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Michael Funke and Holger Strulik

Taxation, growth and welfare: Dynamic effects of Estonia's 2000 income tax act

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Abstract

This paper analyses the long-run effects of Estonia's 2000 Income Tax Act with a dynamic general equilibrium model. Specifically, we consider the impact of the shift from an imputation system to one where companies only pay taxes on distributed profits. Balanced growth paths, transitional dynamics and welfare costs are computed. Our results indicate that the 2000 Income Tax Act leads to higher per capita income and investment, but lower welfare. A sensitivity analysis shows the results are rather robust.

Keywords: growth, welfare, taxation, tax reform, Estonia
JEL Classification: H25, H32, O41, O52

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Michael Funke and Holger Strulik

Taxation, growth and welfare: Dynamic effects of Estonia's 2000 income tax act

Tiivistelmä

Tutkimuksessa käsitellään Virossa vuonna 2000 toteutetun verouudistuksen pitkän aikavälin vaikutuksia dynaamisen yleisen tasapainon mallin avulla. Siinä keskitytään yritysverotuksen uudistukseen, jonka jälkeen yritykset maksavat veroa ainoastaan jakaessaan voittoja. Työssä lasketaan uudistukseen liittyvän tasapainoisen kasvun ura, siirtymä tasapainouralle ja hyvinvointikustannukset. Tulosten mukaan vuoden 2000 verouudistus johtaa korkeampaan per capita -tulotasoon ja suurempiin investointeihin, mutta aheikompaan hyvinvointiin. Tulokset pysyvät samoina, vaikka analyysin lähtöoletuksia muutettaisiin.

Asiasanat: kasvu, hyvinvointi, verotus, verouudistus, Viro.

1 Introduction

The debate over how favourably tax codes should treat capital is an established part of political discourse in many countries. The controversy has been particularly vigorous in the setting of tax reform agendas of transition economies. The World Bank (2000) suggests that the design of tax systems should be guided by tested theory and the lessons of experience, i.e. a broad-based tax system with low statutory rates. This approach advocates the elimination of tax exemptions for favoured enterprises to harden budget constraints, reduction of the tax burden on viable enterprises, encouraging investment and promotion of long-term growth.

Economists have only recently developed tools to assess the impacts of tax reform on long-term growth. Chamley (1981, 1986) presented the earliest general equilibrium analysis of the effects of capital taxation and focusing on the welfare consequences of eliminating a tax on capital. Judd (1987) followed with a different approach that compared the welfare cost associated with the taxation of capital and labour income. Both studies (and numerous others) found significant welfare gains associated with the reduction of capital income taxation. Most researchers, however, quickly realised matters were more complicated. For example, neither study allowed for feedback to the long-run steady state growth rate of the economy, relying instead on models where the growth rate of the economy is exogenously determined. In other words, the reduction of capital income taxation only has transitory impacts upon the growth rate as the economy adjusts towards a new steady state.

The development of endogenous growth models in the late 1980s and 1990s were intended to equip economists with the wherewithal to investigate the possible effects tax policy might have on an economy's long-run growth rate. These new models, pioneered by Romer (1986), Lucas (1990), Ortiguera (1998), Rebelo (1991) and Kim (1998), were motivated by the desire to construct dynamic general equilibrium models that address the steady-state consequences of specific economic policies. In such endogenous growth models, taxes potentially play a greater role. While there are a number of channels through which taxes may affect the growth rate, the growth effects are difficult to detect in cross-sectional data [see, for example, Easterly and Rebelo (1993)]. Jones (1995) extended the search, but also failed to find, growth effects from various policies. Despite problems associated with measurement error and short samples, this evidence as a whole casts serious doubt on the growth effects that endogenous growth models with scale effects generate. In the light of such scanty empirical evidence, we revert to consideration of an exogenous growth model.

The discussion in the literature suggests to us a need for a formal growth model that encompasses scale effects and can assess the relative magnitudes of such effects. In this paper, we transpose to Estonia Strulik's (2003a) growth model that was originally used to analyse Germany's recent corporate tax reform. The objectives of this exercise are, first, to outline a dynamic supply-side-oriented general equilibrium model that allows us to address the question of how changes in the capital income tax rate affect the well-being of households, and second, to illustrate the potential magnitude of the gains that accompany Estonia's 2000 income tax act. This approach also allows us to address a widely neglected issue – transition dynamics.

Various growth models show lower taxation unambiguously increases investment and economic growth. Few, however, indicate such tax policy has a positive impact on welfare, i.e. the models do not derive the foregone consumption necessary to achieve a distinct and higher steady-state growth path. Thus, even if the theoretical growth literature indicates that lower taxation results in a new higher steady-state income, there may well be only minute, or even negative, welfare gains if the shift involves large adjustment costs and high foregone consumption [e.g. Lucas (1990) and Strulik (2003b)].

In the following analysis, we consider Estonia's 2000 income tax reform in the long run, taking into account general equilibrium feedback effects. In an earlier partial equilibrium paper [Funke (2002)], Tobin's *q* theory of investment was applied to analyse the investment effects of the 2000 tax reform in Estonia. The numerical simulations of the calibrated model find a 6.1% increase in the Estonian equipment capital stock. While the model provides clear insights into an important policy issue at relatively low cost in terms of technical complexity, it is limited for our purposes here because it abstracts from general equilibrium responses when evaluating the tax policy. It does not quantify the economic benefits and costs of the reform arising from macroeconomic repercussions.

