initial set of tax rates (rather than the baseline calibration), Table 14 sets the government consumption of taxes to zero, so that $\gamma = 0$, and all tax revenues raised are returned lump sum to the consumer. While in the baseline calibration $\gamma$ is calibrated according to the data, here it is chosen to be $\gamma = 0$ , which would be the value that was optimally chosen if this were endogenous since it is assumed that government expenditure has no benefits. First, initial taxes 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 14 shows the growth and utility changes from 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 14. 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 Sections 5 and 6: 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 14: Raising Revenue from Different Intial Tax Distributions

| | Tax Revenue: $0 \longrightarrow 0.25$ | | | | Tax Revenue: $4.79 \longrightarrow 5.04$ | | | |
|---|---|---|---|---|---|---|---|---|
| | Tax Rate | | $g$ | $\xi\%$ | Tax Rate | | $g$ | $\xi\%$ |
| | Initial | New | | | Initial | New | | |
| $\tau^p$ | 0 | 0.0271 | 0.0280 | -0.0338 | 0.25 | 0.2755 | 0.0193 | -1.7305 |
| $\tau^v$ | 0 | 0.0258 | 0.0281 | -0.0289 | 0.25 | 0.2748 | 0.0196 | -0.9746 |
| $\tau^c$ | 0 | 0.0856 | 0.0281 | -0.1676 | 0 | 0.0742 | 0.0196 | -0.9737 |
| $\tau^d$ | 0 | 0.5124 | 0.0285 | 0 | 0 | 0.5618 | 0.0199 | 0 |

# 8 Conclusions

The model includes an explicit 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 to 16% of consumption. The utility gain from the actual tax reforms from 2000 to 2007, within the closed economy, was 1.5 to 2.6% with Lithuania having the highest gain. The same ranking of gains from actual law changes was also found under open economy assumptions, although only Lithuania showed a positive gain.

Experiments kept the same revenue loss as was found in the actual 2000-2007 reforms, while lowering only one tax rate to yield that revenue loss. This showed that the personal income tax and the social security tax decrease always gave the biggest utility gain, under both closed and open economy assumptions. Another experiment within the closed economy, of again achieving the same revenue as in 2007 law, showed that establishing equal flat tax rate on personal and corporate income with zero tax rates on all other taxes, gave larger utility gains for all three countries than did the actual 2000-2007 reforms. And this equal flat tax policy gave larger utility gains than using any single tax decrease for both Latvia and Lithuania, and gains for Estonia that were almost as high as those achieved by decreasing only the personal income tax rate.

Given the initial set of tax rates in the Baltics and the assumption that government spending is a constant fraction of output, altogether the results suggest that an imbalance of taxes that fall on labor relative to taxes that fall on capital causes welfare to be lower than it needs to be. 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 for example public capital is an important source of infrastructure and growth in many economies. For example, if such expenditures affect the return on physical capital differently from the return on human capital, then these expenditures would be expected to affect how the balance of the tax system, between labor and capital taxes, determines welfare.

Technically, the paper uses Judd's (1992) non-linear simulation method to simulate dynamics. Its simpler human capital investment function from Lucas (1988) allows for more tractable analytic results as compared to Devereux and Love (1994). And the paper contains more tax experiments than is typical in order to bring out the sensitivity of the results.[6]

Inclusion of the inflation tax would further increase the labor type taxes since the inflation tax is similar in effect to a labor tax when modeled with

[6] We are indebted to a referee's helpful summary here.

a goods-leisure margin. Thus with a positive inflation rate, the results for the Baltics would be predicted to show that the capital taxes should be even more relied upon than is found in the paper. Similarly, modelling the evasion of taxes would go in the direction of making balanced labor and capital taxes desirable although this depends upon how evasion is modeled. Evasion often acts as an arbitraging device whereby the higher taxed income is made artificially into the lower taxed type of income. In countries with relatively low corporate tax rates, the personal income can be turned into corporate income by having employees of companies made into consultants that operate their own business, even though they continue to do the same job in all but name.

These extensions would appear to 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, as in the Ramsey solution with exogenous government spending, 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.

# References


Atkinson, A. and Stiglitz, J. (1980). *Lectures on public economics*, McGraw-Hill, London.

Barro, R. (1990). Government spending in a simple model of endogenous growth, *Journal of Political Economy* **98**: S103 – S125.

Devereux, M. and Love, D. (1994). The effects of factor income taxation in a two-sector model of endogenous growth, *Canadian Journal of Economics* **27**: 509 – 536.

Funke, M. and Strulik, H. (2006). Taxation, growth and welfare: Dynamic effects of Estonia's 2000 Income Tax Act, *Finnish Economic Papers* **19**(1): 25 – 38.

IMF (1998). Republic of estonia: Selected issues and statistical appendix, *Staff Country Report 98/12*, IMF.

IMF (1999a). Republic of latvia: Selected issues and statistical appendix, *Staff Country Report 99/99*, IMF.

IMF (1999b). Republic of lithuania: Selected issues and statistical appendix, *Staff Country Report 99/96*, IMF.

IMF (2000a). Republic of estonia: Statistical appendix, *Staff Country Report 00/102*, IMF.

IMF (2000b). Republic of latvia: Selected issues and statistical appendix, *Staff Country Report 00/100*, IMF.

