# Capital Taxation, Investment, Growth, and Welfare

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**Abstract**

This paper formulates a model of economic growth to study the effects of broad capital taxation (of profits, dividends, and capital gains) on macroeconomic outcomes. A framework of exogenous growth permits modeling countries in transition to a country-specific steady state and to discern steady-state and transitory effects of shocks on economic outcomes. The chosen framework is amenable to structural estimation and, given the parsimony in terms of unknown parameters, fits data on 79 countries over the period 1996-2011 extraordinarily well. A quantitative exercise shows that capital tax reductions induce positive effects on output and the capital stock (per unit of effective labor) that are economically significant and are accommodated within time windows of 5 years without much further economic response after that. The effects are strongest for corporate profit tax rates and weaker for dividend and capital gains taxes. From a welfare perspective, reducing capital taxes would be beneficial for some countries (e.g., Germany) but not for others (e.g., the United States).

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# 1 Introduction

Whether countries should remove taxes on mobile capital or not is a vividly-debated question. Empirically, corporate profit tax rates have been found to be more or less unambiguously detrimental for GDP growth across countries (see Lee and Gordon, 2005, for evidence in a panel of 70 countries; Arnold et al., 2011, for evidence in the United States) as well as across subnational units (see Ferede and Dahlby, 2012, for evidence across Canadian provinces). Similar effects along those lines have been found for capital gains taxes (see Hungerford, 2010, for evidence regarding the United States) and for dividend taxes in OECD countries (see Dackehag and Hansson, 2012).

Theoretically, the effects of capital taxation depend on the nature of economic growth (exogenous or endogenous), on the effects of capital taxation on other investments than ones in gross fixed capital formation, and on whether the associated tax revenues generate public goods or spillovers (externalities). For instance, in models of exogenous economic growth, where capital and output in units of effective labor stay constant in the steady state and savings only finance the formation of fixed capital, taxes on capital and capital income do not affect economic growth but have detrimental effects on capital stock and output levels (see Judd, 1985; Chamley, 1986). However, if capital taxation leads to investments in intangibles (e.g., through research and development) capital taxation in a Judd-Chamley framework might even raise output (see Aghion et al., 2013). Clearly, in all models of exogenous economic growth, capital taxation affects growth only in the transition to the new steady state, and then the question is how relatively persistent the growth effects are. In endogenous growth models, capital and output in units of effective labor grow forever. However, even then capital taxation does not need to affect economic growth (see Stokey and Rebelo, 1995), but it will distort economic growth in many such models (see Lucas, 1990; King and Rebelo, 1990; Jones et al., 1993). Stokey and Rebelo (1995) provide a review of the literature of capital taxation with endogenous economic growth. In spite of negative effects on output levels per unit of effective labor emerging from most models of economic growth cum capital taxation, the associated consumer welfare effects do not need to be negative. Russo (2002) finds negative welfare effects along the transition to the new steady state in an exogenous growth model. However, the welfare effects from taxing capital may be positive if tax revenues are used to provide public goods or generate spillovers (see Uhlig and Yanagawa, 1996; Gruener and Heer, 2000; Baier and Glomm, 2001). While most previous theoretical models discussed capital taxation in a relatively narrow definition – through direct taxes on the capital stock or interest payments – the expected effects from dividend and capital gains taxation on investment and transitional growth of output, capital, and consumption are qualitatively similar to those of a direct taxation of capital (see Gourio and Miao, 2011).

Recently, Korinek and Stiglitz (2009) show in a life-cycle model that only anticipated changes in dividend taxation distort economic growth.

This paper contributes to this debate along four lines. First, the main contribution is quantitative, estimating behavioral impulse-responses of macroeconomic aggregates to changes in three different broad corporate capital tax instruments across a relatively large set of economies. Second, it does so by formulating a theoretical dynamic model of a small open economy with exogenous growth and internationally mobile capital that features broad capital taxation through three instruments: corporate profit taxation, dividends taxation, and capital gains taxation. A key purpose of this model is its amenability to structural estimation and quantitative analysis with many countries that are repeatedly observed over time. Third, it collects data on the aforementioned capital tax instruments together with macroeconomic variables such as real GDP, capital stocks, population growth and technological progress for 79 economies and 16 years between 1996 and 2011. Fourth, apart from estimation, it simulates theory-consistent impulse-response functions of changes in broad capital taxation for various economic outcomes, including welfare. The proposed stylized small-open-economy model of exogenous growth with optimal firm-level investment cum broad capital taxation is shown to fit the data extraordinarily well and to result in plausible predictions regarding dividend-payout ratios or Tobin's $q$. Moreover, while capital taxation tends to reduce output and capital per unit of effective labor, lowering it is shown to benefit some but not all economies, and it does so at remarkably big heterogeneity. The reason is that a tax reduction leads to more investment and leaves less income for consumption in the short-run, while consumption will unambiguously increasein the long-run. Depending on country-specific characteristics and transitional dynamics, discounted utility per unit of effective labor may rise or fall with capital taxation or its abolishment. The latter illustrates the qualitative importance of transition path features when evaluating the welfare implications of changes in capital tax policy.

The paper builds on the framework of Abel (1982) and Barro and Sala-i-Martin (2004) in which firms maximize their present value over the optimal capital stock and investment. In order to determine a firm's present value under various taxes, we follow Turnovsky and Bianconi (1992) and Turnovsky (2000). Not only in the data but also in the model, capital may be taxed in the form of profits, of dividends, and of capital gains. The latter are assumed to be realized and taxed at the end of every period (see Auerbach, 1991, and Auerbach and Siegel, 2000, for an analysis of deferral, which we abstract from, here). Stokey and Rebelo (1995) and Mendoza et al. (1997) point out that there is only very little impact of capital taxation on long-run growth, so we consider an exogenous growth model with capital adjustment costs as in Sen and Turnovsky (1990) as appropriate and focus on the transitional dynamics of output, capital, consumption and the associated growth rates.

The results point to a stark heterogeneity in the effects on outcome levels per unit of effective labor of a proportional reduction of the three types of capital tax rates (by 10%) across tax instruments as well as across countries. Growth effects occur mainly in the short-run – within five years after a tax change. Although a reduction of any capital tax rate unambiguously increases output, capital, and consumption in the long-run (as long as those tax rates are positive in the outset, welfare might increase or decline. Hence, representative individuals in some countries (e.g., in Austria, Canada, Italy, Switzerland, and the United States) are predicted to loose from a capital tax reduction for the aforementioned reason. However, in other countries (e.g., in Germany, Spain, Luxembourg, Mexico and the United Kingdom) the opposite is true.

The remainder of the paper is organized as follows. In section 2 we introduce a stylized small-open-economy model of exogenous growth and broad capital taxation. An appendix derives detailed results for that model. In section 3, we confront that model with data on 79 economies and estimate the key parameters. Moreover, we derive the welfare effects for a sub-set of 21 economies. In section 4, we utilize the data on the covered countries and the estimated parameters to generate numerical results about the effects of counterfactually changed capital tax rates. Section 5 concludes.

## 2 Model

In this section we outline a framework of a small-open-economy and the rest of the world (ROW), where governments use three tax instruments: a dividend tax rate levied on dividends ($\tau_d$), a capital gains tax levied on the change in equity value ($\tau_g$), and a corporate income tax levied on firms' profits ($\tau_p$). For simplicity, we assume all tax rates to be flat. Moreover, we assume source-based taxation under which taxes are applied to all profits, capital income, and capital gains within the borders of the country, regardless of foreign or domestic ownership. For the notation it will be useful to distinguish between a domestic (unstarred) and foreign (starred) location of economic activity and between a domestic (superscript $h$) and foreign (superscript $f$) ownership of dividends ($D$ in total and $d$ per equity unit) and equity ($E$ in total and $e$ per capita). By this convention $e^{\star d}$ is the equity owned per domestic individual in the rest of the world and $D^f$ denotes the total dividend payments to foreign individuals from domestic firms. By the above notation, $D = D^d + D^f$ and $E = E^d + E^f$ and $D = dE$ is the total dividend paid to domestic and foreign individuals.

Denote the domestic consumption of final goods per capita at time $t$ as $c(t)$, use $q$ to denote the price per unit of equity, and normalize the price of the final consumption to unity. In general, we define dotted variables as time changes, i.e., $\dot{x} = \frac{\partial x}{\partial t}$. Domestic individuals receive utility from final goods consumption only. They spend their income on final good consumption, $c(t)$, and on new equity at home and abroad, $q\dot{e}^d$ and $q^\star \dot{e}^{\star d}$, respectively. Domestic households receive income from five sources: dividend payments on domestic equity net of dividend taxation, $(1-\tau_d)d^d e^d$, the net-of-tax capital gains of domestic equity, $(1-\tau_g)\dot{q}e^d$, which we assume to be realized at the end of every period, from labor input $w$, from the repatriation of net-returns from foreign equity ($rq^\star e^{\star d}$) – with $r$ denoting the exogenous net rate of return on equity held by domestic individuals in the ROW – and lump-sum transfers $f$ from domestically collected aggregated tax revenues, depending on the efficiency of the domestic tax system, $z \in [0,1]$, where a higher level of $z$ refers to a more efficient tax system.

## 2.1 Households

All $L$ individuals in the small economy have identical preferences and receive a present discounted value of utility of

$$U = \int_0^\infty u(c(t)) exp(-(\rho - n)t) dt, \tag{1}$$

where $u(c(t))$ is the instantaneous utility function depending on the individual consumption of a final good, $c$, with diminishing returns in $c$, $\rho$ is the individual discount factor which we assume such that $\rho \leq r + n$ in order to ensure a non-declining consumption in the steady state. The population (and employment) grows at an exogenous rate $n$.
Individuals maximize $U$ subject to their individual current budget constraint, for which we suppress time index $t$ since it indexes every variable:

$$c + q\dot{e}^d + q^\star \dot{e}^{\star d} = (1-\tau_d)d^d e^d + (1-\tau_g)\dot{q}e^d + rq^\star e^{\star d} + w + zf. \tag{2}$$

Writing the maximization problem for generic period $t$ as a current-value Hamiltonian, we obtain

$$H = u(c) + \underbrace{\mu \; exp^{-(\rho-n)t}}_{a} \Big( (1-\tau_d)d^d e^d + (1-\tau_g)\dot{q}e^d + re^{\star d}q^\star + w + zf - c \Big), \tag{3}$$

where $\mu$ is the present-value lagrange multiplier of wealth and $a$ is the current-value lagrange multiplier of wealth. The resulting first-order conditions (FOCs) are

$$\frac{\partial H}{\partial c} = 0 \quad \rightarrow \quad u_c(c) = a, \tag{4}$$

$$\frac{\partial H}{\partial e^{d}} = (\rho - n)a - \dot{a} \quad \rightarrow \quad (1-\tau_d)\frac{d^d}{q} + (1-\tau_g)\frac{\dot{q}}{q} = \rho - n - \frac{\dot{a}}{a} \tag{5}$$

and

$$\frac{\partial H}{\partial e^{\star d}} = (\rho - n)a - \dot{a} \quad \rightarrow \quad r = \rho - n - \frac{\dot{a}}{a}. \tag{6}$$

In equation (5) we assume, as in Turnovsky and Bianconi (1992), that the individuals take the dividend yields on their equity as given, which allows us to express the first-order condition in terms of dividend yield, $\frac{d^d}{q}$, and the growth rate of the equity value $\frac{\dot{q}}{q}$. Equation (6) is the long-run (steady-state) arbitrage condition. In equilibrium, the rate of return on investment in the domestic country, on the left-hand side of equation (5), has to match the net rate of return on investment in the rest of the world, $r$.

## 2.2 Representative firm

In a generic period $t$ whose index we suppress, the representative firm in a country produces output $Y$ with a Cobb-Douglas production function:

$$Y = F(A, K, L) = K^{\alpha}(AL)^{1-\alpha}, \tag{7}$$

where $L$ is the total labor employed, $K$ is the capital used for production, $A$ is the labor-augmenting technology level, and $\alpha$ is the constant expenditure share on capital in total costs. Labor is immobile and supplied inelastically. Technology grows at the exogenous rate $x$. We may write the production function in intensive form (per unit of effective labor), by dividing it by $AL$:

$$\hat{y} = f(\hat{k}) = \frac{F(A, K, L)}{AL} = \hat{k}^{\alpha}, \tag{8}$$

where $k$ is the capital per worker and $\hat{k}$ and $\hat{y}$ are the capital used and output generated per unit of effective labor, respectively. For further use, we will define $\hat{x} \equiv x/AL$ for any generic variable $x$. The firm's gross profits, $\Pi$, are

$$\Pi = F(A, K, L) - Lw - I\psi, \tag{9}$$

where $\psi = g\left(\frac{I}{K}\right)$ gives the costs of adjusting the physical capital stock and is assumed to be homogeneous of degree one in $\left(\frac{I}{K}\right)$. Furthermore, we assume that the labor market is competitive whereby the firm pays the marginal product of labor as the wage:

$$w = F_L(A, K, L). \tag{10}$$

Net of the corporate profit tax rate, $\tau_p$, profits are either paid as dividends, $D$, or retained in the firm, $R$, so that

$$(1-\tau_p)\Pi = D + R. \tag{11}$$

Total dividend payments are paid either to domestic individuals, $D^d$, or to foreign ones, $D^f$, according to their equity, $E^d$ and $E^f$, respectively. The total value of equity in the economy is $V = qE$. The change in the total value of equity in the domestic economy equals the change in the value of equity plus the change in equity:

$$\frac{\partial V}{\partial t} = \dot{V} = \dot{q}E + q\dot{E}. \tag{12}$$

Total investment is given by has to be equal to retained earnings, $R$, plus the change in equity, $q\dot{E}$:

$$I = \dot{K} + \delta K = q\dot{E} + R. \tag{13}$$

Capital is assumed to depreciate at a constant and exogenous rate $\delta$. Combining equations (11) and (12) with equation (13), we obtain a first-order differential equation for the change in total value of equity:

$$\dot{V} = \frac{r}{1-\tau_g}V - \left(\frac{\tau_g - \tau_d}{1-\tau_g}\right)D - \gamma, \tag{14}$$

where $\gamma \equiv (1-\tau_p)\Pi - I$. See the Appendix A for more details.

Assuming that the firm distributes a share $\phi \in [0,1]$ as dividends and retains $1-\phi$ of the profits, dividend payments are defined as:[1]

$$D = \phi(1-\tau_p)\Pi. \tag{15}$$

Substituting this in equation (14) yields,

$$\dot{V} = \frac{r}{1-\tau_g}V - (1-\tau)\left(F(A,K,L) - wL - I\psi\right) + I, \tag{16}$$

where we define $1-\tau \equiv \frac{(\phi(1-\tau_d)+(1-\phi)(1-\tau_g))}{1-\tau_g}(1-\tau_p)$. We may now integrate equation (16) as in Brock and Turnovsky (1981) and Turnovsky and Bianconi (1992) to obtain the present value of the firm:

$$V(0) = \int_0^\infty \left((1-\tau)\left(F(A,K,L) - wL - I\psi\right) - I\right) exp\left(-\int_0^t \frac{r(s)}{1-\tau_g}ds\right) dt. \tag{17}$$

[1] As shown in equation (13), investment is financed with retained earnings and new equity while the firm takes the dividend payout ratio, $\phi$, as given. Thus, dividend taxation may lead to changes in investment and the model is closer related to the "old view" as discussed in Auerbach (1979) and Keuschnigg (2005).