The remainder of this paper is organized as follows: Section 2 briefly describes the Estonian 2000 income tax reform. Section 3 provides a survey of current corporate tax rates in Eastern Europe. Section 4 lays out the baseline model. Section 5 proposes a numerical exercise, wherein we calibrate the model, provide sensitivity analysis with respect to parameter specification and compute welfare costs. Following analysis of the benchmark model, our focus shifts to foreign direct investment in section 6. Section 7 summarises our main findings.

2 Estonia's 2000 income tax act

Most prevailing tax legislation in Estonia was enacted during the first phase of transition reforms. The Law on Taxation entered into effect in 1994 and has since been amended several times. The Income Tax Act (*Tulumaksuseadus*) was passed December 15, 1999 and went into effect on January 2000.

Estonia's 1994 tax code applied a flat tax rate of 26% to businesses, personal earnings and capital gains.[1] It contained depreciation allowances of up to 40% for equipment and up to 8% for buildings. Additionally, there was a loss-carry-forward possibility over a period of five years. The personal income tax rate was 26%. When companies paid dividends, they had to pay an additional tax rate of 26/74 (i.e. 26 kroons for every 74 kroons) on *net* dividends and shareholders received a dividend tax credit.[2] The effect of this dividend credit system was that distributed profits were taxed at the shareholder's personal rate of income tax rather than under a corporation tax. Thus, the system worked like an imputation system, where the rate of imputation was the corporation tax rate.

The 2000 income tax act turned Estonia's income tax approach on its head. Under the act, resident companies and permanent establishments of foreign entities (including branches) are subject to income tax for distributions (both actual and deemed).

[1] The tax-free income of a resident natural person is 12,000 Estonian kroons, implying that the marginal income tax rate is either 0% or 26%, and the average income tax rate is somewhere between 0% and 26%.

[2] If the after-tax dividend was 74 kroons, then the corporation had to pay 26 kroons in taxes on the dividend. The tax rate of 26/74 thus equals a 26 % personal income tax rate. Summaries of the Estonian tax system are available in Ebrill and Havrylyshyn (1999), IMF (2000), pp. 35-48, Kesti (1995) and Sorainen et al. (2002). On October 24, 2001 the Estonian Parliament passed amendments to Income Tax Act, which include modifications to the regulation concerning the taxation of dividends. Since January 1, 2003, all dividends, regardless of the recipient, are subject to the 26/74 income tax, including dividends paid to resident legal persons [see Sorainen (2002), p. 99].

Distributions include dividends and other profit distributions, fringe benefits, gifts, donations, representation expenses and expenses and payments unrelated to business. However, the new Estonian corporate income tax does not constitute a tax exemption, rather the taxation of profits is postponed until a distribution of profits occurs.

The flat tax rate for all distributions is 26/74 on *net* dividends. The transfer of assets of the permanent establishment to its head office or to other non-residents is also treated as a distribution. Dividends paid to non-residents are additionally liable to withholding tax at the general rate of 26%, unless the non-resident legal entity holds at least 25% of the share capital of the distributing Estonian company.[3] Under the income tax legislation, therefore, corporate entities are exempt from income tax on undistributed profits, regardless of whether these are reinvested or merely retained. Since there are no taxes on corporate income per se, there is no need for depreciation allowances. Capital gains realised by a resident corporate entity (including non-resident permanent establishment) are not taxed until the actual or hidden distribution occurs and ate subject to 26/74 income tax on a monthly basis. Estonia has no thin capitalisation rules.

3 Comparison of corporate taxation in Eastern Europe

Table 1 compares the corporate tax rate for retained earnings, the share of corporate taxes in total tax revenues and the tax depreciation methods applied in twelve Eastern European transition economies. Eastern European states have implemented a series of corporate tax reforms, which have been justified mainly in the context of tax competition. Considering the statutory corporate tax rate for retained earnings, Russia ranks first at 35%, followed by the Czech Republic at 31%, and then Romania, the Slovak Republic and Slovenia at 25%. The corporate tax rate for retained earnings is lowest in Estonia (0%).[4] In most countries, straight-line depreciation can be adopted for machinery and equipment. On the contrary, geometric-degressive depreciation is usually applied for machinery and equipment in the Czech Republic and Poland.[5]

[3] Bilateral conventions for avoidance of double taxation and prevention of fiscal evasion, however, often state a lower withholding tax. A list of these bilateral conventions can be found at http://www.fin.ee/doc.php?4057.

[4] To analyse the impact of tax cuts, economists have used either a "bottom-up" approach, which looks at the impact of specific tax changes, or a "top-down" approach, which seeks to measure the relationship between tax rates and growth over time and in different countries. On the face of it, the Estonia's 2000 income tax act provides an ideal laboratory for "bottom-up" research: the tax rate for retained earnings fell from 26% to 0%.

[5] As taxes on corporate income per se were eliminated after 1 January 2000 in Estonia, there is no need for depreciation allowances.