IMF (2001). Republic of lithuania: Statistical appendix and tax summary, *Staff Country Report 01/40*, IMF.

Jones, L. E., Manuelli, R. E. and Siu, H. E. (2005). Fluctuations in convex models of endogenous growth II: Business cycle properties, *Review of Economic Dynamics* **8**(4): 805–828.

Judd, K. L. (1992). Projection methods for solving aggregate growth models, *Journal of Economic Theory* **58**(2): 410–452.

Kim, S. (1998). Growth effect of taxes in an endogenous growth model: to what extent do taxes affect economic growth?, *Journal of Economic Dynamics and Control* **23**: 125 – 158.

Ljungqvist, L. and Sargent, T. (2000). *Recursive Macroeconomic Theory*, The MIT Press, Cambridge, Mass.

Lucas, Jr., R. E. (1990). Supply-side economics: An analytical review, *Oxford Economic Papers* (42): 293–316.

Lucas, R.E., J. (1988). On the mechanics of economic development, *Journal of Monetary Economics* **22**: 3 – 42.

McGrattan, E. and Prescott, E. (2005). Taxes, regulations, and the value of US and UK corporations, *Review of Economic Studies* **72**: 767 – 796.

McGrattan, E. R. and Prescott, E. C. (2000). Is the stock market overvalued?, *Federal Reserve Bank of Minneapolis Quarterly Review* **24**(4): 20–40.

Mendoza, E., Razin, A. and Tesar, L. (1994). Effective tax rates in macroeconomics: Cross-country estimates of tax rates on factor incomes and consumption, *WP 4864*, NBER.

Mitchell, D. J. (2007). The global flat tax revolution, *Cato policy report*, Cato Institute, Washington DC.

Obstfeld, M. and Rogoff, K. (1996). *Foundations of International Macroeconomics*, MIT Press, Cambridge, MA.

Stokey, N. and Rebelo, S. (1995). Growth effects of flat-rate taxes, *Journal of Political Economy* **103**(3): 519 – 550.

Turnovsky, S. J. (1995). *Methods of Macroeconomic Dynamics*, The MIT Press, Cambridge.

Turnovsky, S. J. (2000). Fiscal policy, elastic labor supply, and endogenous growth, *Journal of Monetary Economics* **45**(1): 185–210.

# A Appendix.

## A.1 Statutory Tax Rate Structure Description

The major taxes included in the model are value added tax, and personal and corporate income direct taxes. Capital gains and dividend taxes are part of the income tax law as statutory rates. In the growth literature that deals with the effect of distortionary taxation on growth, the calibrated tax rates typically are not those specified by tax laws, but rather they are estimated. For example, Mendoza, Razin and Tesar (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. The use of statutory taxes here is justified by fact 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.

The Baltic countries have opted for a reduction in the income taxes and, especially, in corporate income taxes. The corporate income tax fell 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 Latvia, in the case of personal income tax, taxable income is decreased by a nontaxable minimum, by deductions for each dependent person and by expenditures for health care and education up to a certain amount. These deductions do not affect the marginal tax rates that matter for optimality conditions. Their only consequence is to decrease the total tax revenues raised by the government. Use of an average tax rate on the basis of total taxes may therefore be misleading in terms of the effect on the economic margins and on growth. The marginal tax rates appear to be more closely modeled in the Baltic countries by the statutory rates.

In all Baltic states the base rate for the VAT is 18%. Although excise tax can be thought of as part of consumption tax, the rate of consumption tax in the model is set equal to the VAT rate. We justify not accounting for excise taxes by arguing that often there are other reasons to levy an excise tax, for example because goods subject to excise taxes exert externalities that are not captured by the model. And because educational services are excluded from the VAT, this provides additional justification for treating human capital production as a non-market good.

Although the personal income tax is applied to different sources of income, here this refers only to the wage income source. As was mentioned previously this income is decreased by different lump-sum deductions when calculating taxable income. 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. Therefore 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.

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 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 model non-distributed profits are equal to investment. In terms of the model, the Estonian treatment of non-distributed profits as tax exempt is the same as the Lithuanian treatment of investment as tax exempt.

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 $\delta$, then in the model we must use the rate $2\delta$. 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% or, allowing for double depreciation, 40%.

## A.2 Policy Functions

With a tax reform, the initial post-reform state of the economy is not at its steady state equilibrium. To calculate welfare gains from a tax reform, the transition dynamics to the new steady state must be taken into account. In particular, given the paths of consumption and leisure after a tax reform, utility changes from the reform can be calculated. For that, we first solve for the policy functions relating different economic variables to the state variables.