The firm maximizes its present value, $V(0)$, over $I$, subject to $I = \dot{K} - \delta K$ and a given $K(0) > 0$. Taking the net rate of return in the rest of the world, $r$, and all capital taxes as constant over time from the firm's perspective gives the following current-value Hamiltonian:

$$J = exp\left(\frac{-r}{1-\tau_g}\right)\left((1-\tau)\left(F(A,K,L) - wL - I\psi\right) - I + \eta(I - \delta K)\right), \tag{18}$$

where $\eta$ is the current-value lagrange multiplier of the constraint, the shadow price of capital, which is also known as Tobin's $q$. For convenience and in line with a large literature (see, e.g., Caballero, 1999; Altig et al., 2001; Hall, 2004), we assume that the function of capital adjustment cost is $\psi = \frac{b}{2}\frac{I}{K} = \frac{b}{2}\frac{\hat{i}}{\hat{k}}$.

The corresponding FOCs are

$$\frac{\partial J}{\partial I} = 0 \rightarrow \frac{\eta - 1}{b(1-\tau)} = \frac{\hat{i}}{\hat{k}}, \tag{19}$$

and (20)

$$\frac{\partial J}{\partial K} = \eta\left(\frac{r}{1-\tau_g}\right) - \dot{\eta} \rightarrow \dot{\eta} = \left(\frac{r}{1-\tau_g} + \delta\right)\eta - (1-\tau)\left(f_{\hat{k}}(\hat{k}) + \frac{b}{2}\left(\frac{\hat{i}}{\hat{k}}\right)^2\right), \tag{21}$$

where we use the homotheticity of the production function and the capital adjustment cost function to write all expressions in terms of units of effective labor.

### 2.3 Steady-state equilibrium

Using $\dot{\hat{k}} = \hat{i} - (x+n+\delta)\hat{k}$ in equation (19), we may express the change of $\hat{k}$ as

$$\dot{\hat{k}} = \left(\frac{\eta - 1}{b(1-\tau)} - (x+n+\delta)\right)\hat{k}. \tag{22}$$

Since we have $\dot{\hat{k}} = 0$ in the steady state, we can solve the above equation for the steady-state value, $\tilde{\eta}$:

$$\tilde{\eta} = 1 + b(x+n+\delta)(1-\tau), \tag{23}$$

which is independent of $\hat{k}$ and represents a horizontal locus in a phase diagram with $\hat{k}$ on the abscissa. Similarly, we may re-write equation (21) and substitute equation (19) to obtain

$$\dot{\eta} = \left(\frac{r}{1-\tau_g} + \delta\right)\eta - (1-\tau)f_{\hat{k}}(\hat{k}) - \frac{(\eta-1)^2}{2b(1-\tau)}. \tag{24}$$

The two differential equations (22) and (24) may now be used to construct the phase diagram of the dynamic system in Figure 1 in $\hat{k}$-$\eta$-space. The $\dot{\hat{k}} = 0$ locus represents equation (22), whereas the $\dot{\eta} = 0$ locus represents equation (24). The latter is downward sloping near the steady state if $\frac{r}{1-\tau_g} > x + n$. To show this, we use that $\dot{\eta} = 0$ and $\tilde{\eta}$ from equation (23)

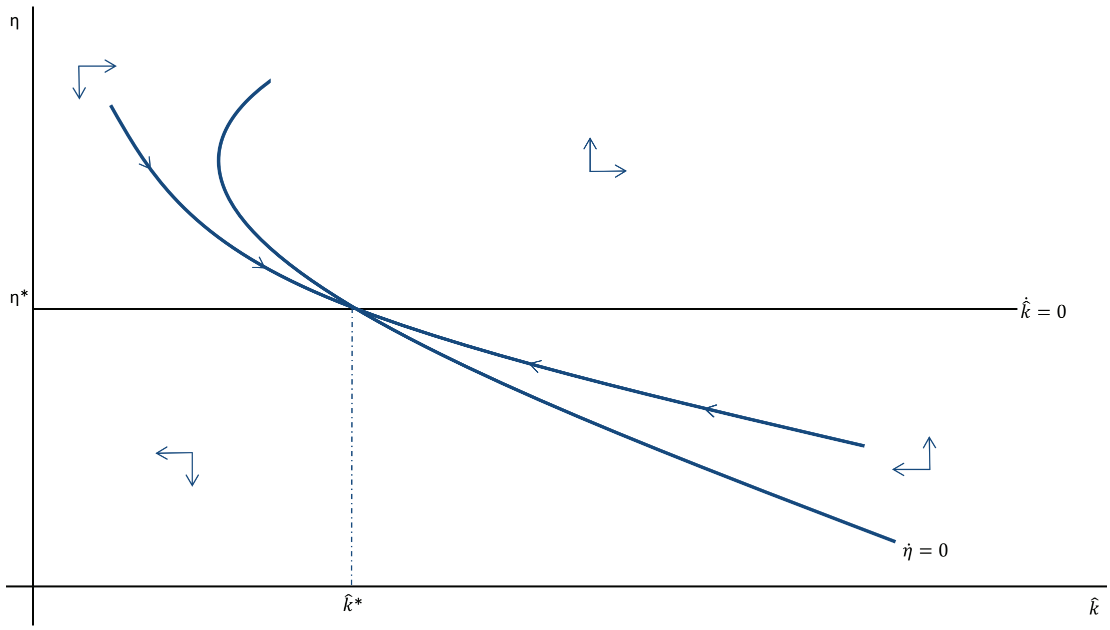


Figure 1: Phase diagramm of $\hat{k}$ and $\eta$. Saddle path stable.

in equation (24) and apply the implicit function theorem to obtain $\frac{\partial \eta}{\partial \hat{k}} = \frac{(1-\tau) f_{\hat{k}\hat{k}}(\hat{k})}{\frac{r}{1-\tau_g} - (x+n)}$. As $f_{\hat{k}\hat{k}}(\hat{k}) < 0$, we have $\frac{\partial \eta}{\partial \hat{k}} < 0$ if and only if $\frac{r}{1-\tau_g} > x + n$. Hence, the $\dot{\eta} = 0$ locus is downward sloping around the steady state. Using that in the steady state $\dot{\eta} = 0$ and substituting equation (23) yields the steady-state value of capital per unit of effective labor, $\tilde{\hat{k}}$, as:

$$\tilde{\hat{k}} = \left( \frac{1}{\alpha} \left( \left( \frac{r}{1-\tau_g} + \delta \right) \frac{1}{1-\tau} + (x+n+\delta) b \left( \frac{r}{1-\tau_g} + \frac{\delta}{2} - \frac{x}{2} - \frac{n}{2} \right) \right) \right)^{\frac{1}{\alpha - 1}}. \tag{25}$$

It is straight-forward to show that the optimal capital stock decreases in $r$, $\tau_p$ and $\tau_d$. For a sufficiently big capital adjustment cost parameter, $b$, the optimal capital stock as well decreases in $\tau_g$.[2]

## 2.4 Dynamics

Linearizing the two dynamic equations (22) and (24) around their steady states yields

$$\begin{pmatrix} \dot{\hat{k}} \\ \dot{\eta} \end{pmatrix} = \begin{bmatrix} 0 & \frac{\tilde{\hat{k}}}{b(1-\tau)} \\ -(1-\tau) f_{\hat{k}\hat{k}}(\tilde{\hat{k}}) & \frac{r}{1-\tau_g} + \delta - \left( \frac{\tilde{\eta} - 1}{b(1-\tau)} \right) \end{bmatrix} \times \begin{bmatrix} (\hat{k} - \tilde{\hat{k}}) \\ (\eta - \tilde{\eta}) \end{bmatrix}, \tag{26}$$

[2] $b > (1-\tau_g)^2 \frac{\delta\phi - r(1-\phi)}{(x+n+\delta) r (1-\tau_p)(\phi(1-\tau_g) + (1-\phi)(1-\tau_d))}$ implies that $\frac{\partial \tilde{\hat{k}}}{\partial \tau_g} < 0$.

after substituting $\tilde{\eta}$ from equation (23) and $\tilde{\hat{k}}$ from equation (25), the two eigenvalues, $\lambda_{1,2}$, are

$$\lambda_{1,2} = \frac{\frac{r}{1-\tau_g} - (x+n)}{2} \pm \left( \left( \frac{\frac{r}{1-\tau_g} - (x+n)}{2} \right)^2 + \frac{(1-\alpha)}{b} \left( \left( \frac{r}{1-\tau_g} + \delta \right) \frac{1}{1-\tau} + (x+n+\delta) b \left( \frac{r}{1-\tau_g} + \frac{\delta - x - n}{2} \right) \right) \right)^{\frac{1}{2}}. \tag{27}$$

Notice that the root is always greater than unity as $f_{\hat{k}\hat{k}}(\tilde{\hat{k}}) < 0$ and, hence, $\lambda_1$ and $\lambda_2$ will have different signs, as already indicated by the saddle path stability in the phase diagram above. Starting from initial values $\hat{k}(0)$ and $\eta(0)$ the paths of $\hat{k}(t)$ and $\eta(t)$ for period $t$ are given by

$$\hat{k}(t) = \tilde{\hat{k}} + (\hat{k}(0) - \tilde{\hat{k}}) exp(\lambda t), \tag{28}$$

$$\eta(t) = \tilde{\eta} + (\eta(0) - \tilde{\eta}) exp(\lambda t), \tag{29}$$

where $\lambda$ corresponds to the stable (negative) eigenvalue.

## 2.5 Dividend payout ratio

So far we have only considered investments financed either by new equity or in form of retained earnings and refrained from debt finance. Moreover, we have taken the dividend payout ratio as given and not as a choice variable of the firm. In this section, we derive the dividend payout ratio, $\phi$, as an endogenous variable in the model. In the optimium, the firm sets the dividend payout ratio such that it equalizes the costs of capital under investment financed by new equity and by retained earnings. Furthermore, for a certain parameterization of the gross interest rate in the domestic country, $\bar{r}$, the cost of financing an investment by retained earnings, new equity, or debt are equivalent. This equivalence allows us to consider only retained earnings and new equity and to omit debt finance in our analysis. To show these results, we proceed as follows. First, we calculate the capital costs of financing an investment by retained earnings or new equity. Second, we compute the dividend payout ratio, that makes the investor indifferent between these two forms of finance. Third, we derive the capital costs of debt finance and show under which condition for the gross interest rate, $\bar{r}$, these costs are identical to the captial costs of retained earnings and new equity.

**Retained earnings:**

Assume that the firm invests one unit of potential dividend payments into capital, thereby reducing actual dividend payments to the individual owners. An individual owner of the firm will loose $\frac{1-\tau_d}{1-\tau_g}$ units of dividend payments after taxes in period $t$ as shown by Devereux and

Griffith (1998). The firm transforms the investment into capital, which gives $\kappa = \left(1 - \frac{b}{2K}\right)$ units of additional capital. We denote the profits created by this additional capital as $\pi^{RE}$ as they are created by retained earnings. In the next period ($t$+1) the firm de-invests the capital, which increases profits by $\left(1 - \frac{b\kappa(1-\delta)}{2(K+\kappa(1-\delta))}\right)$ units. Finally, we assume that the individual investor only compares dividend payments in the two periods and does not consider the effect of this investment strategy on the equity value.[3] The net dividend payments from the profits would be $\phi(1-\tau_p)(1-\tau_d)$. The return of this investment strategy is

$$R^{RE} = -\frac{1-\tau_d}{1-\tau_g} + \frac{\left(\pi^{RE} + \left(1 - \frac{b\kappa(1-\delta)}{2(K+\kappa(1-\delta))}\right)\right)\phi(1-\tau_p)(1-\tau_d)}{\frac{1+r-\tau_g}{1-\tau_g}}, \tag{30}$$

where $\frac{1+r-\tau_g}{1-\tau_g}$ is the discount rate for the case of retained earnings, see citetDevereuxGriffith1998. We set $R^{RE} = 0$ and solve this equation for $\pi^{RE}$, which is the cost of capital:

$$\pi^{RE} = \frac{(1+r-\tau_g)}{\phi(1-\tau_p)} - \left(1 - \frac{b\kappa(1-\delta)}{2(K+\kappa(1-\delta))}\right) \tag{31}$$

**New equity:**

In contrast to the first case with retained earnings, the firm here issues new equity worth one unit, which is again invested into capital. All profits from this invesment, $\pi^{NE} + \left(1 - \frac{b\kappa(1-\delta)}{2(K+\kappa(1-\delta))}\right)$, are paid as dividends to the investor in the next period. This means that profits from this investment are taxed at $(1-\tau_p)(1-\tau_d)$. The investor could gain a net return of $(1-r)$ if she invested in the rest of the world, which gives the discount factor. The return on investment using new equity, $R^{NE}$, is given as

$$R^{NE} = -1 + \frac{\left(\pi^{NE} + \left(1 - \frac{b\kappa(1-\delta)}{2(K+\kappa(1-\delta)}\right)\right)(1-\tau_p)(1-\tau_d)}{1+r}. \tag{32}$$

[3] We do not consider changes in the equity value $\dot{q}$ as they have only a minor impact on the margin if the value of the firm is sufficiently high. The intution for this small change in equity value arises from the fact that the firm de-invests the capital stock it had created in the first period and hence (partly), reverses the initial effect of a higher investment on the equity value. If the value of the firm, $V$, is sufficiently high, a samll change in the flow of profits will lead to only small changes in the value of the firm and, hence, in the equity value. To see this more formally, combine equations (5) and (6) and solve for the change in equity value, $\dot{q}$:

$$\dot{q} = \frac{r}{1-\tau_g}q - \frac{1-\tau_d}{1-\tau_g}\frac{D}{V}.$$

Given the value of the firm, $V$, and the price of equity, $q$, reducing dividends by one unit increases the value of equity by $\frac{1-\tau_d}{1-\tau_g}\frac{1}{V}$ units, as it increases the capital stock and, hence, future profits. In the next period, the reverse effect takes place, which decreases the value by the same amount. The change is smaller the bigger is the value of the firm. The net effect of changes in the equity value is given by

$$\frac{1-\tau_d}{1-\tau_g}\frac{1}{V} - \frac{\frac{1-\tau_d}{1-\tau_g}\frac{1}{V}}{1+r-\tau_g} = \frac{1-\tau_d}{1-\tau_g}\frac{1}{V}\left(\frac{r-\tau_g}{1+r-\tau_g}\right),$$

which is decreasing in $V$. Thus, for high values of $V$ the net effect is rather small and we omit it in the analysis to simplify notation.