Table 1. International comparison of corporate taxation in Eastern Europe in 2003

Country	Corporate Tax Rate for Retained Earnings, (%)	Share of Corporate Taxes in Total Tax Revenues, (%)	Tax Depreciation Rules for Machinery and Equipment
Bulgaria	15	6.40	Straight-line depreciation in 5 years
Croatia	20	2.57	Straight-line depreciation (4–10 years)
Czech Republic	31	8.30	Geometric-degressive depreciation (12 years)[c]
Estonia	0	3.58	-
Hungary	18	6.92	Straight-line depreciation (20%)
Latvia	19[a]	6.72	Straight-line depreciation (20-40%)
Lithuania	5	3.02	Straight-line depreciation (4-10 years)
Poland	24[b]	8.81	Geometric-degressive depreciation (20%)
Romania	25	11.43	Straight-line depreciation in 10 years
Russia	35	11.69	Straight-line depreciation in 4-10 years
Slovak Republic	25	9.09	Straight-line depreciation in 15 years
Slovenia	25	3.51	Straight-line depreciation in 4-10 years

Notes: a. The Latvian parliament has decided to reduce the corporate tax rate to 15% in 2004. b. The tax rate will be reduced to 22% in 2004. c. The depreciation rate amounts to 8.33% for the first year and 15.28%, 13.89%, 12.5%, 11.11%, 9.72%, 8.33%, 6.94%, 5.56%, 4.17%, 2.78% and 1.39% for subsequent years. The share of corporate taxes in total tax revenues in 2000 was calculated using revenue data from the IMF. Sources: PriceWaterhouseCoopers (2002) *Corporate Taxes – Worldwide Summaries 2002-2003*, New Jersey (John Wiley & Sons) and IMF *Government Finance Statistics Yearbook 2001*, Washington.

While these tax rates provide an interesting snapshot of corporate taxation around Eastern Europe, we should remember that a low tax rate does not necessarily mean a low tax burden. For individual countries, the tax rate must be applied to the tax base to measure tax burdens. That said, in the absence of harmonised tax bases, a comparison of tax rates only gives a partial impression of international tax burdens. We therefore also provide the share of corporate taxes in total tax revenues in 2000.

The comparison reveals that the Estonian corporate tax system provides rather favourable conditions for investors and tends to promote private investment that is financed by retained earnings. This positive assessment of corporate taxation in Estonia is further substantiated by the share of corporate taxes in total tax revenues and the qualitative tax measures published by the EBRD.[6]

[6] See EBRD (2002), pp. 42-43. To assess whether taxation is an obstacle to firm operation and growth, the EBRD and the World Bank have examined the extent to which firms seek to avoid taxes. In the survey, they ask businesses to indicate the extent to which firms underreport sales for tax purposes, recognising the difficulty of firms complying with taxes. However, some caution is required in drawing conclusions from such survey ratings. For instance, like any qualitative rating, they could be influenced by the prevailing sense of economic optimism and could therefore be closely related to a country's current macroeconomic performance.

4 A dynamic general equilibrium model

To get a handle on some of the issues raised in the introduction, we develop an intertemporal closed-economy Ramsey-type model of optimal growth with three sectors: the state, firms and households. The model covers a variety of taxes on retained earnings, dividends and consumption, and can thus provide insights into how and to what extent the 2000 income tax act might influence a firm's investment decisions, output and consumption. Our decision to exclude consideration of how the financial structure and financial policies of a firm are affected by the tax reform is motivated by our wish to treat one difficulty at a time and simplify our analysis. We outline the features of the model in terms of the objectives and constraints various agents are facing. The model is deterministic and agents have perfect (point) expectations of future variables.

The representative firm acts optimally and simultaneously chooses its real investment so as to maximise an objective function. To define the objective function of the firm, we need to determine its net-of-tax cash flow at each time. The firm is assumed to produce output with capital, K, and labour, L, using a Cobb-Douglas production function. The technology parameter A grows at an exogenous rate γ and the firm faces expenses for labour, wL. As a result of these assumptions, and taking the output price as a numeraire, economic profits of the firm are given by

(1) $$\pi = K^{\alpha}(AL)^{1-\alpha} - wL - \delta K,$$

where δ is the (geometric) economic depreciation rate. We carefully distinguish in the model between economic depreciation and depreciation for tax purposes. Following Sinn (1987), tax depreciation is divided up into a part z of gross investment that is written off immediately and the remainder (1-z) that depreciates at the economic rate. Hence with I denoting *net* investment, current depreciation for tax purposes is given by $z(I + \delta K) + (1-z)\delta K$ or equivalently $z(I + \delta K)$. On the dividend side, *gross* dividends are defined as

(2) $$D = \pi - I - T,$$

where corporate taxes on retained earnings are defined as

(3) $$T = \tau(\pi - zI - D).$$

Equation (1) – (3) imply that in every period we have

(4) $$D = K^{\alpha}(K, AL)^{1-\alpha} - wL - \delta K - \frac{(1-\tau z)I}{1-\tau}.$$

The optimal behaviour of the firm depends upon both the personal tax rate and the corporate tax rate. We therefore define the tax system in terms of these two tax rates. The first, defined above, is the corporate tax rate for retained earnings (τ). The second measures the degree of discrimination between earnings retentions and dividend payments. This "tax discrimination variable" is denoted by θ and is defined as the opportunity cost of retained earnings in terms of *net* dividends (θD) foregone.[7] Thus, if the Estonian firm distributes one kroon (*EEK*), the shareholder receives $\theta\, EEK$ in after-tax dividends. For an imputation system, this tax discrimination variable is given as

(5) $$\theta = \frac{1-m}{1-\tau},$$

where m is the personal tax rate on dividends. Equation (5) allows a straightforward taxonomy of corporate tax systems. Dividends are tax-favoured when $\theta > 1$, while for $\theta < 1$ a preferential tax treatment of retained earnings exist. When $\theta = 1$ and $z = 0$, the corporate tax system is neutral with respect to retentions and distributions. Firms are assumed to maximise the discounted stream of after-tax dividends, i.e.