The dynamic economy evolves according to the following system of equations, where variables growing in the long run are normalized by human capital, using the notation $k_t = K_t/H_t$, $c_t = C_t/H_t$ and $y_t = Y_t/H_t$:

$$c_t^{-\theta} l_t^{\epsilon(1-\theta)} = c_{t+1}^{-\theta}(A_h z_t + 1 - \delta_h)^{-\theta} l_{t+1}^{\epsilon(1-\theta)} \beta(1 + r_{t+1}), \tag{50}$$

$$w_t(1 + r_{t+1}) = w_{t+1}\left[A_h(1 - l_{t+1}) + 1 - \delta_h\right], \tag{51}$$

$$c_t = \frac{(1 - \tau^{sw})(1 - \tau^p)}{(1 + \tau^v)\epsilon} w_t l_t, \tag{52}$$

$$w_t(1 + \tau^{se}) = (1 - \alpha) A k_t^{\alpha} u_t^{-\alpha}, \tag{53}$$

$$(1 - \tau^s)\left(\frac{r_t}{1 - \tau^g} + \delta_k\right) + m_t(\delta - \delta_k) - \tau^c \delta = (1 - \tau^c)\alpha A k_t^{\alpha - 1} u_t^{1-\alpha}, \tag{54}$$

$$y_t = Ak_t^{\alpha} u_t^{1-\alpha}, \tag{55}$$

$$l_t + u_t + z_t = 1, \tag{56}$$

$$(1-\gamma)y_t = c_t + k_{t+1}(A_h z_t + 1 - \delta_h) - (1-\delta_k)k_t, \tag{57}$$

$$(1 - \tau^g + r_{t+1})m_t = (1-\tau^g)\tau^c\delta + (1-\tau^g)(1-\delta)m_{t+1}. \tag{58}$$

Note that during transition a constant share of government consumption of output, $\Gamma_t = \gamma Y_t$ is assumed in (57). Although there are four state variables $k_t = K_t/H_t$, $k_t^a = K_t^a/H_t$, $B_t/H_t$ and $E_t$, the real economy given by equations (50)–(58) depends only on $k_t$. The accounting capital does not affect the production decisions of the firm, and the evolution of $k_t^a$ is given once the time path of $k_t$ is determined. The level of accounting capital only affects the value of the firm, which in turn affects the financial wealth of households. However, all changes in the financial wealth — bond holding and the value of equity — are offset by changes in government transfers, $T_t$, leaving consumption and time allocation decisions unaffected.

Since the evolution of the economy depends on non-linear difference equations (50), (51), and (58), we solve for the policy functions numerically. Following the methodology described in Judd (1992), we approximate the policy functions for consumption $c$ and the time allocated to work $u$, and variable $m$ as functions of capital:

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

where $\varphi_i$ 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 equations (50)–(58) 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 $\left[\frac{2}{3}k^{ss}, \frac{4}{3}k^{ss}\right]$, where $k^{ss}$ is the steady state $K/H$ ratio. The choice of domain 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 Figure 1. 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 Figure 2. Figure 1 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]

### A.2.1 Solving The Open Economy Model

The system of equations (50)–(56) also describes the open economy equilibrium, while the resource constraint (57) needs to be modified to allow for the international trade:

$$Y_t = C_t + I_t + \Gamma_t + X_t, \tag{59}$$

where $X_t$ denotes net exports. Given constant $r$, it follows from (23) that $m$ is also constant and given in (38). (Therefore, equation (58) is redundant.) It is assumed that there is an unexpected and permanent change in tax rates at the beginning of period 0. $k_0$ has been already installed but other period 0 variables are still to be decided. Note that equation (54) is the first order condition with respect to the next period capital. Though $u_0$ is flexible, it is not assumed that (54) holds in period 0. But it will hold from period 1 onwards, which implies that $k_t/u_t$ is constant for $t \geq 1$ and so is $w_t$ according

[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 Figures 1 and 2, we do not present them again. The magnitudes of the error of approximation are also similar to those shown in Figure 1. Note, however, when $\delta = 0$, $m = 0$ according to (23) and we only need to solve for $c(k)$ and $u(k)$.