We solve for the cost of capital under finance with new equity, $\pi^{NE}$, by setting $R^{NE} = 0$:

$$\pi^{NE} = \frac{1+r}{(1-\tau_p)(1-\tau_d)} - \left(1 - \frac{b\kappa(1-\delta)}{2(K+\kappa(1-\delta))}\right). \tag{33}$$

**Dividend payout ratio:**

We determine the endogenous dividend payout ratio, $\phi$, that makes the firm indifferent between the two investment strategies by equalizing the capital costs of investment for both strategies:

$$\pi^{NE} = \pi^{RE}, \tag{34}$$

which leads to

$$\phi = \frac{(1+r-\tau_g)(1-\tau_d)}{1+r}. \tag{35}$$

**Debt:**

In the case of debt finance the firm borrows one unit in $t$ and repays $(1+\bar{r})$ units in $(t+1)$. We denote the profits from this investment by $\pi^D$ and the return by $R^D$. For the individual investor, the gross costs reduce the profits, $\pi^D$, in period $(t+1)$ and hence implicitly the dividends and capital gains in this period:

$$R^D = \left(\pi^D + \left(1 - \frac{b\kappa(1-\delta)}{2(K+\kappa(1-\delta))}\right)\right)(1-\tau_p) - (1+\bar{r}). \tag{36}$$

Again we solve for $\pi^D$ using $R^D = 0$:

$$\pi^D = \frac{1+\bar{r}}{1-\tau_p} - \left(1 - \frac{b\kappa(1-\delta)}{2(K+\kappa(1-\delta))}\right). \tag{37}$$

For the firm to be indifferent between financing by debt or retained earnings, the capital cost have to be equal, $\pi^D = \pi^{RE}$:

$$\frac{1+\bar{r}}{1-\tau_p} = \frac{(1+r-\tau_g)}{\phi(1-\tau_p)}. \tag{38}$$

We solve this expression for $\phi$:

$$\phi = \frac{(1+r-\tau_g)}{(1+\bar{r})} \tag{39}$$

The dividend payout ratio in equations (35) and (39) is the same if

$$\bar{r} = \frac{1+r}{1-\tau_d} - 1. \tag{40}$$

### 2.6 Consumption

We may use the individual budget constraint to determine the change of total asset holdings per unit of effective labor, $\dot{\hat{\nu}}$, as a function of the level of asset holdings per unit of effective labor, $\hat{\nu}$, as well as wages, transfers, and consumption per efficiency unit, $\{\hat{w}, \hat{f}, \hat{c}\}$, respectively:

$$\dot{\hat{\nu}} = \hat{w} + (r - x)\hat{\nu} + z\hat{f} - \hat{c}. \tag{41}$$

We linearize equation (41) around its steady state, using that the wage $\hat{w}$ and transfers $\hat{f}$ are a function of $\hat{k}$ and that $\hat{c}$ is a function of the marginal utility of wealth, $a$. Moreover, we linearize equation (5) and solve the differential equation to express $a$ as a function of $\hat{k}$. Additionally, we assume that the markets are forward-looking so that $\eta$ immediately adjusts to the new steady state. Then, we can express $\dot{\hat{\nu}}$ as a function of $\hat{k}(0)$, $\tilde{k}$, $\hat{a}(0)$, $\tilde{a}$, $\hat{\nu}(0)$, and $\tilde{\nu}$. Last, note that with log-utility and $\rho = n + x$, $\hat{c}$ is constant in the steady state and, hence, $\frac{\dot{\hat{a}}}{\hat{a}}$ is constant. Based on this catalogue of assumptions, we may solve (implicitly) for the steady-state level of consumption, $\tilde{\hat{c}}$. See Appendix C for the detailed derivations.

# 3 Empirical analysis

### 3.1 Data

We combine data from the Pennworld Tables (Version 8.0), Feenstra et al. (2013), with comprehensive data for corporate profit tax and capital taxes for 79 countries between 1996 and 2011 which were collected by the authors. For the corporate profit tax rate, $\tau_p(t)$, we use the maximum corporate profit tax rate in a country and year. The capital gains tax rate, $\tau_d(t)$, is the maximum tax rate at the national level on corporate capital gains in a country of residence. The dividend tax rate, $\tau_d(t)$, is defined as the maximum tax rate at the national level for distributed dividends in a country at time $t$. In Appendix D we provide data sources for each tax instrument and describe how the heterogeneity in the tax systems across countries is acknowledged when calculating the tax rates. Table 1 provides summary statistics for the three tax instruments across all countries and years in the data. Figures 2 to 4 show the distribution of the aforementioned tax rates for each year in the data, using whisker-plots. The area around the median (a horizontal bar) indicated by a box refers to the interquartile range (IQR), whereas the extended lines, the *whiskers*, indicate values within a maximum of 1.5 times the IQR. The corporate profit tax rates in Figure 2 show a relatively high degree of variability over time, even at the median. The median capital gains tax rate in Figure 3 decreases smoothly and modestly over the sample period. The distribution of dividend tax rates in Figure 4 is skewed towards zero with the median being constant at zero throughout the sample period.

Table 1: Capital taxes. Summary statistics.

| Variable | # Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| $\tau_p$ | 1264 | 28.72 | 9.01 | 0 | 57 |
| $\tau_g$ | 1264 | 22.79 | 13.03 | 0 | 55 |
| $\tau_d$ | 1264 | 6.47 | 9.40 | 0 | 40 |

Corporate profit tax rate, $\tau_p$, capital gains tax rate, $\tau_g$ and dividend tax rate, $\tau_d$, 1996 - 2011. 79 countries. Various sources.

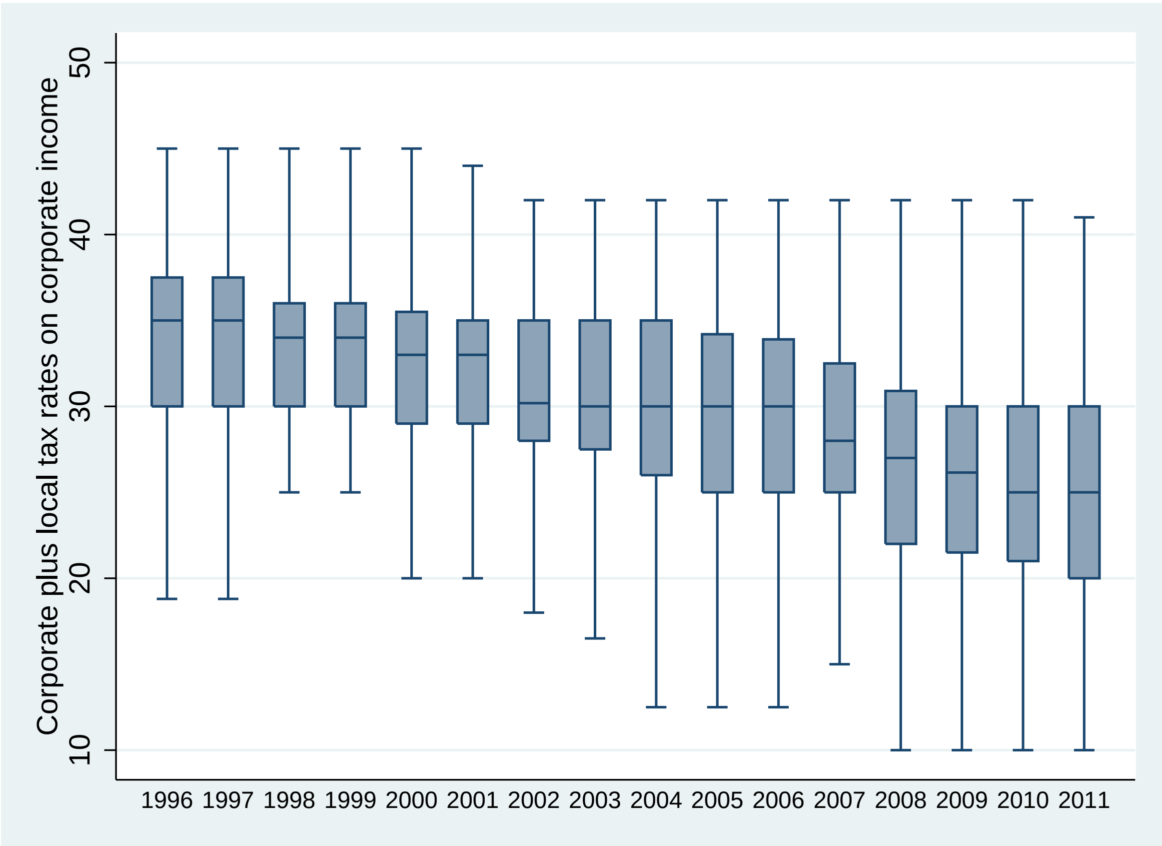


Figure 2: Corporate profit tax. 79 countries, 1996 - 2011

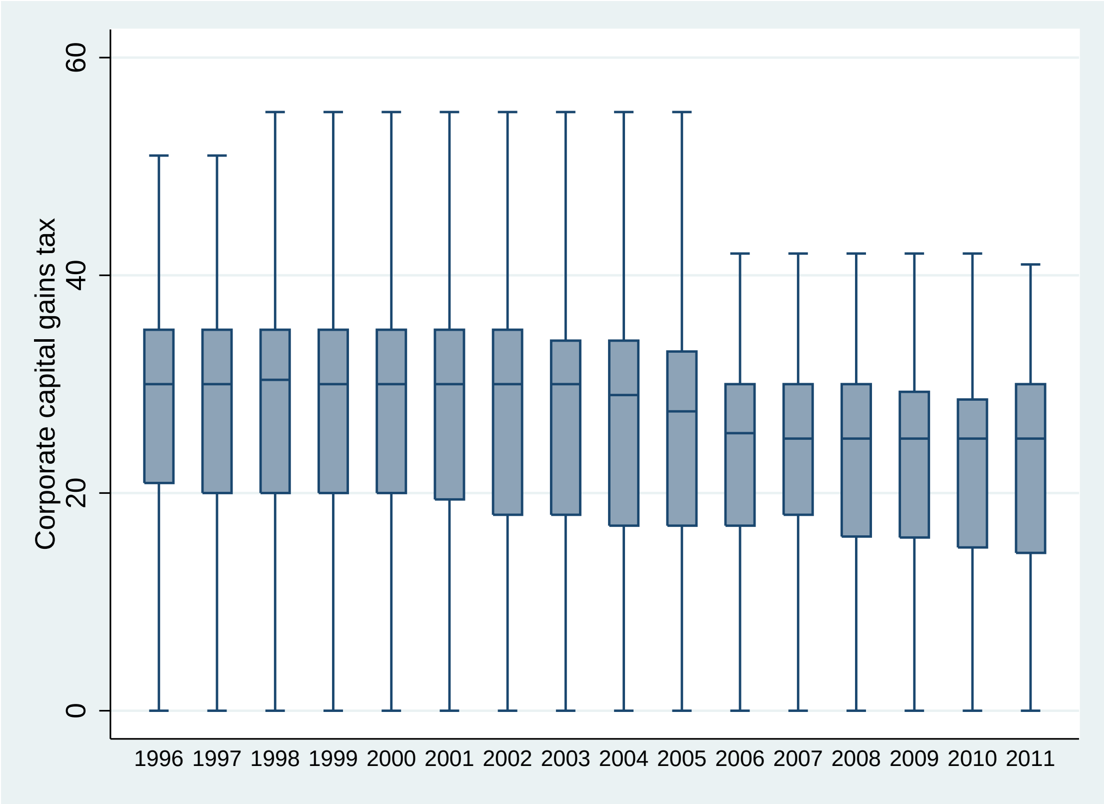


Figure 3: Capital gains tax. 79 countries, 1996 - 2011

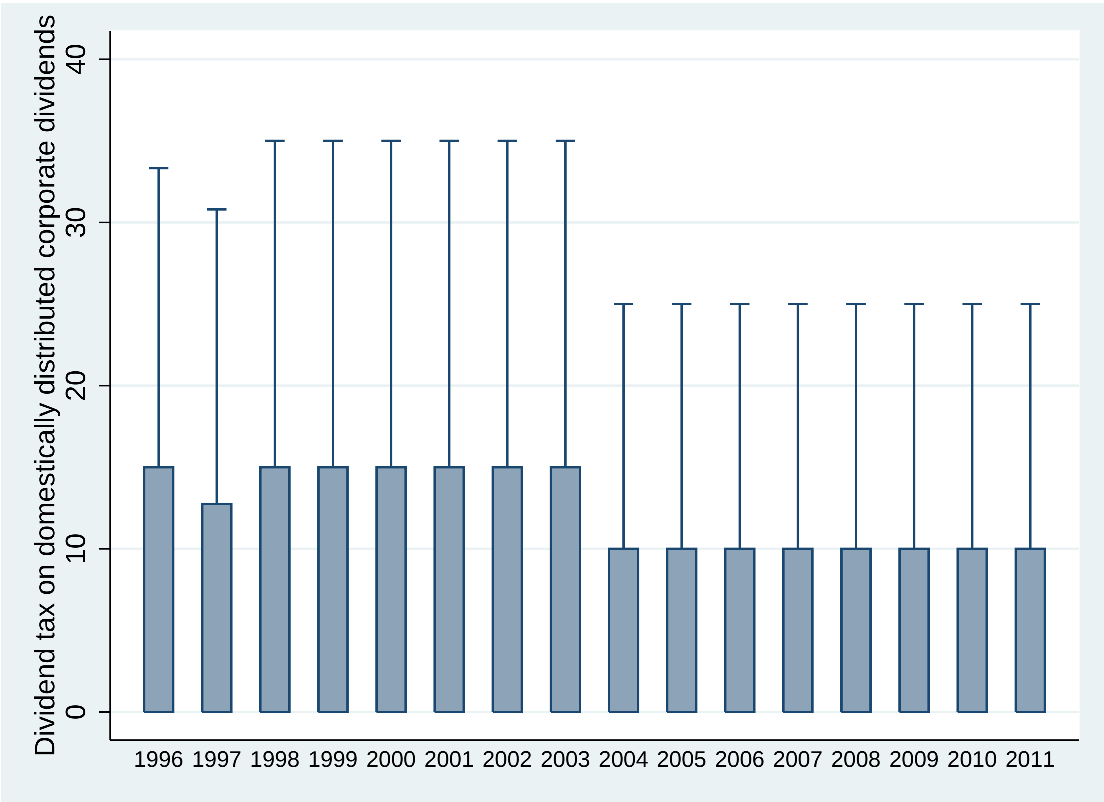


Figure 4: Dividend tax. 79 countries, 1996 - 2011

Other variables such as real GDP, total employment, the capital share of production and total real capital stock are taken from the Penn World Tables. The key variable of the model is the capital stock per unit of effective labor. We take the total capital stock for each country and year directly from the Penn World Tables and divide it by the number of workers employed in each country and year. In order to obtain the labor technology parameter, we solve the Cobb-Douglas production function for $A_j(t)$ for each country $j$ and year $t$:

$$A_j(t) = \left( \frac{y_j(t)}{k_j(t)^{\alpha_j}} \right)^{\frac{1}{1-\alpha_j}}, \tag{42}$$

where $y_j(t)$ is the real GDP per worker in constant 2005 USD in country $j$ and year $t$, $k_j(t)$ is the capital stock per worker in constant 2005 USD, and $\alpha_j$ is the average capital share of production in each country between 1996 and 2012. For each country separately we use a Hodrick-Prescott filter with a smoothing parameter of 6.25 for annual data to detrend the technology parameter as it varies strongly with the business cycle. We obtain the capital stock per unit of effective labor by dividing the total real capital stock, $K_j(t)$, by the number of workers emnployed times the labor technology parameter, $A_j(t)L_j(t)$, for each country and year. Moreover, we utilize the obtained $A_j(t)$ to compute the average growth rate of $A_j(t)$ for each country from 1996 to 2012, $x_j$.