(6) $$V(0) = \int_0^\infty \theta D\, e^{-\int_t^v (1-m) r(s) ds}\, dv.$$

The interest rate r is assumed to be exogenously given for the firm. In choosing its policies, the firm has to satisfy a number of technological and legal constraints. The most obvious constraint is that *net* investment (I) increases the capital stock and therefore the evolution of capital is given by

(7) $$\dot{K} = I.$$

We can now apply the standard techniques of optimal control theory, and solve the firm's maximisation problem or the path of controls, given the tax rate. The necessary first-order conditions for optimality yields the capital user cost condition

(8) $$\alpha \left[K/(AL)\right]^{\alpha-1} - \delta = \theta(1-\tau z) r.$$

Equation (8) equates the net return of spending one *EEK* for equity versus bonds.

The representative forward-looking household is infinitively lived and maximises utility over an infinite horizon, as summarised by the following functional form

(9) $$U = \int_0^\infty \frac{C^{1-\sigma}}{1-\sigma} e^{-\rho t}\, dt,$$

where C denotes consumption ρ is the time preference rate taken to be constant in all periods, and $1/\sigma$ is the intertemporal elasticity of substitution.[8] Thus, the determination of optimal consumption is fundamentally an intertemporal problem. Note that we are abstracting from consumer durables here, i.e. consumption services that yield utility are identical to purchases of consumer goods.

Household financial wealth (W) consists of equity (V) and bonds (B). The accumulation of bonds is therefore constrained by the dynamic budget constraint

(10) $$\dot{B} = (1-m)w + (1-m)rB + \theta D + Z - (1+\tau_c)C,$$

[7] For a detailed discussion, see King (1977), pp. 47-56, and King and Fullerton (1984), pp. 21-22.

where Z denotes lump-sum transfers from the government and τ_c is the tax on consumption purchases. Inserting $\dot{V}$ obtained from differentiating (6) yields the law of motion for wealth as

(11) $$\dot{W} = (1-m)w + (1-m)rW + Z - (1+\tau_c)C .$$

With the particular specification of preferences above, the first-order condition is given by the Ramsey rule

(12) $$\frac{\dot{C}}{C} = \frac{r(1-m)-\rho}{\sigma} .$$

The government finances a constant share of government consumption $G = gY$ with tax earnings and issues of bonds. Given Ricardian equivalence, the path of government debt necessary to balance the current budget can then be represented by a time series of transfers. Since labour supply is normalised to one, *GDP* is obtained as $Y = K^{\alpha}A^{1-\alpha}$. It is used for private consumption (C), investment (I) and government consumption (G), i.e. $I = (1-g)K^{\alpha}A^{1-\alpha} - C - \delta K$. Dividing by K and inserting (7) provides capital accumulation according to

(13) $$\frac{\dot{K}}{K} = (1-g)(K/A)^{\alpha-1} - (C/K) - \delta .$$

For equilibrium analysis, we use the following transformed variables: $c \equiv C/Y$ and $k \equiv K/AL$. Using this change of variables and inserting r from (8) implies that equation (12) and (13) can be rewritten as

(14) $$\frac{\dot{k}}{k} = (1-g)k^{\alpha-1} - c - \delta - \gamma$$

and

(15) $$\frac{\dot{c}}{c} = \frac{\phi(\alpha k^{\alpha-1} - \delta) - \rho}{\sigma} - \gamma - \frac{\dot{k}}{k} ,$$

where $\phi = (1-\tau)/(1-\tau z)$. Equations (14) and (15) are the two equations of motion driving the system, together with the transversality condition and initial $K(0)$ and $A(0)$. The unique steady state, k^* and c^*, is defined by $\dot{c} = \dot{k} = 0$, which implies

(16) $$k^* = \left[\frac{\gamma\sigma + \rho + \phi\delta}{\alpha\phi}\right]^{1/(\alpha-1)}$$

and

(17) $$c^* = (1-g)k^{*\alpha-1} - \gamma - \delta .$$

[8] The alternative dynastic interpretation assumes that those making decisions today take the welfare of future

From the linearisation of the above system, we see the model displays a saddle path dynamic structure, regardless of the tax rate. This implies that adjustment dynamics after a tax reform are uniquely determined as a movement along a stable manifold. One can also see from $\partial\phi/\partial\tau < 0$ and $\partial k^*/\partial\phi > 0$ that a corporate tax reduction unambiguously increases the capital stock in efficiency units. This can also be seen in the capital user cost condition (8), where a tax reduction reduces the tax discrimination variable θ. The equilibrium interest rate is given by

(18) $$r^* = \gamma\sigma + \rho \, .$$

To evaluate the welfare consequences of a change in tax policy, we report the equivalent variation (*EV*) for an infinitively lived household. We normalise $A(0) = 1$, use $(C/K)\cdot(K/A) = ck$ and write

(19) $$U = \int_0^\infty \frac{(C/A)^{1-\sigma} A^{1-\sigma} e^{-\rho t}}{1-\sigma} dt = \int_0^\infty \frac{(ck)^{1-\sigma} e^{-[\rho-\gamma(1-\sigma)]}}{1-\sigma} dt \, .$$

Following Lucas (1990, 2003), we measure the welfare gain as the percentage change in consumption that equates intertemporal utility from remaining in the pre-reform state compared to the post-reform state. We solve this numerical problem several times and decrease the maximum discretisation error of the employed Runge-Kutta method until a further decrease of the error does not lead to a reduction of the welfare gain by more than 10^{-5}.