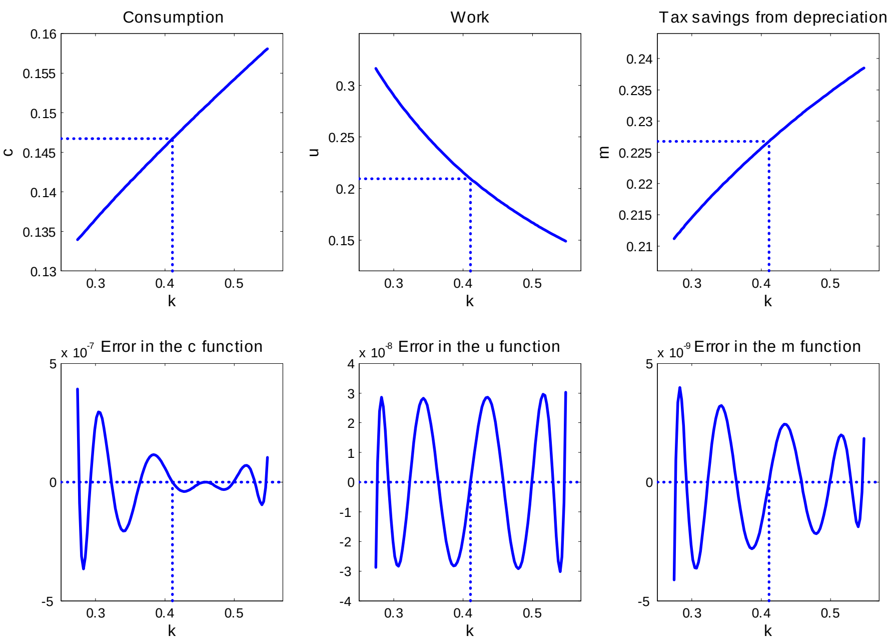


Figure 1: Policy functions and errors of approximation

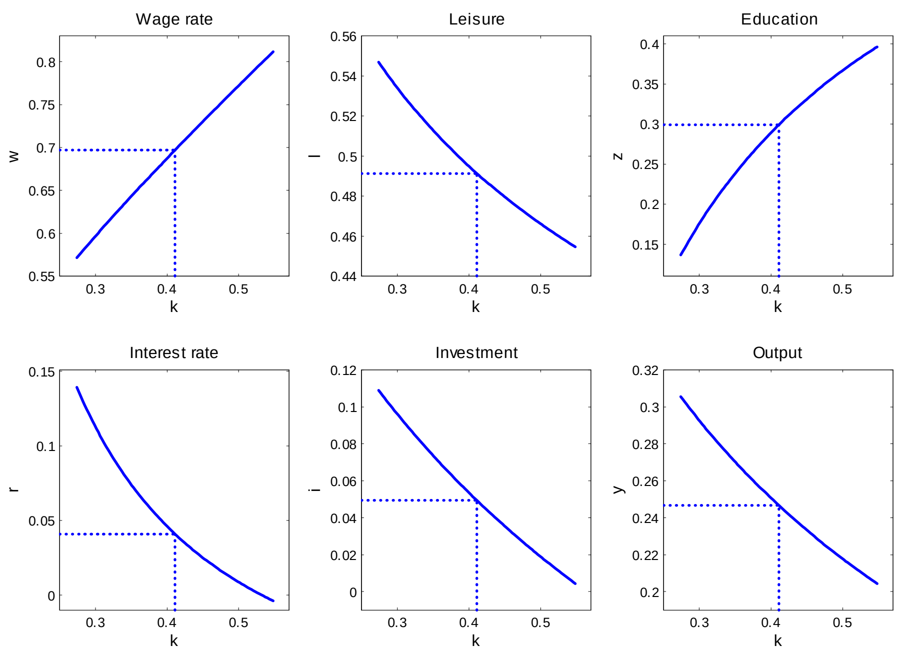


Figure 2: Policy functions (continued)

to (53). But then from (51), $l_t$ is constant starting *period 2*, which in turn implies from (52) that $c_t$ is constant for $t \geq 2$, from (50) that $z_t$ is constant for $t \geq 2$, and so on. That is, starting in period 2 the economy is in the steady state. Further, although the real economy is in the steady state from period 2 onwards, some financial variables will exhibit lengthy adjustment because it still takes time for the accounting capital to adjust to its new steady state value.

To solve for the equilibrium, first a guess is made for $k_1 = K_1/H_1$. Given $k_0$, $k_1$ and the fact that starting in period 2 the economy is in the new steady state, the rest of variables for periods 0 and 1 are recovered from equations (50)-(56) and (59) (without invoking equation (54) for period 0.) Next, the time path of financial variables $B_t$, $V_t$, $D_t$, $K_t^{\alpha}$ and $T_t$ is calculated. Finally, the intertemporal budget constraint of the consumer must be satisfied; following Obstfeld and Rogoff (1996, Section 2.5.1) this budget is given by

$$\begin{aligned} &(1+r) B_0 + q_1 E_0 + \left(1-\tau^d\right) D_0 - \tau^g \left(q_1 E_0 - q_0 E_0\right) \\ &+ \sum_{t=0}^{\infty} \frac{(1-\tau^p)(1-\tau^{sw}) w_t u_t H_t + T_t - (1+\tau^v) C_t}{(1+r)^t} = 0. \end{aligned} \tag{60}$$

## A.3 Transitional Dynamics

Figures 3-5 show the transitional dynamics for each of the three Baltic countries in the closed economy model while figures 6-8 show the transitional dynamics in the open economy model.

For Latvia, Figure 3 (the dotted line indicates the old steady state values) illustrates the transition of different variables to the new steady state assuming that the economy was initially in the steady state corresponding to the year 2000 tax rates. To move to its new steady state the agent must increase accumulation of 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. Taking into account the transition, the present discounted value of utility in Latvia is $W(0, \tau_{2007}) = -414.955$, implying a gain of $\xi = 1.54\%$ in consumption terms.

For Estonia, Figure 4 provides a transition pattern that is similar to Latvia's. Since the new steady state capital stock of 0.751 is above the old steady state level of 0.726, the accumulation of physical capital is accelerated. Work time $u$ is above the new steady state level, leading to higher-than-steady-state output. And since consumption $c$ is below, it follows that investment is above its new steady state level and the accumulation of physical capital is accelerated. Since the leisure time $l$ is also above its new steady state along the transition path, it follows that the time devoted to human capital production $z$ is below its new steady state value and the accumulation of human capital is decelerated.

Figure 5 gives the Lithuanian transition dynamics to the new steady state. Unlike the cases of Latvia and Estonia, the new steady state capital stock of 0.418 is below the old steady state level of 0.435. Therefore, the transition pattern 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 accelerated 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 time $l$.

Note that the initial Lithuanian stock of accounting capital at the baseline is $k^a = 0.2372$, and $\delta = 0.2$ in equation (41); everywhere else $\delta$ is set at $\delta = 0$. The firm keeps track of its accounting capital, although the depreciated capital cannot decrease taxable profit and the level of accounting capital has no effect on the real economy.