As Bond et al. (2003) we set one common depreciation rate $\delta$ equal to 8% for all countries and years.[4] We take the net rate of return from the MSCI Global Equity Index, which considers approximately 99% of each market's free-float-adjusted market capitalization. The composite net rate of return is around 4.19% per year across all countries.[5] The MSCI Index includes emerging and developing countries some of which, despite of the recession, had high returns on investment throughout the sample period, which may explain why the net rate of return is higher than the typically assumed interest rate of 3% for the United States.

We excluded observations that violate the necessary and sufficient condition for saddle path stability, where thr rate of technological progress and population growth are higher than the rate of return in the rest of the world, $r/(1-\tau_g) < x + n$. Furthermore, we use the bacon procedure given by Weber (2010) to detect multi-dimensional outliers using a p-value of 30%. Table 2 reports the summary statistics for the aforementioned variables across all countries and years after adjusting the data as described.

[4] Mankiw et al. (1992) notes that depreciation rates vary greatly between countries. For the United States Feenstra et al. (2013) uses a depreciation rate of about 6%. Schündeln (2013) estimates depreciation rates for developing countries between 10% and 14%. The parameterization of Bond et al. (2003) seems to be a good balance, as our sample includes relatively more developed countries than developing countries. Still the results do not change qualitatively when using slightly higher or lower depreciation rates.

[5] We thank Credit Swiss for providing us with the data for the MSCI Global Equity Index.

Table 2: Variables. Summary statistics

| Variable | # Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Basic variables | | | | | |
| Real GDP in mn. USD of 2005 (Y) | 1264 | 502566.7 | 1426616 | 1197.52 | 1.32E+07 |
| Real GDP per worker in USD of 2005 (y) | 1264 | 38008.93 | 26488.12 | 2603.804 | 118168.7 |
| Employment in mn. (L) | 1264 | 12.29957 | 22.42637 | 0.072834 | 147.8036 |
| Real capital in mn. USD of 2005 (K) | 1264 | 1607431 | 4528786 | 4198.18 | 4.09E+07 |
| Real capital per worker in USD of 2005 ($k$) | 1264 | 114462.7 | 82683 | 1246.885 | 328435 |
| Trend labor tech. ($A$) | 1264 | 16683.26 | 14988.87 | 350.97 | 69955.17 |
| Variables used in estimation | | | | | |
| Real capital per labor eff. unit ($\hat{k}$) | 1264 | 12.91268 | 17.681 | 0.0341958 | 174.1426 |
| Capital share in % ($\alpha$) | 1264 | 46.87472 | 11.04922 | 24.64034 | 77.96856 |
| Net rate of return ROW in % ($r$) | 1264 | 4.196 | 0 | 4.196 | 4.196 |
| Depreciation rate in % ($\delta$) | 1264 | 6 | 0 | 6 | 6 |
| Trend labor tech. growth rate in % ($x$) | 1264 | 0.72366 | 2.20085 | -9.87384 | 5.98180 |
| Employment growth rate in % ($n$) | 1264 | 1.72655 | 1.16437 | -1.33595 | 4.48508 |

All real variables are constant 2005 USD. 79 countries, 1996 - 2011. Source: Penn World Tables Version 8.0. Notice that while $x$ and $n$ are calculated as annual changes above, we use country-specific time averages across all years for those two parameters.

For illustrative purposes we calculate the mean dividend payout ratio and compare it the dividend payout ratio we observe for a sub-set of 70 countries in our sample.[6] We take the mean tax rates and the (net) rate of return in the rest of the world to calculate the dividend payout ratio, $\phi$, using equation (35) that makes firms indifferent between financing an investment with retained earnings or new equity.

$$\frac{(1+0.041-0.2279)(1-0.0647)}{1+0.041}=0.731, \tag{43}$$

which is reasonable close to the dividend payout ratio of 0.612 we observe for the subset of 70 countries in our analysis.

Using the same numerical example as above from equation (40) we obtain a gross interest rate in the domestic country of $\bar{r}=\frac{1+0.041}{1-0.0647}-1=0.113$. It follows that an individual investor is indifferent between new equity and retained earnings finance given the endogenously determined dividend payout parameter. Furthermore, the firm is indifferent between debt, retained earnings and new equity finance given the dividend payout ratio, if the gross interest rate is given by equation (40).

To determine consumption, we need the total asset holdings of domestic individuals. We

[6]The data for the observed dividend payout ratio is described in more detail in the Appendix D.

use the net international investment position, NIIP, in percent of GDP as published by the International Monetary Fund (2013) for 21 countries in the year 2008. We calculate the asset holdings per worker as $\nu = k + NIIPy$ for 2008. Appendix E provides the list of countries for which NIIP data are available together with the corresponding NIIP values for 2008.

### 3.2 Estimation

**General outline:**

In this section, we focus on estimating the convergence parameter, $\lambda$, which can be calculated from equation (27). The higher is $|\lambda|$ the faster is the convergence to the new steady state after a change in tax policy. A value of $\lambda = 0$ implies an absence of convergence. For estimating or calculating $\lambda$,[7] we need to estimate the capital adjustment cost parameter, $b$. We may check the plausibility of the regression results in terms of Tobin's $q$. Based on equation (23) and measured variables in conjunction with model estimates, we may compute Tobin's $q$. While Blanchard et al. (1993) report very low $q$-ratios below 1.8 for the 1980s, research based on more recent data such as Hall (2001) and Laitner and Stolyarov (2003) report values of 3 (based on the ratio of market value to reproduction cost of plant and equipment) and of 2.06, respectively, each of them for data of the year 2000. In the interest of simplifying the notation, it will be useful to define $\theta_j(t) \equiv \frac{r}{1-\tau_{g,j}(t)}$, $\sigma_j \equiv x_j + n_j$, and $1 - \tau_j \equiv \frac{(\phi(1-\tau_{y,j}(t))+(1-\phi)(1-\tau_{g,j}(t))}{1-\tau_{g,j}(t)}(1-\tau_{p,j}(t))$ for later use. For all models in levels we will assume an error components structure of $\upsilon_j + \omega_j(t+1)$, where $\upsilon_j$ is time-invariant and $\omega_j(t+1)$ is not, and $E[\upsilon_j \omega_j(t+1)] = 0$. For all models in first differences we will assume an error term of $\Delta\omega_j(t+1)$, where $\Delta$ denotes the (first-)differencing operator. Since all of the models will turn out to be non-linear in the parameters of interest, we will generally rely on nonlinear least-squares estimation of dynamnic models.

**Estimating $\lambda$ on the basis of estimates from the steady-state equation in levels only:**

Using the definitions of $\theta_j(t)$ and $\sigma_j$, we may rewrite the steady-state equation in (25) as

$$\tilde{\hat{k}}_j(t) = \left(\frac{1}{\alpha_j}\left(\frac{\theta_j(t)+\delta}{1-\tau_j(t)} + (\sigma_j+\delta)b\left(\theta_j(t) + \frac{\delta-\sigma_j}{2}\right)\right)\right)^{\frac{1}{\alpha_j-1}}. \quad (44)$$

We will refer to model estimates based on this equation with an error components structure $\upsilon_j + \omega_j(t+1)$ as Model (1).

**Estimating $\lambda$ on the basis of estimates of the convergence equation in levels:**

[7] We generally use the delta method on the respective equation determining $\lambda$ to derive its standard error.

$$\hat{k}_j(t+1) = (1 - exp(\lambda_j(t)))\tilde{\hat{k}}_j(t) + exp(\lambda_j(t-1))\hat{k}_j(t-1) + \upsilon_j + \omega_j(t+1), \qquad (45)$$

where $\tilde{\hat{k}}_j(t)$ on the right-hand side of (45) is replaced by the expression in (44) and $\lambda_j(t)$ is replaced by

$$\begin{aligned} \lambda_j(t) =& \frac{\theta_j(t) - \sigma_j}{2} - \\ & \left( \left( \frac{\theta_j(t) - \sigma_j}{2} \right)^2 + \frac{(1-\alpha_j)}{b} \left( \frac{\theta_j(t) + \delta}{1 - \tau_j(t)} + (\sigma_j + \delta) b \left( \theta_j(t) + \frac{\delta - \sigma_j}{2} \right) \right) \right)^{\frac{1}{2}}. \end{aligned} \qquad (46)$$

We will refer to model estimates based on equation (45) with an error components structure $\upsilon_j + \omega_j(t+1)$ as Model (2).

**Estimating $\lambda$ on the basis of estimates of the first-differenced convergence equation:**

This approach utilizes the model in (45) in first differences:

$$\Delta\hat{k}_j(t+1) = \Delta(1 - exp(\lambda_j(t)))\tilde{\hat{k}}_j(t) + \Delta exp(\lambda_j(t))\hat{k}_j(t) \qquad (47)$$

where $\tilde{\hat{k}}_j(t)$ and $\lambda_j(t)$ are defined in (44) and (46), respectively. We will refer to model estimates based on this equation with an error term $\Delta\omega_j(t+1)$ as Model (3).

**Estimating $\lambda$ on the basis of estimates of the first-differenced convergence equation with a control function:**

This approach utilizes the same model as in (47) except for an additive control function $\epsilon_j(t)$:

$$\Delta\hat{k}_j(t+1) = \Delta(1 - exp(\lambda_j(t)))\tilde{\hat{k}}_j(t) + \Delta exp(\lambda_j(t))\hat{k}_j(t) + \epsilon_j(t), \qquad (48)$$

where $\epsilon_j(t)$ is the residual of the regression

$$\Delta\hat{k}_j(t) = \sum_{n=0}^{t-2} \beta(t-2-n)\hat{k}_j(t-2-n) + X_j(t-2-n)\gamma + \upsilon\epsilon_j(t), \qquad (49)$$

where the vector $X_j(t-2-n)$ includes all independent variables of the second stage, and $\gamma$ is an unknown, conformable parameter vector. We will refer to model estimates based on (48) with an error term $\Delta\omega_j(t+1)$ as Model (4) if $\phi$ is endogenously determined in the model, as Model (4a) if observed dividend payout ratios are used in the estiamtion and as Model (4b) if $\phi$ is an estimated parameter.

**Summary of regression results:**

Table 3 presents the estimation results for Models (1)-(4b). Clearly, in view of the literature on Tobin's $q$ and, somewhat less so, on estimates of $\lambda$, the result of Model (1) seems implausible. In terms of explanatory power and our priors regarding Tobin's $q$, the results of the other models look much better. While Model (2) has the highest explanatory power, the estimated capital adjustment costs, $b$, and Tobin's q seem relatively low compared to the common literature. Hence, the two models which are based on data in levels have problems.

This is not the case for the differenced models. In Model (3), we use differenced data, but ignore lagged differences of capital stocks per unit of effective labor on the right-hand side which may induce an endogeneity problem. However, that problem should be relatively small due to the length of the time series (16 years). Model (4) appears to match key moments in the data and the literature best. In that model, Tobin's $q$ is also quite close to what had been found by others in the 2000s. All estimates of $\lambda$ are significantly negative, which ensures saddle path stability and convergence. Finally, the difference in the estimated $\lambda$ between Models (3) and (4) is very small and never statistically significant, which adds confidence in the estimates. Lastly, the estimates for $\lambda$ are in the range of what Russo (2002) finds computing numerically the speed of convergence between 0.384 and 0.474 after changes in the corporate profit tax in a linearized Ramsey model using a standard parameterization as Barro and Sala-i-Martin (2004).

Table 3: Estimation results.

| | (1) | (2) | (3) | (4) | (4a) | (4b) |
|---|---|---|---|---|---|---|
| $b$ | 41.733 | 5.244 | 17.978 | 18.25 | 17.475 | 16.589 |
| | (4.754) | (.462) | (4.202) | (4.192) | (4.095) | (4.317) |
| $\phi$ | | | | | | 0.723 |
| | | | | | | (.361) |
| $\lambda$ | -.516 | -.321 | -.400 | -.401 | -.397 | -.392 |
| | (.021) | (.03) | (.023) | (.023) | (.023) | (.024) |
| Tobin's $q$ | 5.314 | 1.441 | 2.512 | 2.534 | 2.391 | 2.391 |
| N | 1264 | 1178 | 1085 | 1001 | 633 | 1001 |
| $R^2$ | .163 | .973 | .689 | .700 | .597 | .516 |

Non-linear least squares. Bootstrapped std. errors in parentheses. Column (1) represents the steady-state level equation. Column (2) represents the transistion equation. Column (3) is the transistion equation in first differences. Column (4) is the transistion equation in first differences with control function for endogenous lagged dependent variables. Column (4a) is the transistion equation in first difference with control function and observed $\phi$. Column (4b) is the transistion equation in first difference with control function in which we estimate thedividend payout ratio, $\phi$.

### 3.3 Robustness

**Endogenous and exogenous $\phi$**

To show that our results are not driven by the endogenous $\phi$ parameter in the model, we estimate Model (4) taking $\phi$ as an exogenous parameter. Therefore, we use the observed dividend payout ratio of a subset of 70 countries, the results are given in Column (4a).[8] Alternatively, we take $\phi$ as an independent variable in the estimations in Column (4b). The results in terms of capital adjustment costs, $b$, speed of convergence, $\lambda$, and Tobin's q are very similar in all Models (3) - (4b). Moreover, the $\phi$ observed for the subset of 70 countries is very similar to the $\phi$ based on equation (39) and observed capital taxes. Lastly, the estimates for $\phi$ when taking it as an independent variable are not significantly different from the observed or endogenously derived dividend payout ratios.

**Rich and poor countries**

As an additional robustness check, we split our sample into rich and poor countries, defined by being over or below the sample median GDP per capita, and estimated our preferred specification (4) in the two subsamples, separately. The results for rich countries are almost identical: capital adjustment costs are 18.49, $\lambda$ is -0.402 and Tobin's q is 2.55. The capital adjustment costs for poor countries are slightly lower with 14.46 and the convergence parameter is -0.379, while Tobin's q is 2.21. Still, the results seem neither be driven by poor nor rich countries.

**Pre-financial-crisis**

If we only use years before the financial crisis 2008 the capital adjustment costs are higher with 21.31, as well as Tobin's q, 2.79, while $\lambda$ is -0.418. In general the results seem quite robust in terms of speed of convergence, $\lambda$, and capital adjustment costs, $b$.

**Effective tax rates**

In our estimations, we focus on using the statutory tax rates for two reasons. First, ex-ante effective tax rates include already a behavioral response of a model firm (e.g., its investment structure and its financing structure), and ex-post effective tax rates (i.e., the actual tax revenues generated from the average firm relative to the tax base) depend even more on firm-level responses (e.g., due to the location decisions and tax avoidance through transfer pricing, profit shifting and debt shifting). Second, the ratio of effective (average or marginal) tax rates to the statutory tax rates on corporate profits is stable over time and countries (see Appendix F). Nevertheless, we report comparable estimates to the preferred specification (4) using ex-ante effective tax rates for corporate profits instead of statutory ones as a further

[8] See Appendix D for more detailed information about observed divivdend payout ratios.

robustness check. In general effective average and marginal tax rates on corporate profits are lower than the statutory tax rates for various reasons. The estimate for the capital adjustment cost parameter $b$ is slightly lower (around 14 when using either one of the two effective tax rates) and the convergence parameter $\lambda$ in those alternative regressions is almost identical to the estimates in specification (4) that is based on statutory tax rates.