5 Calibration results for the baseline model

In this section, we seek to determine the extent to which the 2000 income tax act promotes or inhibits investment, consumption and welfare. The analysis is carried out through calibrations and numerical solutions that account for the effects of government policy without estimating real-economy parameters for the model. We first pin down the Estonian benchmark economy using parameters that are "calibrated" from data on actual allocations. This procedure establishes a benchmark equilibrium with existing tax rules and prices. Starting from this verified benchmark, we then calculate the effects (unanticipated) of the tax act.

We select the first values for the benchmark model from other calibration exercises, i.e. we adopt $\alpha = 0.33$ and $\rho = 0.02$. Next, since the capital stock data for Estonia are unavailable, we set $(K/Y)^* = 2.0$ which is the year 2000 value for Finland. Estonia's current *GDP* growth rates of have to be regarded as a temporary phenomenon, so we set the equilibrium growth rate to the average German value prior to unification ($\gamma = 1.75\%$). The economic depreciation rate is set equal to 8.25%. Admittedly, this figure is somewhat arbitrary, but nevertheless reasonable given that it is below the 10% rate of depreciation assumed by King and Rebelo (1990) and employed in much of the RBC literature, and further because it generates a fairly realistic investment ratio of 20%. The value of g is set to Estonia's share of government consumption in *GDP* (0.2) and the pre-reform depreciation rate for tax purposes to $d = 0.4$ as in Funke (2002). The pre-reform corporate tax rate for retained earnings is $\tau = 0.26$, and the tax rate of wage and dividend income is $m = 0.26$. The value-added tax rate is $\tau_c = 0.18$. For an asset life of ten years, the present value of tax depreciation allowances is then $\sum_{t=1}^{9}\left[d(1-d)^{t-1}/(1+r)^t\right]+\left[(1-d)^9/(1+r)^{10}\right]$ in discrete time. A continuous time approximation

generations into account.

is $y_1 := \int_0^\infty de^{-dt} e^{-rt} dt = d/(r+d)$. The present value of economic tax depreciation allowances is $y_2 := \delta/(r+\delta)$, and hence the artificial variable for immediate write-offs, z, solves $y_1 = z + (1-z)y_2$. The benchmark model implies $z = 0.72$. Since we have already set the equilibrium growth rates, the capital-output ratio and therefore r^*, the remaining parameter $\sigma = [(1-\tau)r^*-\rho]/\gamma = 3.0$ is endogenously determined. The resulting benchmark parameters are given in Table 2 below. We assume a particularly simple government sector, i.e. one where the government balances its budget each period.[9] On the expenditure side, the government uses its proceeds to finance g. All remaining tax revenues are used for lump-sum transfers to the household sector.

Table 2. Benchmark parameter values

α	ρ	γ	σ	δ	g	τ	M	d	τ_c	$(K/Y)^*$	$(I/Y)^*$
0.33	0.02	0.0175	3.0	0.082	0.2	0.26	0.26	0.4	0.18	2.0	0.2

In our (unanticipated) policy scenario, we reduce the tax rate for retained earnings permanently from 26% to 0% and compare the results in all scenarios to the benchmark steady state equilibrium with the initial tax rate in place.[10] In order to assess the robustness of the estimates, we executed an extensive sensitivity analysis. Baseline parameter values are employed in all scenarios, except for the parameter subjected to sensitivity analysis. In table 3 we report the results.

Table 3. Estonia's 2000 income tax act – a quantitative assessment

Parameter	$(I/Y)^*$	k^*	Consumption		Welfare Gain (EV)		
			Impact	Long Run	Transitional	Steady State	Net
Benchmark	1.22	9.24	-2.63	0.87	-1.38	0.87	-0.51
$g_c^* = 0.03$[a]	1.37	9.24	-3.79	0.50	-1.15	0.50	-0.65
$g_c^* = 0.043$[b]	1.53	9.24	-4.88	0.09	-0.86	0.09	-0.77
$(K/Y)^* = 2.5$	.096	5.76	-2.90	0.09	-0.59	0.09	-0.50
$(K/Y)^* = 1.5$	1.37	13.9	-2.22	2.20	-2.63	2.20	-0.43
$d = 0.2$	1.91	14.5	-4.24	1.26	-2.02	1.26	-0.76
$d = 0.6$	0.89	6.71	-1.88	0.65	-1.03	0.65	-0.38
$\rho = 0.01$	1.22	9.24	-2.38	0.87	-1.36	0.87	-0.49
$\rho = 0.02$	1.22	9.21	-3.42	0.87	-1.43	0.87	-0.57

Notes: The table gives the deviations from pre-reform steady states in percentage points for I/K and in per cent for other variables; a) $g_c^* = 0.03$ implies $(I/Y)^* = 0.225$; b) $g_c^* = 0.043$ implies $(I/Y)^* = 0.25$.

[9] The Estonian government is constitutionally obliged to maintain a balanced central budget. To plug revenue gaps, the government currently plans to introduce protective tariffs against non-EU countries, including the US. The goal is to confront possible budget deficits without raising interest rates or dampening investment and growth.