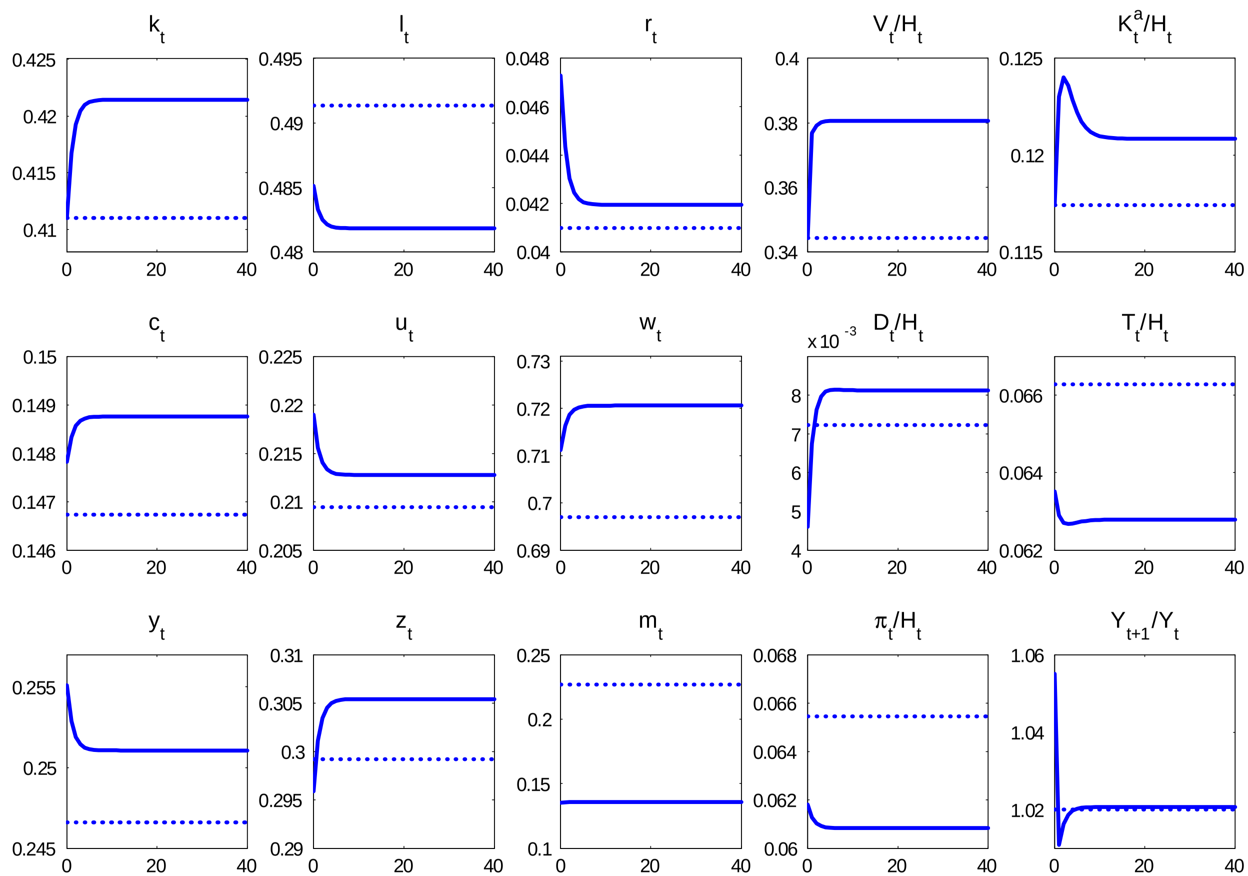


Figure 3: Transitional dynamics for Latvia; closed economy case

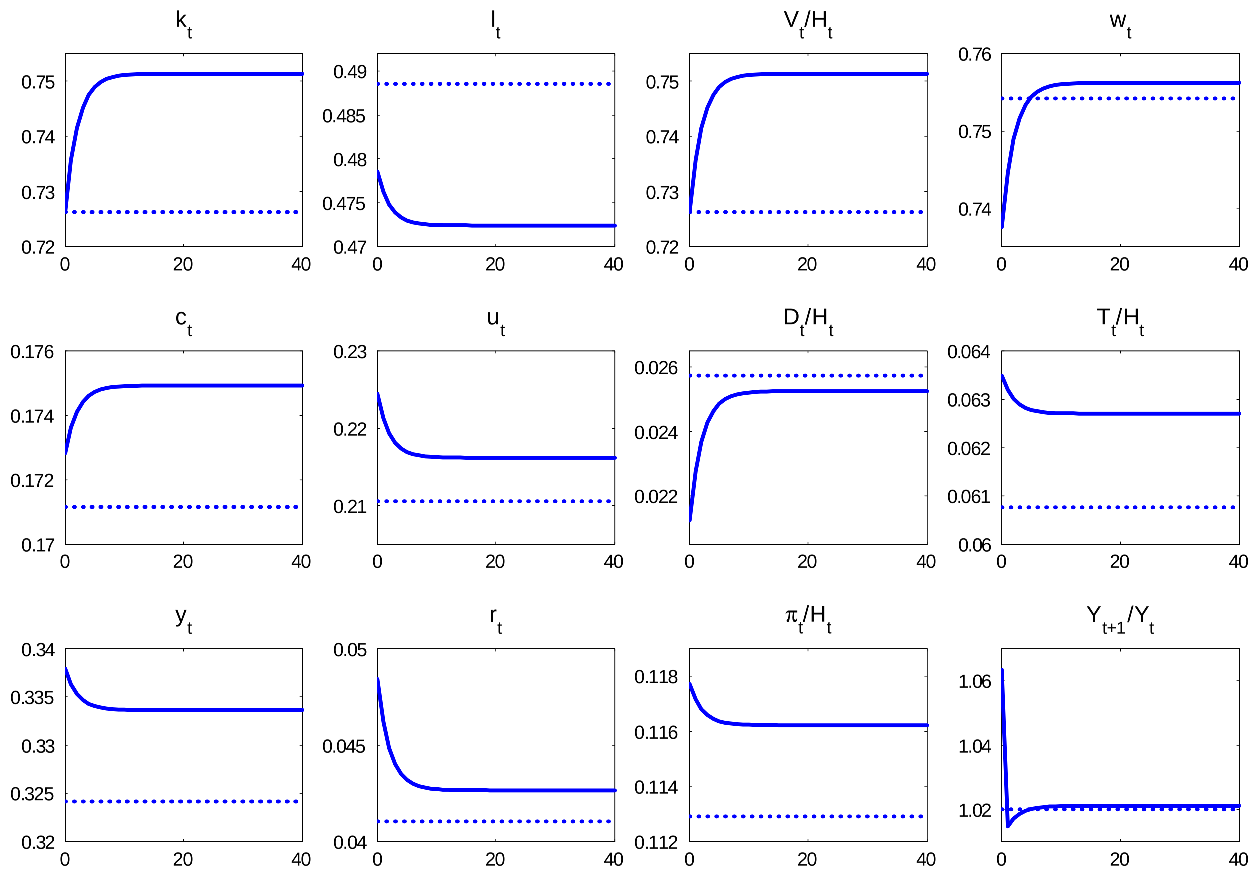