# 4 Simulation

We use the estimate of $b$ from the preferred Model (4) to calculate the dynamic adjustment in response to a counterfactual change in tax policy. The simulation analysis proceeds in two steps. First, it uses the observed data for the year 2008 and the 79 economies covered to calculate the underlying steady-state equilibrium that is consistent with those data and the estimates of $b$. This steady-state equilibrium serves as the benchmark equilibrum which we shock for each country separately by a counterfactual tax policy. Second, for the counterfactual tax policy relative to the tax instruments as of 2008, we compute the counterfactual steady-state equilibrium and adjustment path for each economy using the 2008 steady-state level of capital in efficiency units of labor from Step 1 as $\hat{k}_j(0)$ in equation (28). This is done separately for a reduction of each tax instrument ($\tau_p$, $\tau_d$, and $\tau_g$) by 10%, one at a time, as well as for a simultaneous reduction. The differential path after the shock and the steady-state equilibrium (i.e., the impulse-response functions) are at the heart of interest to this analysis.

## 4.1 Impulse-response functions for output and capital

Figures 5, 6, 7, and 8 present the dynamic adjustment processes for all 79 economies graphically (using point estimates of $b$ and ignoring imprecision of the estimates for illustration). All results are presented per unit of effective labor. Hence, changes in the growth rates only reflect the impact of changes in tax policy and disregard potentially simultaneous exogenous shocks of technological progress and population growth.

In the interest of brevity, we focus on a detailed discussion of the results where we cut all three tax rates by 10% simultaneously; see Figure 5. The model suggests that a reduction in any one of the individual tax instruments has a positive effect on capital accumulation. Accordingly, the cut of all three tax instruments should increase capital accumulation and growth rates as well. Quantitatively, we find that such a shock in tax policy increases the level of capital per unit of effective labor on average by 5.33% and at the median by 4.86%. The effect on the level of output per unit of effective labor is lower and output increases on average by 2.56% and at the median by 2.11%. The range of the effects on capital per unit

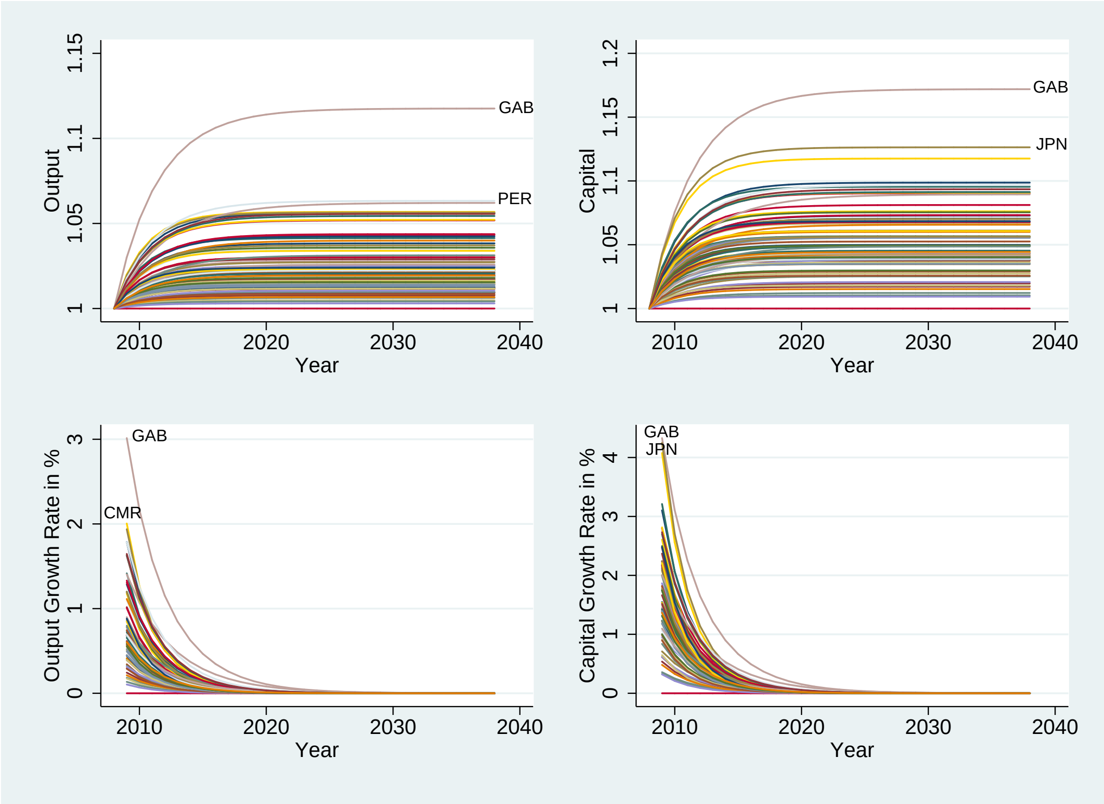


Figure 5: Dynamics after reducing all taxes by 10% in the year 2008 for 79 countries. Output and capital per unit of effective labor.

of effective labor is rather wide with a minimum of 0% (for The Bahamas, which do not tax any base the three instruments pertain to) and a maximum effect of 17.19% (for Gabon). The interquartile range amounts to 3.68 percentage points. Clearly, the functional form of the growth equation implies that the heterogeneity in steady-state responses in capital per unit of effective labor entails a heterogeneity in the speed of adjustment and, hence, the short-and-medium-run growth rates of capital and output. On average, the convergence parameter amounts to -0.390 and is not very different from the median of -0.402. 99% of the gap in output – due to a cut of 10% in the three tax instruments – is closed after 2.44 years on average (after 2 years at the median). Hence, there is a fast convergence towards the new steady state. Thus, the reduction of the three tax instruments has strong short-run effects. It increases capital growth on average by 1.03% (at the median by 0.90%) within 5 years after the change, but the effect diminishes (to virtually zero) after 5 years. In the short-run, countries could increase their capital stock per unit of effective labor by up to 2.84% (as it is predicted for Gabon) on average over 5 years.

While we discussed a simultaneous reduction of all tax rates in the previous paragraph, 10% reductions of the individual tax rates, one at a time, compare as follows. A change in the corporate profit tax rate has a much bigger effect on outcome of interest than one in the dividend tax rate or the capital gains tax rate (see Figures 6, 7, and 8): capital per unit of effective labor increases by 3.64% on average (by 3.40% at the median) in response to a reduction of the corporate profit tax rate, which is much higher than the effect of the dividend tax rate (with 0.46% on average and 0% at the median) or the one of the capital gains tax rate (with 1.01% on average and 0.95% at the median). The heterogeneity in the responses to shocks of the individual tax rates has two reasons. First, among the three tax instruments considered here, the corporate tax rate has the highest level in percentage points. Hence, a 10% decline implies a bigger percentage-point change. Second, the corporate tax rate, $\tau_p$, is hierarchically closer to the source (i.e., gross profits) than the dividend tax rate, $\tau_d$, or the capital gains tax rate, $\tau_g$. The reason is that the latter two tax rates implicitly – at least to some extent – tax residual profits in the form of dividend payments or retained earnings as discussed in Keuschnigg (2005). In terms of the speed of convergence or the time to close the ouput gap, all three instruments behave very similarly. Analogous to the general tax reduction, the growth effects occur mainly in the short-run. Capital per unit of effective labor grows on average by 0.70%, 0.09%, and 0.22% (by 0.65%, 0%, and 0.19% at the median) over a period of 5 years directly after a (separate) reduction of corporate profit tax rates, dividend tax rates, or capital gains tax rates, respectively.[9]

In general, we find that a change in the tax policy can have significant and permanent level effects, while the growth effects are mainly in the short-run.

## 4.2 Impulse-response functions for consumption and welfare analysis

For calculating the effects of tax policy shocks on consumption and welfare, we use the net investment position (NIIP) in percent of GDP and the steady-state capital stock and output per unit of effective labor to calcualte the initial asset holdings for each country from

$$\hat{\nu}_j(0) = \tilde{\tilde{y}}_j \mathrm{NIIP}_j + \tilde{\tilde{k}}_j. \tag{50}$$

We use the observed consumption share in GDP in the year 2008, $\chi_j(0) = \frac{C_j(2008)}{Y_j(2008)}$, to compute a model-consistent steady-state level of consumption per unit of effective labor, $\tilde{\tilde{c}}_j(0) = \chi_j(0)\tilde{\tilde{y}}_j(0)$. Then, we derive the initial marignal utility of wealth as

$$\hat{a}_j(0) = \frac{1}{\tilde{\tilde{c}}_j(0)} = \frac{1}{\chi_j(0)\tilde{\tilde{y}}_j(0)}. \tag{51}$$

For the initial values of $\hat{\nu}_j(0)$ and $\hat{a}_j(0)$, we calculate the steady-state levels that are consistent with $\tilde{\tilde{k}}$ and the tax strucuture as described in Appendix C. Given the path of $\hat{\nu}_j(t)$, we obtain $\dot{\hat{\nu}}_j(t)$ and the level of consumption per unit of effective labor, $\hat{c}_j(t)$.[10]

[9] Clearly, since the steady-state and the convergence equations are inherently nonlinear in their arguments, the effects of shocks on the individual tax instruments do not generally sum up to the one on all instruments simultaneously.

[10] Recall that missing data on the net investment position are responsible for a loss of observations at the

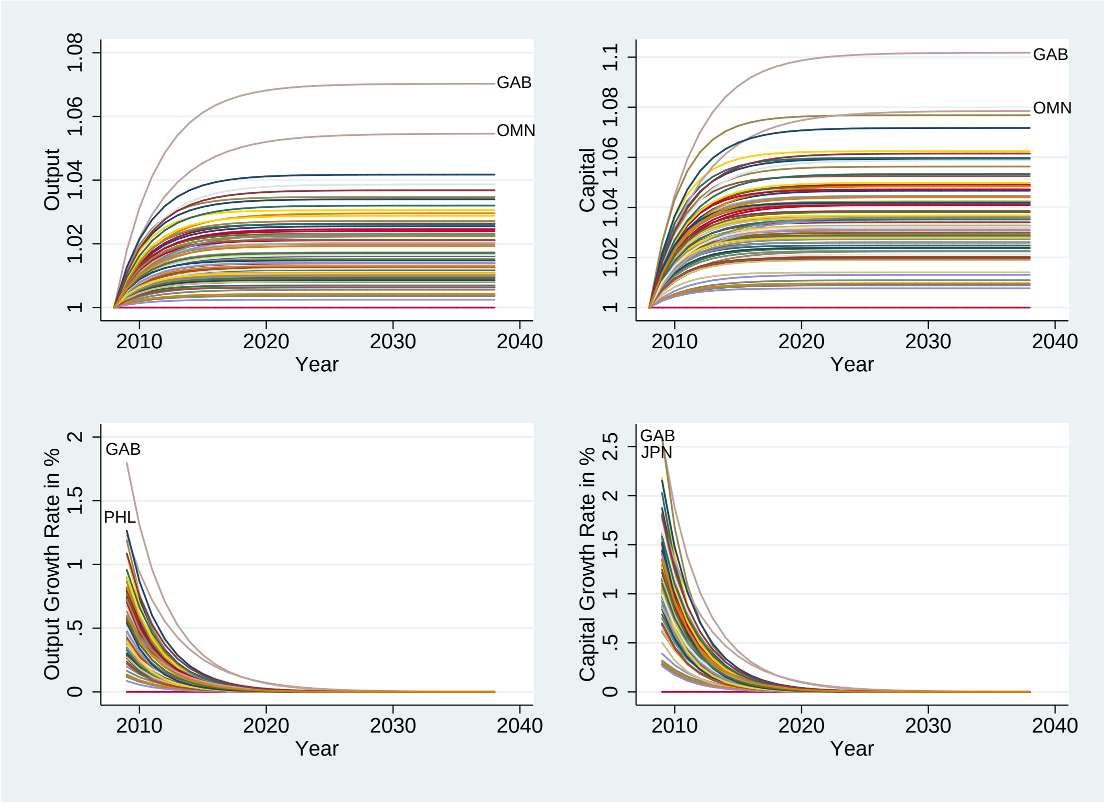


Figure 6: Dynamics after a reduction of corporate profit tax of 10% in the year 2008 for 79 countries. Output and capital per unit of effective labor

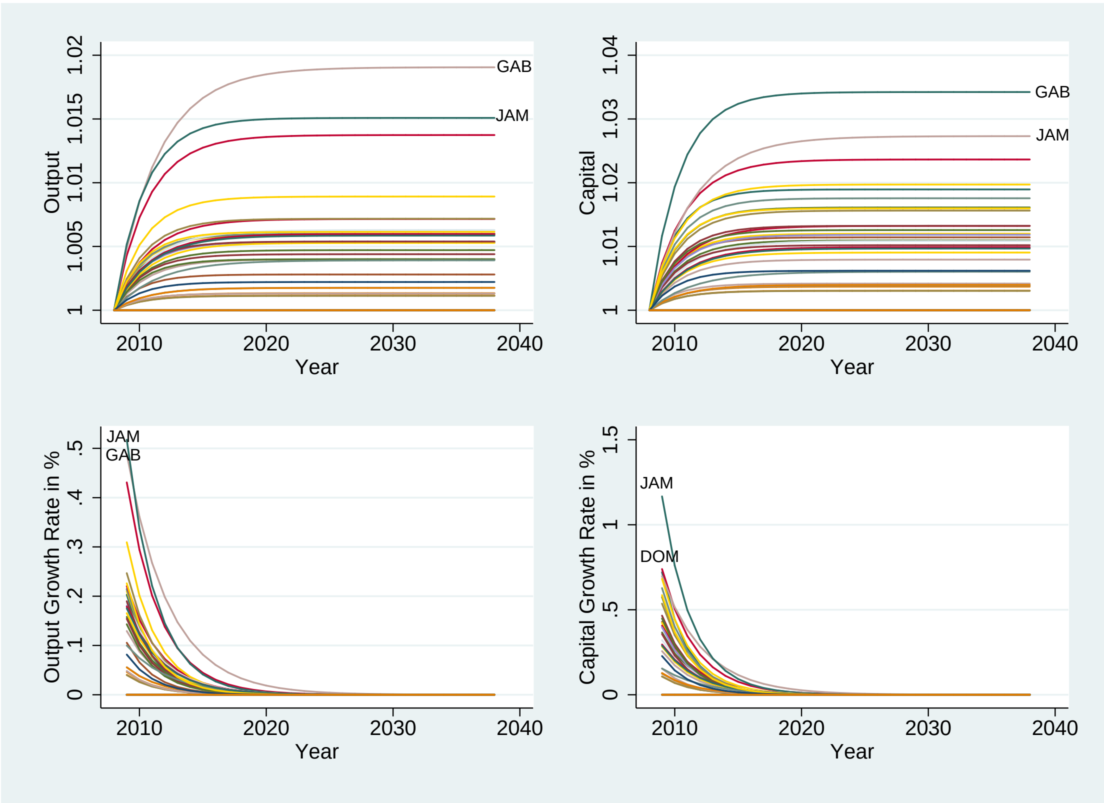


Figure 7: Dynamics after a reduction of dividend taxation of 10% in the year 2008 for 79 countries. Output and capital per unit of effective labor.