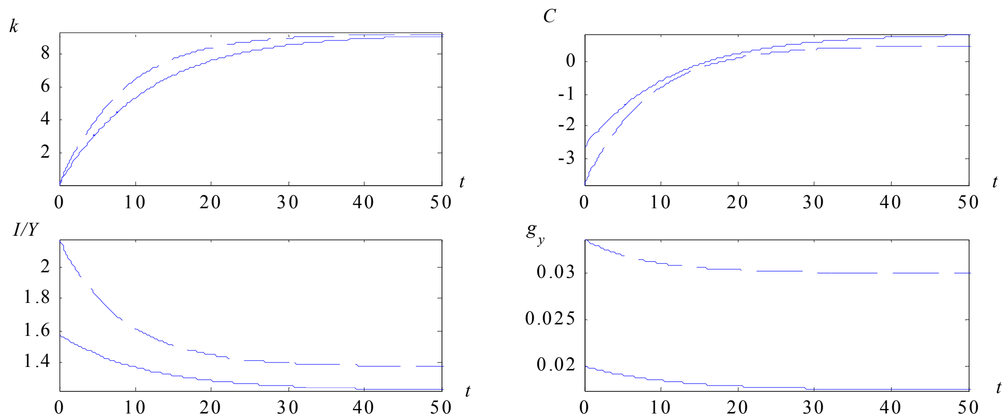
[10] The tax discrimination variable prior to the reform is given by $\theta = (1-0.26)/(1-0.26) = 1.0$, and $\theta = (1-0.26)/(1-0.0) = 0.74$ effective January 1, 2000. The new tax system therefore implies a preferential treatment of retained earnings.

The "prototypical" benchmark results for $\gamma = g_c = 0.0175$ are given in the first row of Table 3. When reducing the tax rate for retained earnings, equivalent variation declines by 0.51% over the infinite horizon. What is driving these results is the following. The removal of the tax rate for retained earnings increases investment expenditures. The increase of investment has an immediate impact upon consumption. In the short run, consumption decreases by 2.63% relative to the benchmark (-2.63%). The transitional welfare effect is also negative (-1.38%). In the long run, however, consumption is increasing by 0.87% because of the level effect.[11] In other words, the economy is investing more by reducing consumption in the short- and medium run. This increase in the capital stock does not occur painlessly.

In order to better understand the impact of the parameters in our model we have also performed a comprehensive sensitivity analysis reported in the remaining eight rows of Table 3. The results in Table 3 indicate that the welfare estimates for the same tax cut ranged up to –0.43% for $(K/Y)^* = 1.5$, and down to –0.77% for $g_c^* = 0.043$. The positive long-run impact upon consumption is also highest for $(K/Y)^* = 1.5$. The sensitivity analysis illuminates the qualitative robustness of the results. The welfare effect and the impact effect upon consumption are negative, while the long run impact upon consumption generally turns out to be positive.

We also summarise the transitional dynamics in Figure 1.[12] To compute the transitional dynamics, we use the backward integration procedure of Brunner and Strulik (2002) to rule out explosive behaviour. The procedure uses the backward stability of the stable manifold and the fact that state variables cannot jump. The analysis begins arbitrarily close to the post-reform steady state and integrates (13) and (14) backwards until the capital stock k reaches its pre-reform steady state. A second revision of time then provides the forward-looking solution using Runge-Kutta methods.

Figure 1. Transitional dynamics for the benchmark model



Note: The solid lines represent $g_c^* = 0.0175$ (benchmark case), the dashed lines represent $g_c^* = 0.03$

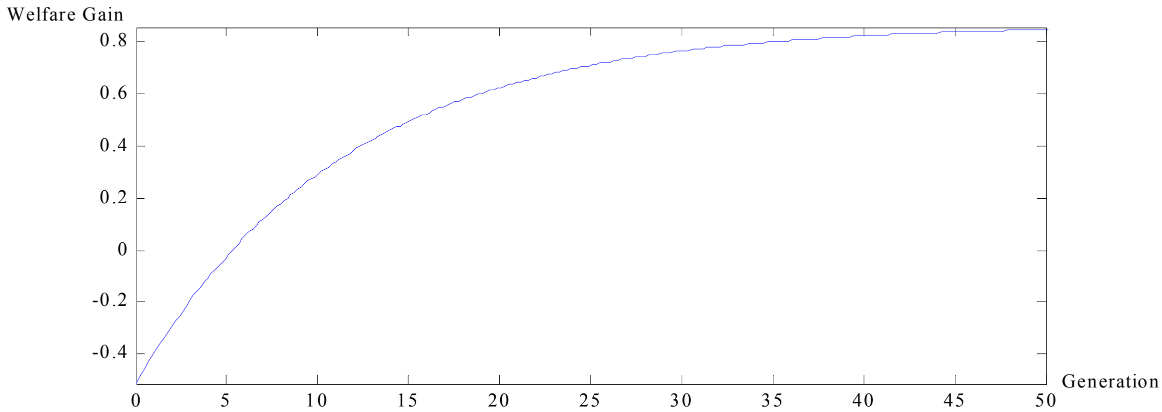
[11] Lucas (1990) has estimated that the welfare gain from the elimination of capital income taxation in the US would equal about 6% of annual consumption when transition effects are ignored, but less than 1% when transitional costs are taken into account. For comparison, Lucas (1990) notes that this is about 20 times the gain from eliminating post-war US business cycles. Subsequent papers by King and Rebelo (1990) and Jones et al. (1993) have tended to confirm these findings.

[12] Note that the economy converges only asymptotically to the steady state. We therefore truncate the transitional dynamics in the effective computation at the horizon $T = 50$.