Figure 4: Transitional dynamics for Estonia; closed economy case

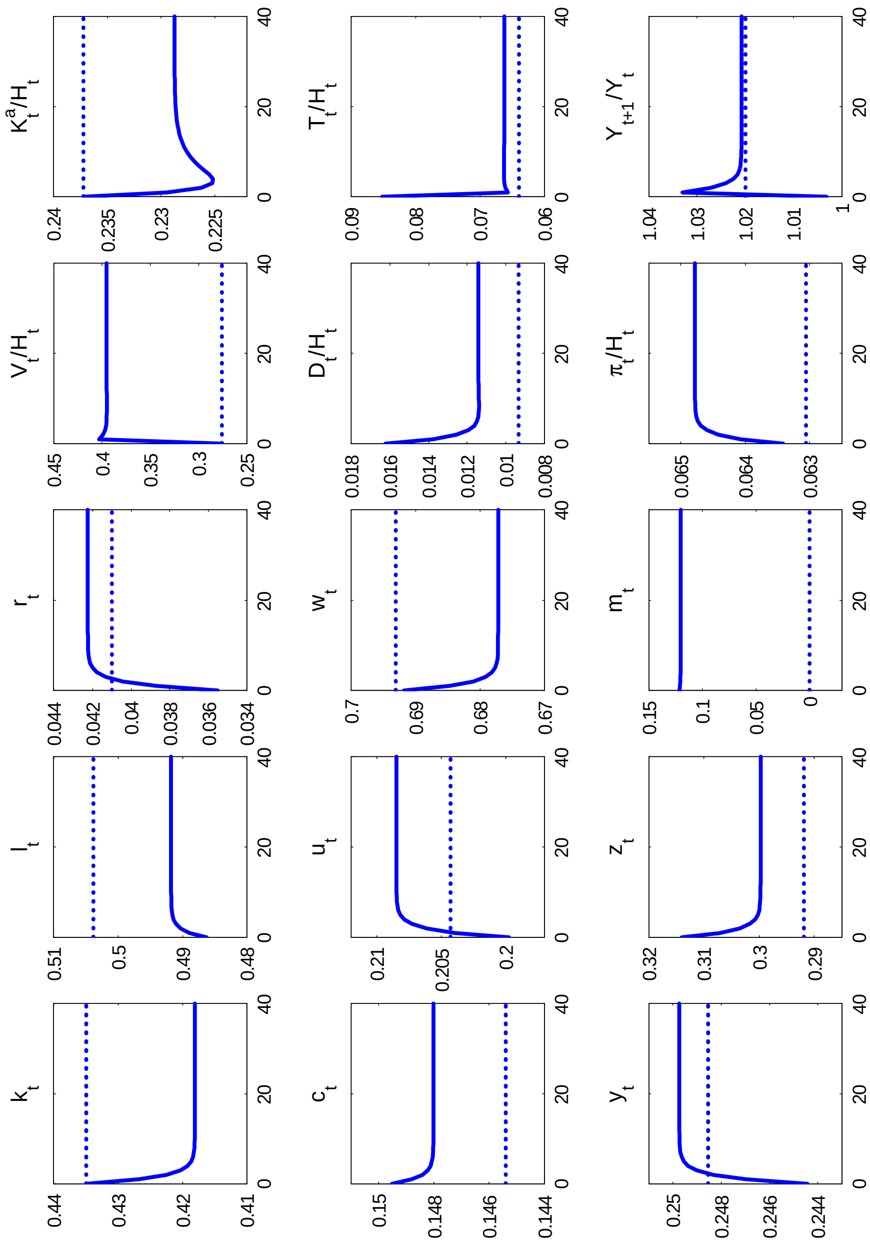


Figure 5: Transitional dynamics for Lithuania; closed economy case