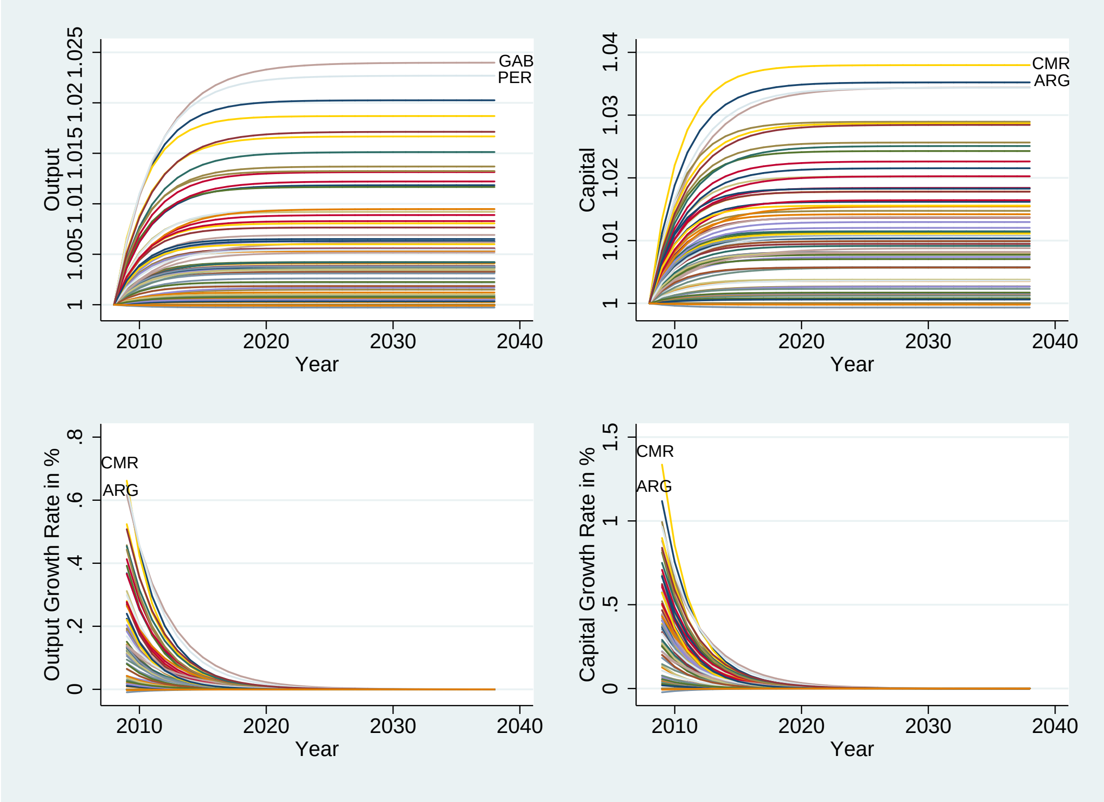


Figure 8: Dynamics after a reduction of capital gains tax of 10% in the year 2008 for 79 countries. Output and capital per unit of effective labor.

The question is whether this implied level of $\hat{c}_j(t)$ based on equation (41) using the estimates of the steady-state and convergence equations for capital per unit of effective labor in conjunction with the marginal utility of wealth, $\hat{a}$, derived with observed consumption share data, compare sufficiently well with data on the level of consumption. We check this issue as follows. Given the observed tax policy in 2008, we compute the model out-of-estimation-sample prediction of consumption for the year 2009 based on the initial values and steady-states for 2008. The consumption share only indirectly enters through the marginal utility of wealth, $\hat{a}$. Figure 9 plots consumption (not per effective labor!) predicted from the model against the observed consumption in 2009. The figure suggests that measured consumption expenditures of 2009 in real terms are well predicted by the slugglishly adjusting model economies of 2008. A simple regression of the model real consumption for 2009 on the observed consumption obtains an $R^2$ of 0.86. Hence, while the model is estimated on data of capital per unit of effective labor, it works well also for consumption. This justifies using $\hat{\nu}_j(0)$ and $\hat{a}_j(0)$ as initial values to compute consumption and welfare effects.
Figure 10 shows the impulse-response functions for consumption and total asset holdings after a simultanous reduction of the three tax instruments for the 21 countries for which we

country level in this analysis. Accordingly, the consumption and welfare analysis can only be conducted for 21 of the otherwise 79 economies covered.

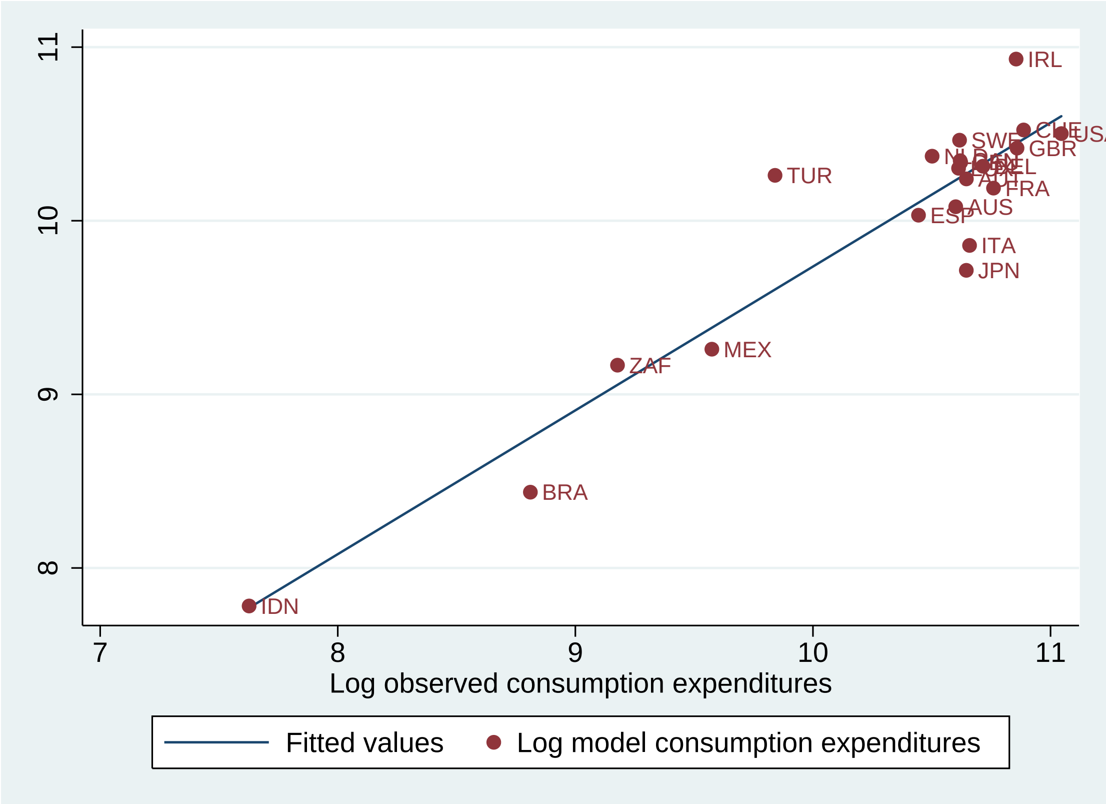


Figure 9: Log final good consumption expenditures against log model consumption prediction. 21 countries, 2009.

are able to compute the initial values for $a_j(0)$ and $\nu_j(0)$.

Again, we focus on a discussion of the effects of a simultaneous reduction of all three considered tax instruments by 10%. It turns out that, immediately after the tax cut, the consumption per unit of effective labor decreases dramatically. This has two reasons. First, lower capital taxation increases the capital accumulation. Hence, individuals consume less and save more, and total asset holdings increase as shown in the right panel of Figure 10. Second, lower tax rates imply an immediate decline of tax revenues and, hence, lump-sum transfers, as capital adjustment is sluggish. The latter effect reverses later as the capital stock increases over time which raises the revenues (and associated lump-sum transfers) collected from the capital gains tax bases and also the other tax base. Still, the numerical results show that we are generally to the left of the peak of the Laffer curve with those tax rates, as in none of the countries the total tax revenues exceed the initial tax revenues in the long-run.

Quantitatively, for the 21 countries in the sub-sample, consumption per unit of effective labor increases in the long-run relative to the initial steady-state level of 2008 on average by 8.2% (at the median by 5.9%). The United States are predicted to enjoy the biggest gains (30.1%) while Canada is predicted to gain the least (1.12%) from the instituted policy.

The initial fall in consumption may lead to ambiguous welfare effects. We calculate

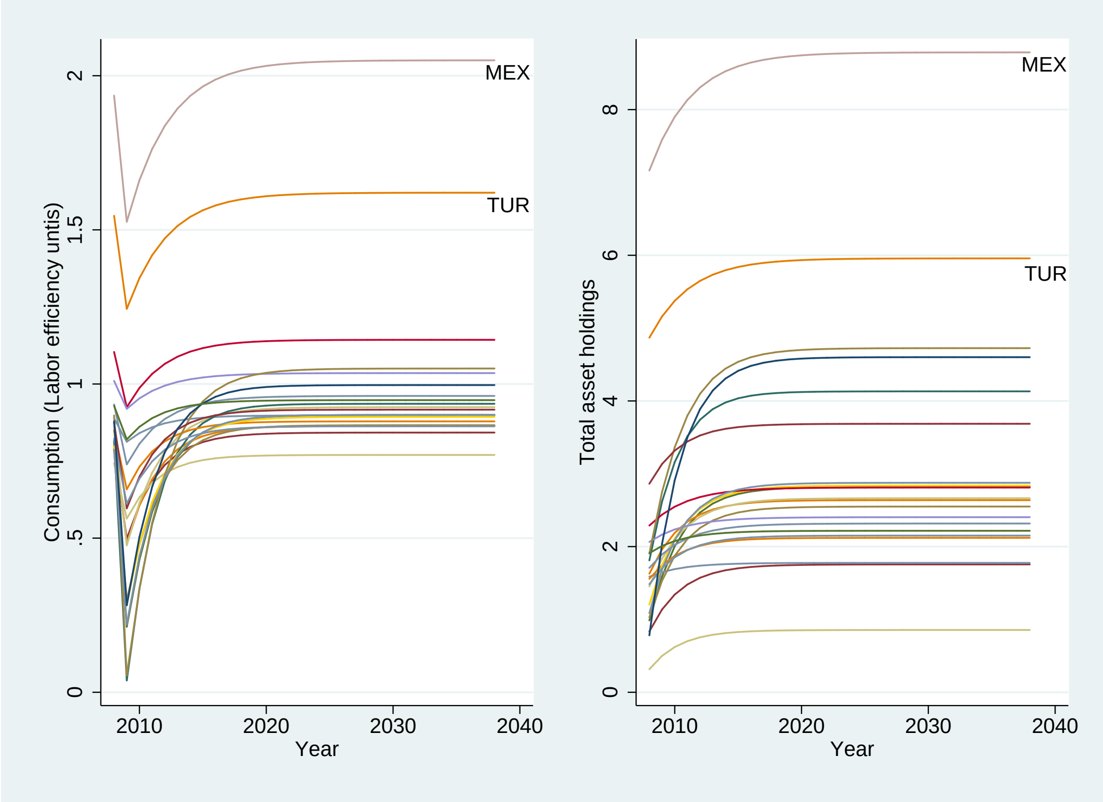


Figure 10: Dynamics of consumption and total asset holdings. 10% tax reduction in $\tau_p$, $\tau_g$ and $\tau_d$ in 2008. 21 countries.

the present discounted utility under the benchmark and counterfactual tax policies using real consumption per unit of effective labor.[11] For 14 out of the 21 countries, the tax reduction raises present discounted utility (e.g., in Brazil, Germany, Indonesia, Luxembourg, and South Africa), while for other countries the effect is negative (e.g., Austria, Canada, Italy, Switzerland, and the United States). The model predicts the largest gain for Ireland (51.98%) and the largest loss for Japan (-67.71%). The welfare results are not mainly driven by the decline in transfers, even if none of the tax revenues are redistributed, $z = 0$, the present discounted utility of the representative agent in some countries increases while it decreases in others. Table 6 in Appendix F presents the numerical results in greater detail for the case of a general tax reduction of 10% after 2008.

The magnitude of welfare effects depends strongly on the country-specific marcoeconomic fundamentals. For example, higher initial asset holdings make it less likely to gain from a reduction of capital taxation. Intuitively, countries with large asset holdings have high consumption levels, in combination with a concave instantaneous utility function, $u(c)$, an increase of consumption has smaller welfare effects. A faster speed of convergence, higher

[11] Since the model has an infinite time horizon, we need to approximate the present discounted utility using 1,000 periods. In the 1,000th period, the incremental discounted utility of this period is less than $1E^{-17}$ for all countries and assumed negligible.

$|\lambda|$, has ambigous effects. The long-run consumption levels are reached earlier. This might either reduce or raise welfare in response to reduced capital taxation: the immediate consumption level drops more drastically, but this negative shock is also shorter-lived. A priori it is not clear which effect dominates. In our sample of 21 countries, we find a clear tendency that countries with higher $|\lambda|$ are more likely to loose welfare after a reduction of capital taxation. Recall that $\lambda$ is a function of various country-specific parameters, such as employment growth, technological growth and the capital share of income. An increase of either of the three variables reduces $|\lambda|$ and, hence, makes it more likely that a country gains after a capital tax reduction.

# 5 Conclusion

This paper formulates a dynamic model of a small open economy to analyze the impact of broad capital taxation (through corporate profit taxes, dividend taxes, and capital gains taxes) for macroeconomic outcomes such as steady-state levels and growth transitions of the capital stock, output, consumption, and welfare.

The model is generally amenable to structural nonlinear estimation and it is informed by data of 79 economies for which the authors collected detailed panel data information on corporate profit tax rates, dividend tax rates, and capital gains tax rates, apart from macroeconomic variables for the years 1996-2011. The model may be used to estimate a capital adjustment cost parameter and the dividend payout ratio. In conjunction with data determining the steady-state level and the transition path of capital per effective unit of labor, these estimated parameters permit computing model-consistent values of the speed of convergence and of Tobin's $q$. In the preferred specifications discussed in the paper, the estimated levels of the dividend payout ratio, of the speed of convergence, and of Tobin's $q$ are well in line with data and with estimates reported in earlier work for selected countries. This makes the authors confident that the estimates may be used for counterfactual analysis of the dynamic effects of capital tax policy.

Important findings of this analysis are the following. First, macroeconomic outcomes appear to be more sensitive to a proportional change in corporate profit tax rates than in dividend or capital gains tax rates. The reason is that corporate profit tax rates are on average much higher than dividend or capital gains tax rates and, hence, they cause bigger distortions. However, the reason is also that dividend and capital gains taxes apply to residual profits (net of corporate profit tax) whereas corporate profit tax rates apply to gross profits.