A few comments are in order. The simulation starts in period 0, where the government suddenly changes the tax rates. This unanticipated policy shock induces a reaction from all economic variables. Figure 1 shows the time paths of k and c expressed as percentage deviations from the pre-reform state. Deviations of I/Y from pre-reform steady states are given in percentage points. The capital stock increases by 9.24% because the 2000 income tax act provides a more favourable tax treatment for investment.[13] The immediate and medium-run impact upon consumption is negative (crowding-out effect). While consumption increases in the long run, the lower income tax does not increase overall welfare: the equivalent variation corresponding to it is slightly negative. This implies that the effect of taxation in a dynamic setting is more subtle than often supposed. In particular, we need to distinguish between the short-term impact and the effects upon the steady state levels. The increase in *GDP* is brought about by higher investment. This requires lower consumption, particularly in the early years of the simulation, and lowers welfare. In other words, the results remind us that increasing investment does not necessarily increase welfare – higher consumption in the long run can only be achieved at the cost of lower consumption in the present. And so a trade-off has to be made. The final graph indicates that the growth rate of the economy (g_y) increases during transition dynamics. Over time, however, the growth rate gradually declines and converges again to the (exogenous) growth rate.

As an additional thought experiment, one can interpret the immortal representative individual as a dynasty, where an individual born s years after the tax reform has utility $\int_s^\infty U(C(t))e^{-\rho t}dt$. This modification allows us to attribute losses to different generations. In Figure 2 we assume that a new generation is born every year. For the sake of brevity, we present only the results for the benchmark case. The results indicate that the current generation bears the main burden of the reform. The break-even occurs approximately at t = 5. Generations born six years after the reform already enjoy beneficial welfare effects.

Figure 2. Generational distribution of welfare gains and losses



The graph indicates that the country is facing the problem of determining the optimal trade-off between consumption and investment across generations. This conclusion is important for policy purposes. Clearly, the choice of a tax reform strategy plays a critical part in meeting wider generational and social objectives.

[13] This increase is slightly more pronounced than the increase in Funke (2002).

6 Foreign direct investment

The three-sector model used in section 5 clearly offers plenty of opportunities for improvement. One can argue, for example, that the results are incomplete since our benchmark model is for a closed economy, i.e. Estonia is assumed to live in financial autarky and therefore investment expenditures have to be financed by the sacrifice of domestic consumption over time. Thus, we now consider an augmented open economy version of our model by allowing for foreign direct investment (*FDI*).[14]

We introduce *FDI* by assuming that a constant fraction of total investment in Estonia originates from abroad. Let this fraction be denoted by β. Consequently, foreigners own a constant fraction β of the total capital stock, and by implication a constant fraction β of a representative firm's shares. Hence, the firm side of the model remains unchanged except from the fact the V now denotes the value of shares held by Estonians and foreigners.

The Estonian household consumption plan, i.e. the Ramsey rule, also remains unchanged. To see this, note that the representative Estonian household now holds a constant fraction $(1-\beta)$ of shares and receives dividends $(1-\beta)D$. Hence $\dot{W} = \dot{B} + (1-\beta)\dot{V}$ implies

$$\dot{W} = (1-m)w + (1-m)rW + Z - (1+\tau_c)C \tag{20}$$

after insertion of $\dot{V}$ obtained from (6). This is the same dynamic budget constraint as in the original model and thus equation (15) remains valid. This, in turn, implies that the introduction of *FDI* does not change the equilibrium capital stock, which is determined by tax rates and parameters of preference and technology.

The occurrence of *FDI*, however, reduces national income (*GNP*). Since foreigners own a fraction β of Estonia's capital stock, a share β of dividends flows into foreign countries at any point in time. *GNP* is obtained as $K^{\alpha}L^{1-\alpha} - \beta D$ and is used for private consumption, investment, and government expenditures.[15] Hence, $I = (1-g)K^{\alpha}A^{1-\alpha} - C - \delta K - \beta D$. Substituting (4) and (7), we obtain

$$\frac{\dot{k}}{k} = \frac{1-g-\alpha\beta}{\phi-\beta}k^{\alpha-1} - \frac{\phi}{\phi-\beta}c - \frac{\delta(1-\beta)\phi}{\phi-\beta}\delta - \gamma\ , \tag{21}$$

which replaces (14). Note that (21) reduces to (14) for $\beta = 0$. Steady state consumption is obtained as

$$c^* = (1-g-\alpha\beta)k^{*\alpha-1} - \frac{(\phi-\beta)}{\phi}\gamma - \delta(1-\beta)\ , \tag{22}$$

[14] To keep things tractable, we overlook all aspects of maximization in the Rest-of-the-World. This would complicate the model without providing additional insights for the purpose at hand. Hines (1999) and the OECD (2001) have shown the increasing sensitivity of FDI to country tax burdens, consistent with trends towards globalisation. Agreements on the avoidance of double taxation of income and capital, based on the OECD model agreement, have been concluded between Estonia and the following countries: Belarus, Canada, China, the Czech Republic, Denmark, Finland, Germany, Iceland, Ireland, Latvia, Lithuania, Moldova, the Netherlands, Norway, Poland, Sweden, Ukraine, the United Kingdom and the US. Agreements with France and Italy await ratification.