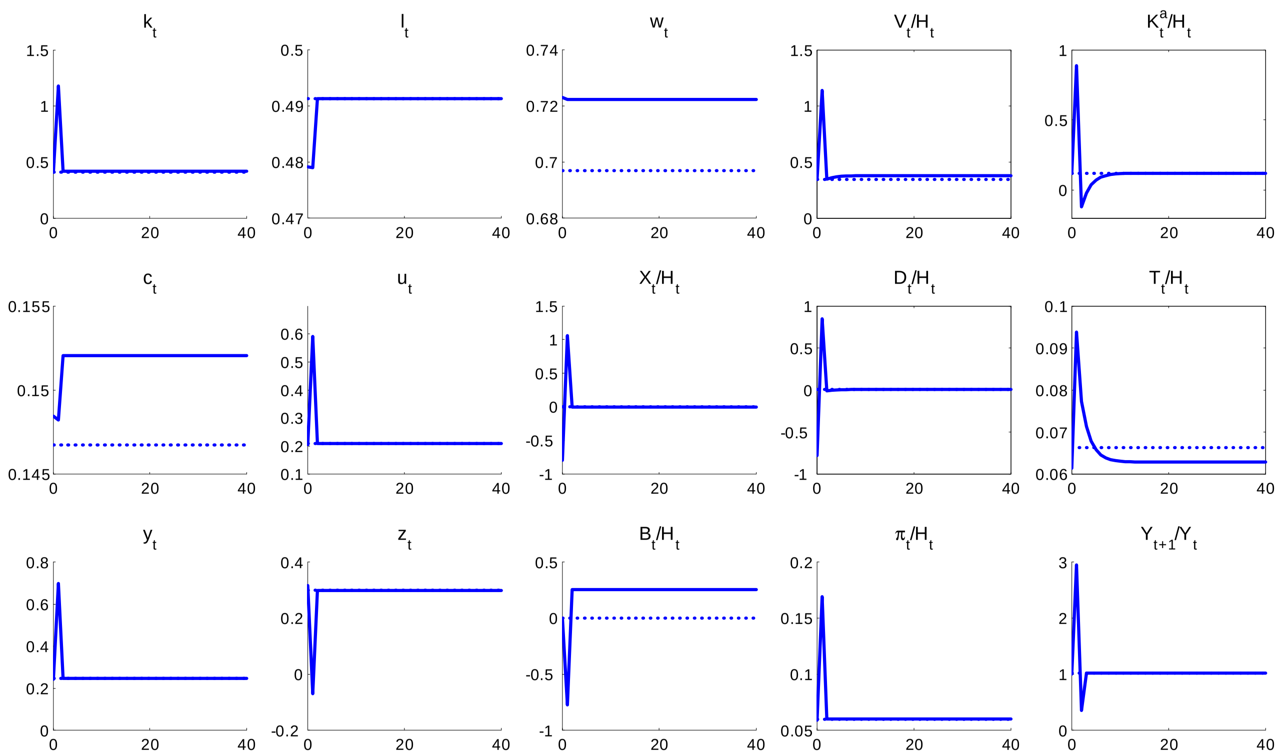


Figure 6: Transitional dynamics for Latvia; open economy case

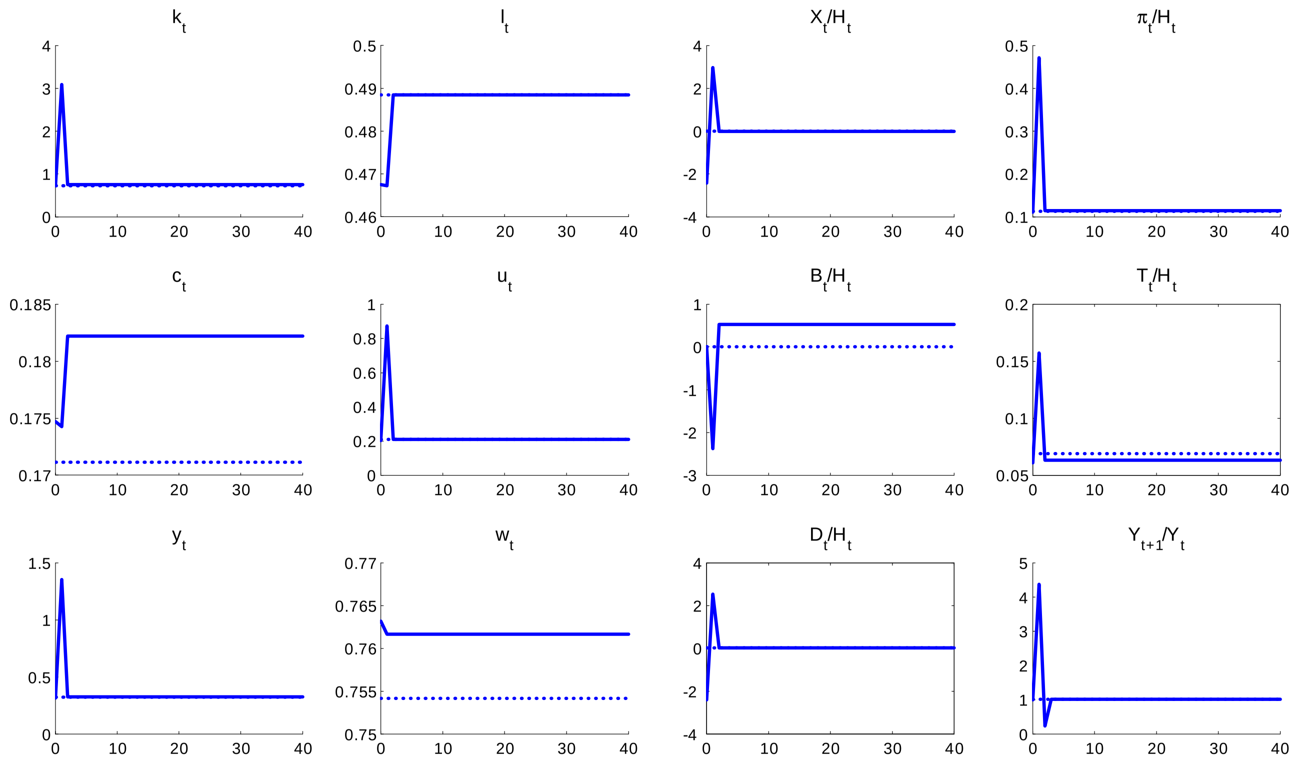