The effects of a uniform (percentage-wise) effect of a tax reduction are quite heterogeneous across countries for two reasons, namely that both initial tax policy levels and macroeconomic fundamentals are inherently different across economies. For instance, simulated effects on steady-state capital stocks per unit of effective labor are bigger in percentage points than the median effect is in percent. Similar conclusions apply for the effects on output per effective unit of labor. Growth effects per unit of effective labor occur mainly in the short-run of up to 5 years, but effects on levels are economically quite significant for some economies.

Present discounted utility per unit of effective labor is ambiguously affected by such borad capital tax policy in spite of the unambigously positive effects on capital and output. The reason is that bigger savings together with a reduction in tax revenues (and, hence, transfers to consumers) reduce consumption in the short-run and raise it in the long-run so that, on net, (representative consumers per unit of effective labor in) some countries are found to loose while others are found to gain. From that perspective, some countries (such as Austria, Canada, Switzerland, and the United States) should be inclined to raise capital tax rates while others (such as Brazil, Germany, Indonesia, Luxembourg, and the South Africa) should be inclined to reduce them.

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## A Change in total value of equity

We define

$$E \equiv E^d + E^f \quad \text{and} \quad D \equiv D^d + D^f. \tag{52}$$

After taking the time derivative of $V = qE$,

$$\frac{\partial V}{\partial t} = \dot{V} = \dot{q}E + q\dot{E}, \tag{53}$$

we may substitute $R$ from equation (13) in equation (11) and solve for $q\dot{E}$:

$$q\dot{E} = D + \dot{K} + \delta K - (1 - \tau_p)\Pi. \tag{54}$$

Substituting (54) in equation (53) obtains

$$\dot{V} = \dot{q}E + D + \dot{K} + \delta K - (1 - \tau_p)\Pi \tag{55}$$

which, after defining $\gamma \equiv (1 - \tau_p)\Pi - \dot{K} - \delta K$, may be written as

$$\dot{V} = \dot{q}E + D - \gamma. \tag{56}$$

We then may solve (5) for $\dot{q}$ using the arbitrage condition from the FOCs in equations (5) and (6):

$$\dot{q} = \frac{r}{1 - \tau_g} q - \frac{1 - \tau_d}{1 - \tau_g} \frac{D^d}{E^d}. \tag{57}$$

Substituting this in equation (56) and using $V \equiv qE$ as well as that the dividend yields are the same for domestic and foreign individuals, $\frac{D^d}{V^d} = \frac{D^f}{V^f}$, which implies that $E^d D^f = E^f D^d$, obtains

$$\begin{aligned} \dot{V} &= \frac{r}{1 - \tau_g} V - \frac{1 - \tau_d}{1 - \tau_g} \frac{D^d}{E^d} (E^d + E^f) + D - \gamma \\ &= \frac{r}{1 - \tau_g} V - \frac{1 - \tau_d}{1 - \tau_g} \frac{D^d E^d + D^f E^d}{E^d} + D - \gamma \\ &= \frac{r}{1 - \tau_g} V - \frac{1 - \tau_d}{1 - \tau_g} D + D - \gamma \\ &= \frac{r}{1 - \tau_g} V + \left(1 - \frac{1 - \tau_d}{1 - \tau_g}\right) D - \gamma \\ &= \frac{r}{1 - \tau_g} V - \left(\frac{t_c - \tau_d}{1 - \tau_g}\right) D - \gamma, \end{aligned} \tag{58}$$

which gives equation (14). Last, note that as in Turnovsky and Bianconi (1992) in equilibrium $qE = K$ and, hence, $\dot{q}E = R$.

## B Transfers

We write total tax revenues, $F$, as a function of capital:

$$\begin{aligned} F &= \tau_p \Pi + \tau_d D + \tau_g \dot{q} E \\ &= \tau_p \Pi + \tau_d \phi (1-\tau_p)\pi + \tau_g E \left( \frac{r}{1-\tau_g} q - \frac{1-\tau_d}{1-\tau_g} \frac{D}{E} \right) \\ &= (\tau_p + \tau_d \phi (1-\tau_p) - \frac{\tau_g}{1-\tau_g}(1-\tau_d)(1-\tau_p)\phi)\Pi + \frac{\tau_g}{1-\tau_g} rK. \end{aligned} \tag{59}$$

Tax revenues per unit of effective labor, $\hat{f}$, are given by

$$\hat{f} = (\tau_p + \tau_d \phi (1-\tau_p) - \frac{\tau_g}{1-\tau_g}(1-\tau_d)(1-\tau_p)\phi) \left( \alpha \hat{k}^{\alpha} - \frac{b}{2} \left( \frac{\hat{i}}{\hat{k}} \right)^2 \hat{k} \right) + \frac{\tau_g}{1-\tau_g} r \hat{k}. \tag{60}$$

## C Consumption

The change of asset holdings per unit of effective labor is given by

$$\dot{\hat{\nu}} = \hat{w} + (r-x)\hat{\nu} + z\hat{f} - \hat{c}, \tag{61}$$

where $z \in [0,1]$ gives the share of tax revenues that is actually redistributed, $\hat{w} = (1-\alpha) f(\hat{k})$, and $\hat{c}$ is the consumption per efficiency unit of labor. We linearize this equation around its steady state to obtain:

$$\dot{\hat{\nu}} \approx \left( \hat{w}_{\hat{k}}(\tilde{\hat{k}}) + z \hat{f}_{\hat{k}}(\tilde{\hat{k}}) \right) (\hat{k}(t) - \tilde{\hat{k}}) - \hat{c}_{\hat{a}}(\tilde{\hat{a}})(\hat{a}(t) - \tilde{\hat{a}}) + (r-x)(\hat{v}(t) - \tilde{\hat{v}}). \tag{62}$$

From the FOC use that

$$\dot{\hat{a}} = (\rho - n - x - (1-\tau_p)\frac{\Pi}{\hat{k}}((1-\tau_d)\phi + (1-\tau_g)(1-\phi)))a, \tag{63}$$

which we linearize to obtain

$$\dot{\hat{a}} \approx (((1-\tau_d)\phi + (1-\tau_g)(1-\phi))(1-\tau_p)\alpha(1-\alpha)\tilde{\hat{k}}^{\alpha-2}(\hat{k}(t) - \tilde{\hat{k}}))\hat{a}, \tag{64}$$

where we assume that the shadow value of capital, $\eta$, immediately adjusts to the new steady state. We substitute $\hat{k}(t) - \tilde{\hat{k}} = (\hat{k}(0) - \tilde{\hat{k}}) exp(\lambda t)$ and solve the differential equation, which leads to

$$\hat{a}(t) = \tilde{\hat{a}} exp(-\zeta t), \tag{65}$$

where $\zeta = \left(\alpha(1-\alpha)\tilde{\hat{k}}^{\alpha-2}((1-\tau_d)\phi + (1-\tau_g)(1-\phi))(1-\tau_p)\right)(\hat{k}(0)-\tilde{\hat{k}})exp(\lambda t)$. If capital is in its steady state, $\zeta = 0$ and, hence, $exp(\tilde{\zeta}t) = 1$. Extending equation (65) yields

$$\hat{a}(t) - \tilde{\hat{a}} = \tilde{\hat{a}}(exp(-\zeta t) - 1). \tag{66}$$

We subsitute $\hat{k}(t) - \tilde{\hat{k}}$ and $\hat{a}(t) - \tilde{\hat{a}}$ in equation (62) and solve the differential equation to obtain

$$\hat{v}(t) = \tilde{\hat{v}} + \frac{1}{\lambda - r + x} exp(\lambda t)\left(\hat{w}_{\hat{k}}(\tilde{\hat{k}}) + z\hat{f}_{\hat{k}}(\tilde{\hat{k}})\right)(\hat{k}(0) - \tilde{k}) + \frac{1}{\tilde{a}}\left(\frac{1}{r-x} + \frac{1}{\zeta - r + x} exp(-\zeta t)\right). \tag{67}$$

For a given $\tilde{\hat{a}}$, $\tilde{\hat{v}}$, and $\hat{k}(0)$, we may calculate the level and change of total assets, $\hat{v}(t)$ and $\dot{\hat{v}}$, respectively, the level of consumption, $\hat{c}(t)$, all in units of effective labor, at each point in time.

# D Taxes

## D.1 Corporate profit tax rates ($\tau_p$)

For corporate profit taxes, we utilize the maximum tax rate levied at the national level on corporate profit in a country of residence. In federal states, the total corporate tax rate is calculated as the weighted average of the local (subnational) taxes combined with federal tax rates (e.g., for Germany or Canada as reported by the OECD) or the tax rate prevailing in the economic center (e.g. for Switzerland, where the rates of the canton of Zurich are taken).

The primary sources for corporate profit tax rates are the following:

- Ernest and Young *Worldwide Corporate Tax Guide* 1998-2012
- Coopers and Lybrand *International Tax Summaries* 1996-1997
- International Bureau of Fiscal Documentation *Global Corporate Tax Handbook* 2007-2012
- Price Waterhouse Coopers *Corporate Taxes - Worldwide Summaries* 1999-2000, 2001-2003, 2012-2013
- OECD *www.taxfoundation.org*

## D.2 Capital gains tax rates ($\tau_g$)

For corporate capital gains taxes, we utilize the maximum tax rate levied at the national level on corporate capital gains in a country of residence.

The primary sources for corporate capital gains tax rates are the following:

- Ernest and Young *Worldwide Corporate Tax Guide* 1998-2012
- Coopers and Lybrand *International Tax Summaries* 1996-1997
- International Bureau of Fiscal Documentation *Global Corporate Tax Handbook* 2007-2012
- Price Waterhouse Coopers *Corporate Taxes - Worldwide Summaries* 1999-2000, 2001-2003, 2012-2013

### D.3 Dividend tax rates ($\tau_d$)

For corporate dividend taxes, we utilize the maximum tax rate levied at the national level on after-tax income, classified as dividends, which are distributed to (mostly corporate) shareholders. Shareholder taxation is not taken into account. If an imputation system (as, e.g., in Australia) is stated in the tax code the tax rate on dividends is set to 0. In some cases tax codes allow for differentiated dividend tax rates conditional on holding requirements of the recipient. Here we choose tax rates applied to dividends paid to corporations holding 10% or less of the distributing entity. In such cases dividend taxation decreases with higher shares held by the receiving entity and our dividend tax rates represent the upper bound.

The primary sources for corporate dividend tax rates are the following:

- Ernest and Young *Worldwide Corporate Tax Guide* 1998-2012
- Coopers and Lybrand *International Tax Summaries* 1996-1997
- International Bureau of Fiscal Documentation *Global Corporate Tax Handbook* 2007-2012
- Price Waterhouse Coopers *Corporate Taxes - Worldwide Summaries* 1999-2000, 2001-2003, 2012-2013

### D.4 Corporate dividend payout ratio ($\phi$)

We use the measured time-invariant (rather than the implied) dividend payout ratio, $\phi_j$, as a robustness check for the results. To collect the corresponding data we took for each country the total dividends paid by each firm over the whole sample period from Standard and Poor's Compustat data-set and divided them by the total profits of each firm over the whole sample period. Compustat contains almost 24,000 companies in 70 countries between 1996 and 2012. We excluded firms where either dividend payments or income was missing or negative. Summary statistics for these variables are provided in Table 4.

Table 4: Dividend payout ration. Summary statistics.

| Variable | # Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| $\phi$ | 70 | .612 | .568 | .081 | 4.018 |
| Total dividends per country | 70 | 3.10e+11 | 6.12e+11 | 1.54e+8 | 3.23e+12 |
| Total profits per country | 70 | 9.85e+11 | 2.85e+12 | 1.80e+8 | 1.99e+13 |

Standard and Poor's Compustat, 1996 - 2012, 70 countries.

The share of corporate after-tax profits which is paid as dividends to shareholders is calculated as:

$$\phi_j = \frac{\text{Total dividends}}{\text{Net income}} = \frac{\sum_{t=0}^{T} \sum_{s_j=0}^{S_j} D_s(t)}{\sum_{t=0}^{T} \sum_{s_j=0}^{S_j} I_s(t)}, \tag{68}$$

where $s_j = 1, 2, ..., S_j$ indicate firms in country $j$ and $T$= 17 years (1996-2012).

- *Total dividends*: To calculate total dividends we use the annual amount of dividends in current million USD from the corporate income statement as stated in Standard and Poor's *Compustat* database.
- *Net income*: To calculate net income we use annual income after all expenses in current million USD from the corporate income statement as stated in Standard and Poor's *Compustat* database.

# E Net investment position (NIIP)

Table 5: Net investment position (NIIP)

| Country | NIIP | Country | NIIP | Country | NIIP |
|---|---|---|---|---|---|
| Australia | -56.9 | Indonesia | -32.7 | Spain | -79.3 |
| Austria | -17 | Ireland | -71.9 | Switzerland | 115.6 |
| Belgium | 39.8 | Italy | -24.1 | Sweden | -11.1 |
| Brazil | -21.7 | Japan | 45.1 | South Africa | -9 |
| Canada | -7.5 | Luxembourg | 120.7 | Turkey | -32.1 |
| France | -12.9 | Mexico | -35.9 | United Kingdom | -6.9 |
| Germany | 25.5 | Netherlands | 4.2 | United States | -22.1 |

Net investment position (NIIP) in percent of GDP, 2008. Source: International Monetary Fund (2013).

# F Ratio effective average (marginal) to statutory corporate profit tax

Figure 11 plots the ratio of effective average (marginal) to staturtory corporate profit taxes for our sample over the period between 1996 and 2011. The ratios stay relatively constant over time. The median ratio of the effective average corporate profit tax decreases from 0.944 in 1996 to 0.939 in 2011. Similarly, the median ratio of the effective marginal corporate profit tax decreases from 0.830 in 1996 to 0.800 in 2011.

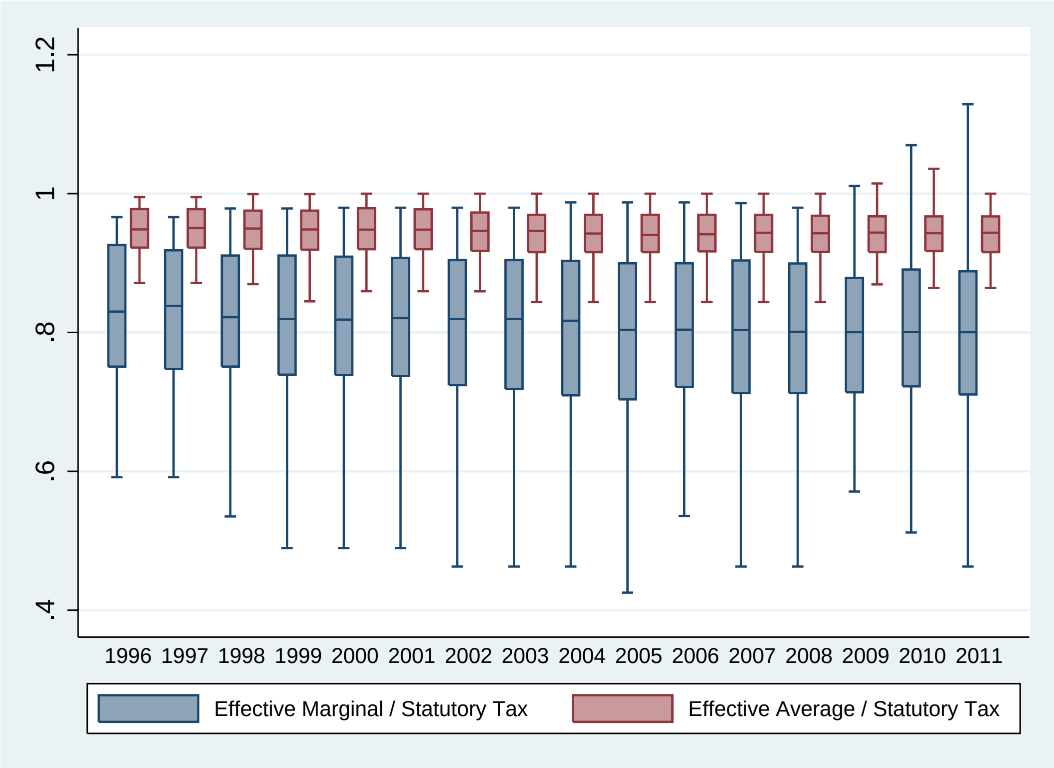


Figure 11: Whisker plot of the ratio of effective average (marginal) to statutory corporate profit tax rate. 79 countries, 1996 - 2011.