[15] The term βD represents the term "Factor Payments to Abroad" in the National Accounts.

implying

(23) $$\frac{\partial c^*}{\partial \beta} = -\left(\alpha k^{*\alpha-1} - \delta\right) - \frac{\gamma}{\phi} = -\frac{\gamma(\sigma-1)}{\phi} - \frac{\rho}{\phi},$$

where we have used k^* to obtain the right hand sides. A sufficient condition for this derivative to be negative is $\sigma \geq 1$, which is almost surely satisfied for reasonable parameter values.[16] Therefore, if we are willing to focus on comparisons of steady states and ignore transitional effects, *FDI* unambiguously lowers Estonian steady state consumption for reasonable parameter values.

FDI also influences consumption and welfare through a second channel. If foreigners undertake part of Estonia's investment, we should expect a less dramatic reaction in consumption following the increase of investment caused by the corporate tax cut. Further, we may expect a faster adjustment after a shock, which again leads to a less pronounced transitional welfare loss. To verify these propositions, we reconsider our policy experiment by assuming that foreigners own 20-30% of Estonia's capital stock.[17] The results are summarised in Table 4 and Figure 3.

Table 4. The Impact of *FDI* – a quantitative assessment

Parameter	$(I/Y)^*$	k^*	Consumption		Welfare Gain (*EV*)		
			Impact	Long Run	Transitional	Steady State	Net
Benchmark	1.22	9.24	-2.63	0.87	-1.38	0.87	-0.51
$\beta = 0.2$	1.22	9.24	-2.39	1.05	-1.34	1.05	-0.29
$\beta = 0.3$	1.22	9.24	-2.26	1.15	-1.32	1.15	-0.18

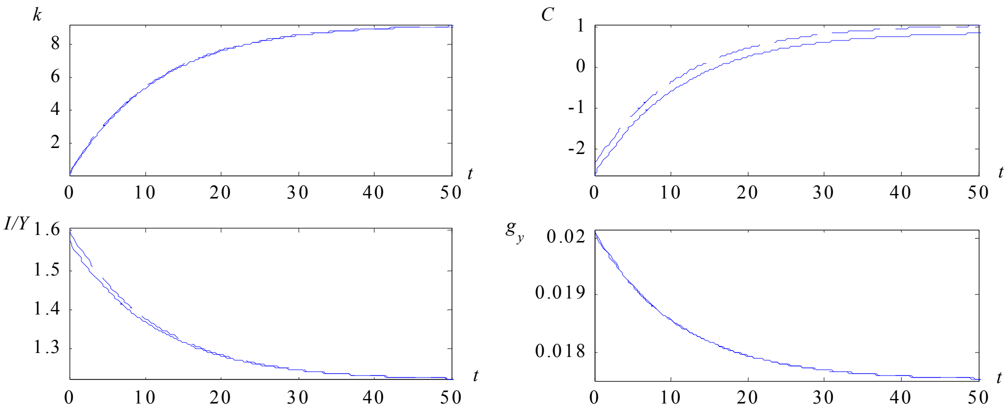
Note: The table gives the deviations from pre-reform steady states in percentage points for *I/K* and in per cent for other variables.

This results confirm the above intuition. Transitional dynamics are less painful because consumption falls less in the early years relative to the benchmark case. The ability of the country to attract FDI, and therefore borrow on international capital markets, helps consumers smooth their consumption. The impact of *FDI* is also visible from the transitional dynamics in Figure 3 where the solid (dashed) lines indicate adjustment without (with) *FDI*.

[16] Hall (1988) and Ogaki and Reinhard (1998) provide evidence that the intertemporal elasticity of substitution $1/\sigma$ is well below one.

[17] $0.2 < \beta < 0.3$ is consistent with the *net* inflow of foreign direct investment into Estonia. Estonia is one of the few transition economies with sufficient *FDI* outflows to produce a significant difference between the *gross* and *net* figures. At the beginning of the 1990s, *FDI* in the Baltic states was closely correlated with privatisation receipts. More recently, the Baltics have begun to attract substantial non-privatisation-related *FDI* inflows. See EBRD (2001, 2003).

Figure 3. Transitional dynamics with and without *FDI*



7 Conclusions

The general reputation of economists for disagreeing with each other and serving up politically expedient theories on everything is only partly deserved. Many purported economists would never be considered colleagues in more serious circles and the extent of disagreement among the brightest scholars is often exaggerated outside the academic community. Nonetheless, such charges should make any economist somewhat self-conscious. Here, for example, we have applied a rigorous mathematical footing to the highly controversial real world problem of setting tax policy. We have constructed and calibrated a dynamic general equilibrium growth model that could offer plausible predictions about the impact of Estonia's 2000 income tax reform.[18] Overall, it appears the tax reform benefits the investment climate and fares quite favourably in the long run.[19] Hopefully, this will pave the way for empirical work aimed at identifying tax impacts upon investment spending of firms in Estonia.[20]

[18] The welfare effects we estimate in our model are a combination of level effects and transitional dynamics; they are not the result of a different steady-state growth path. Strulik (2003b) shows that the welfare effects of tax changes in endogenous growth models are quite similar to those in growth models with exogenous technological progress.

[19] We have abstracted from the question of the credibility of the reform. A more favourable tax treatment of capital generally encourages the accumulation of capital, but only if investors believe that the lower rates will remain in place. However, once the private sector has build up the capital stock in response to lower tax rates, the government faces an incentive to raise the tax rates on capital. Investors will realise this incentive and so will be wary of betting too much on the persistence of lower tax rates into the future.

[20] The calibration results indicate it will be important in such empirical work to distinguish between transitional dynamics and long-run steady-state tendencies.

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