Figure 7: Transitional dynamics for Estonia; open economy case

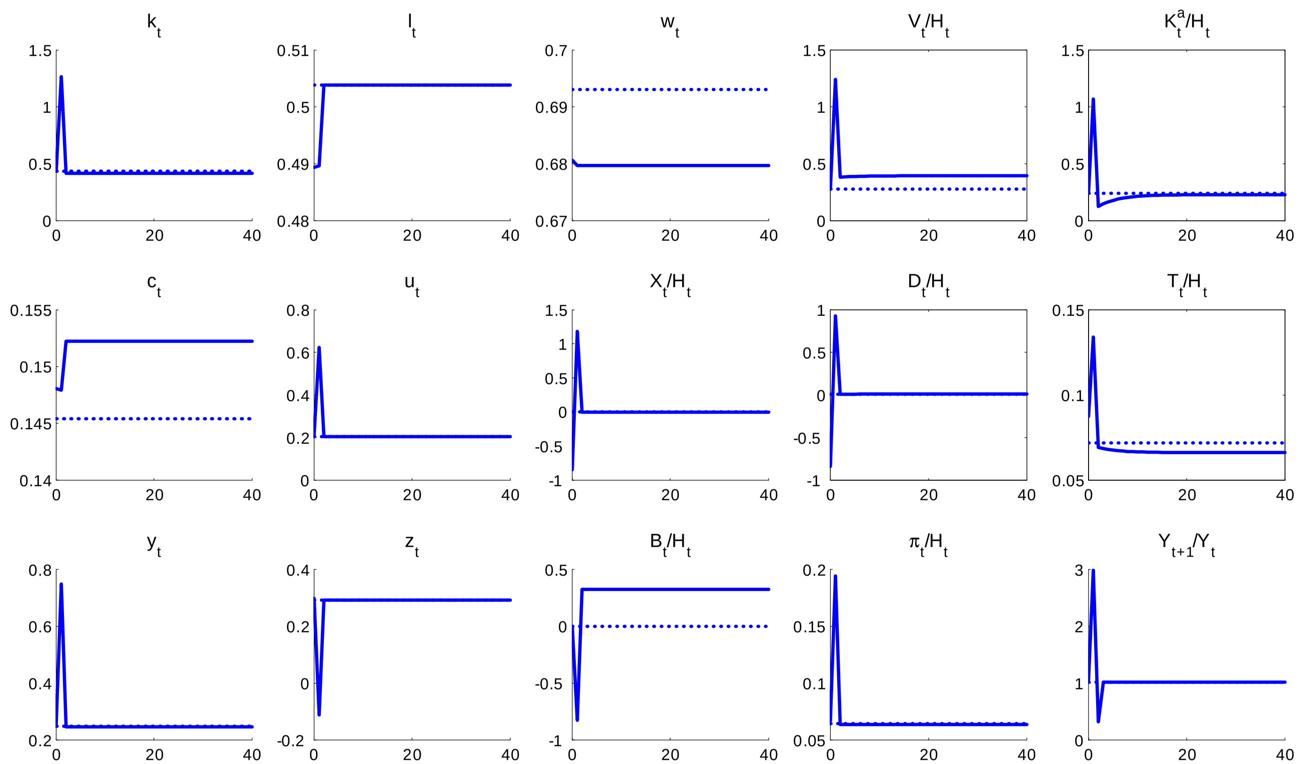


Figure 8: Transitional dynamics for Lithuania; open economy case