# G Numerical Results

# Table 6: Baseline numerical results. Base year 2008, 10% tax cut.

| | Taxes | | | Base 2008 | | | | 10% tax cut on $\tau_p$, $\tau_g$ and $\tau_d$. | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\tau_p$ | $\tau_g$ | $\tau_d$ | $\hat{y}$ | $\hat{k}$ | $\hat{c}$ | U | $\hat{y}$ | $\overline{g}_y^{08-37}$ | $\overline{g}_y^{08-13}$ | $\overline{g}_y^{13-18}$ | $\hat{k}$ | $\overline{g}_k^{08-37}$ | $\overline{g}_k^{08-13}$ | $\overline{g}_k^{13-18}$ | $\hat{c}$ | $(\hat{c}_37 - \hat{c}_{08})/\hat{c}_{08}$ | U | $\lambda$ | Gap Close |
| Argentina | 35 | 33 | 0 | 2.004 | 3.319 | | | 2.116 | 0.183 | 1.080 | 0.008 | 3.646 | 0.317 | 1.872 | 0.014 | | | 0.237 | -0.377 | 5 |
| Australia | 30 | 30 | 0 | 1.184 | 1.509 | 0.790 | -5.732 | 1.208 | 0.066 | 0.401 | 0.002 | 1.583 | 0.160 | 0.978 | 0.005 | 0.842 | 6.623 | -5.524 | -0.415 | 2 |
| Austria | 25 | 25 | 25 | 1.059 | 1.166 | 0.800 | -5.439 | 1.081 | 0.069 | 0.427 | 0.002 | 1.232 | 0.185 | 1.151 | 0.005 | 0.900 | 12.508 | -5.699 | -0.437 | 2 |
| Belgium | 33.99 | 33.99 | 5 | 1.071 | 1.202 | 0.812 | -5.073 | 1.095 | 0.073 | 0.452 | 0.002 | 1.274 | 0 | 1 | 0 | 0.863 | 6.361 | -5.029 | -0.426 | 2 |
| Bulgaria | 10 | 10 | 0 | 2.004 | 3.859 | | | 2.017 | 0.021 | 0.117 | 0.001 | 3.907 | 0.041 | 0.228 | 0.003 | | | | -0.346 | 0 |
| Bahamas, The | 0 | 0 | 0 | 4.477 | 12.424 | | | 4.477 | 0.000 | 0.000 | 0.000 | 12.424 | 0.000 | 0.000 | 0.000 | | | | -0.262 | 0 |
| Bolivia | 25 | 25 | 0 | 1.528 | 2.390 | | | 1.560 | 0.070 | 0.414 | 0.003 | 2.494 | 0.144 | 0.854 | 0.006 | | | | -0.388 | 2 |
| Brazil | 34 | 34 | 0 | 1.286 | 1.733 | 0.849 | -3.998 | 1.325 | 0.099 | 0.600 | 0.004 | 1.849 | 0.217 | 1.318 | 0.008 | 0.925 | 8.989 | -3.623 | -0.407 | 3 |
| Barbados | 25 | 0 | 15 | 0.923 | 0.723 | | | 0.932 | 0.030 | 0.192 | 0.001 | 0.750 | 0.123 | 0.784 | 0.003 | | | | -0.466 | 0 |
| Canada | 31.4 | 10.25 | 0 | 1.239 | 1.680 | 0.888 | -2.881 | 1.260 | 0.057 | 0.342 | 0.002 | 1.750 | 0.137 | 0.829 | 0.005 | 0.898 | 1.125 | -2.884 | -0.403 | 2 |
| Switzerland | 24.5 | 24.5 | 35 | 0.921 | 0.746 | 0.817 | -4.921 | 0.935 | 0.051 | 0.329 | 0.001 | 0.788 | 0.183 | 1.171 | 0.004 | 0.936 | 14.562 | -6.857 | -0.473 | 1 |
| Chile | 17 | 17 | 0 | 2.388 | 4.831 | | | 2.421 | 0.046 | 0.255 | 0.003 | 4.953 | 0.084 | 0.461 | 0.006 | | | | -0.327 | 1 |
| Cote d'Ivoire | 25 | 25 | 10 | 1.567 | 2.437 | | | 1.611 | 0.092 | 0.544 | 0.004 | 2.573 | 0.182 | 1.081 | 0.008 | | | | -0.387 | 3 |
| Cameroon | 38.5 | 38.5 | 16.5 | 1.245 | 1.553 | | | 1.315 | 0.185 | 1.149 | 0.005 | 1.736 | 0.375 | 2.328 | 0.011 | | | | -0.426 | 4 |
| Colombia | 33 | 33 | 0 | 1.601 | 2.498 | | | 1.656 | 0.115 | 0.673 | 0.005 | 2.670 | 0.224 | 1.316 | 0.011 | | | | -0.375 | 4 |
| Costa Rica | 30 | 30 | 0 | 1.120 | 1.334 | | | 1.141 | 0.064 | 0.395 | 0.002 | 1.401 | 0.163 | 1.011 | 0.005 | | | | -0.433 | 2 |
| Cyprus | 10 | 20 | 0 | 1.509 | 2.472 | | | 1.521 | 0.026 | 0.151 | 0.001 | 2.514 | 0.057 | 0.332 | 0.003 | | | | -0.377 | 0 |
| Czech Republic | 21 | 21 | 15 | 1.273 | 1.747 | | | 1.296 | 0.061 | 0.367 | 0.002 | 1.823 | 0.141 | 0.853 | 0.005 | | | | -0.404 | 2 |
| Germany | 30.2 | 15.825 | 5 | 1.093 | 1.279 | 0.849 | -3.972 | 1.109 | 0.049 | 0.300 | 0.002 | 1.332 | 0.136 | 0.832 | 0.004 | 0.879 | 3.461 | -3.900 | -0.420 | 1 |
| Denmark | 25 | 25 | 28 | 1.015 | 1.044 | | | 1.034 | 0.063 | 0.390 | 0.002 | 1.103 | 0.184 | 1.144 | 0.005 | | | | -0.437 | 2 |
| Dominican Republic | 25 | 25 | 25 | 2.057 | 3.439 | | | 2.163 | 0.169 | 0.992 | 0.008 | 3.750 | 0.291 | 1.706 | 0.014 | | | | -0.371 | 5 |
| Egypt | 20 | 20 | 0 | 4.569 | 10.828 | | | 4.681 | 0.080 | 0.412 | 0.009 | 11.245 | 0.126 | 0.647 | 0.014 | | | | -0.284 | 4 |
| Spain | 30 | 30 | 0 | 1.049 | 1.149 | 0.743 | -7.243 | 1.065 | 0.048 | 0.299 | 0.001 | 1.198 | 0.140 | 0.866 | 0.004 | 0.770 | 3.681 | -7.171 | -0.429 | 1 |
| Estonia | 21 | 21 | 0 | 1.210 | 1.613 | | | 1.224 | 0.038 | 0.232 | 0.001 | 1.660 | 0.096 | 0.583 | 0.003 | | | | -0.416 | 1 |
| Finland | 26 | 26 | 0 | 1.189 | 1.539 | | | 1.208 | 0.051 | 0.309 | 0.002 | 1.599 | 0.127 | 0.771 | 0.004 | | | | -0.414 | 1 |
| Fiji | 31 | 0 | 0 | 1.465 | 2.261 | | | 1.498 | 0.075 | 0.440 | 0.003 | 2.372 | 0.160 | 0.943 | 0.007 | | | | -0.381 | 3 |
| France | 34.43 | 34.43 | 5 | 1.059 | 1.167 | 0.785 | -5.892 | 1.083 | 0.074 | 0.456 | 0.002 | 1.238 | 0.199 | 1.232 | 0.006 | 0.866 | 10.369 | -5.952 | -0.429 | 2 |
| Gabon | 35 | 35 | 20 | 4.944 | 9.787 | | | 5.525 | 0.374 | 1.976 | 0.036 | 11.469 | 0.535 | 2.834 | 0.052 | | | | -0.290 | 9 |
| United Kingdom | 30 | 30 | 0 | 1.096 | 1.280 | 0.798 | -5.480 | 1.113 | 0.054 | 0.331 | 0.002 | 1.337 | 0.146 | 0.897 | 0.005 | 0.894 | 11.919 | -5.358 | -0.422 | 2 |
| Greece | 25 | 25 | 0 | 1.545 | 2.493 | | | 1.574 | 0.061 | 0.353 | 0.003 | 2.590 | 0.128 | 0.742 | 0.006 | | | | -0.369 | 2 |
| Guatemala | 31 | 31 | 0 | 1.888 | 3.161 | | | 1.961 | 0.126 | 0.732 | 0.006 | 3.383 | 0.228 | 1.330 | 0.012 | | | | -0.367 | 4 |
| Hong Kong SAR | 16.5 | 0 | 0 | 1.646 | 2.821 | | | 1.662 | 0.031 | 0.183 | 0.002 | 2.877 | 0.065 | 0.380 | 0.003 | | | | -0.374 | 0 |
| Honduras | 25 | 10 | 0 | 1.251 | 1.723 | | | 1.266 | 0.040 | 0.244 | 0.001 | 1.774 | 0.098 | 0.596 | 0.003 | | | | -0.410 | 1 |
| Croatia | 29 | 20 | 0 | 1.053 | 1.163 | | | 1.065 | 0.039 | 0.241 | 0.001 | 1.204 | 0.115 | 0.709 | 0.003 | | | | -0.433 | 1 |
| Hungary | 22 | 16 | 0 | 1.204 | 1.614 | | | 1.216 | 0.032 | 0.195 | 0.001 | 1.654 | 0.083 | 0.502 | 0.003 | | | | -0.404 | 0 |
| Indonesia | 30 | 30 | 15 | 1.771 | 2.869 | 1.104 | 2.409 | 1.848 | 0.142 | 0.821 | 0.007 | 3.101 | 0.262 | 1.520 | 0.014 | 1.143 | 3.558 | 2.617 | -0.363 | 4 |
| Ireland | 12.5 | 20 | 0 | 1.863 | 3.404 | 1.010 | 0.249 | 1.883 | 0.035 | 0.198 | 0.002 | 3.475 | 0.069 | 0.391 | 0.004 | 1.035 | 2.488 | 0.479 | -0.354 | 1 |
| Iceland | 18 | 18 | 0 | 0.977 | 0.918 | | | 0.982 | 0.016 | 0.100 | 0.000 | 0.934 | 0.060 | 0.373 | 0.002 | | | | -0.444 | 0 |
| Israel | 27 | 25 | 0 | 1.237 | 1.660 | | | 1.258 | 0.056 | 0.339 | 0.002 | 1.727 | 0.134 | 0.812 | 0.005 | | | | -0.411 | 2 |
| Italy | 31.4 | 27.5 | 5 | 1.381 | 2.041 | 0.934 | -1.674 | 1.416 | 0.082 | 0.479 | 0.004 | 2.154 | 0.181 | 1.061 | 0.008 | 0.961 | 2.980 | -1.707 | -0.376 | 3 |
| Jamaica | 33.33 | 0 | 33.33 | 1.204 | 1.517 | | | 1.254 | 0.136 | 0.829 | 0.005 | 1.662 | 0.307 | 1.874 | 0.010 | | | | -0.410 | 4 |
| Japan | 42 | 42 | 21 | 1.160 | 1.381 | 0.898 | -2.616 | 1.226 | 0.184 | 1.126 | 0.006 | 1.555 | 0.402 | 2.461 | 0.013 | 1.050 | 16.946 | -4.309 | -0.410 | 5 |
| Kenya | 30 | 0 | 5 | 0.993 | 0.979 | | | 1.005 | 0.041 | 0.257 | 0.001 | 1.018 | 0.130 | 0.823 | 0.003 | | | | -0.455 | 1 |
| Korea, Rep. | 27.5 | 27.5 | 27.5 | 1.226 | 1.564 | | | 1.267 | 0.112 | 0.686 | 0.004 | 1.683 | 0.247 | 1.516 | 0.008 | | | | -0.419 | 3 |
| Lebanon | 15 | 10 | 10 | 2.546 | 5.004 | | | 2.599 | 0.069 | 0.390 | 0.004 | 5.185 | 0.118 | 0.672 | 0.007 | | | | -0.350 | 3 |
| Lesotho | 25 | 25 | 0 | 1.087 | 1.260 | | | 1.100 | 0.041 | 0.257 | 0.001 | 1.304 | 0.115 | 0.714 | 0.003 | | | | -0.434 | 1 |
| Luxembourg | 30.38 | 30.38 | 15 | 1.173 | 1.447 | 0.875 | -3.250 | 1.207 | 0.096 | 0.590 | 0.003 | 1.546 | 0.222 | 1.372 | 0.007 | 0.917 | 4.778 | -3.225 | -0.425 | 3 |
| Morocco | 35 | 35 | 0 | 1.366 | 1.906 | | | 1.415 | 0.118 | 0.711 | 0.004 | 2.050 | 0.244 | 1.478 | 0.009 | | | | -0.402 | 4 |
| Mexico | 28 | 28 | 0 | 2.995 | 5.944 | 1.546 | 10.596 | 3.115 | 0.131 | 0.720 | 0.010 | 6.334 | 0.213 | 1.172 | 0.016 | 1.621 | 4.845 | 10.894 | -0.323 | 5 |
| Macedonia | 10 | 10 | 0 | 1.340 | 2.039 | | | 1.345 | 0.014 | 0.083 | 0.001 | 2.059 | 0.034 | 0.202 | 0.001 | | | | -0.387 | 0 |
| Malta | 35 | 35 | 0 | 1.280 | 1.726 | | | 1.319 | 0.099 | 0.599 | 0.004 | 1.843 | 0.220 | 1.328 | 0.008 | | | | -0.401 | 3 |
| Mauritania | 25 | 25 | 16 | 1.313 | 1.816 | | | 1.346 | 0.083 | 0.503 | 0.003 | 1.918 | 0.183 | 1.107 | 0.007 | | | | -0.404 | 3 |
| Malaysia | 26 | 0 | 0 | 1.480 | 2.308 | | | 1.505 | 0.055 | 0.331 | 0.002 | 2.391 | 0.118 | 0.708 | 0.005 | | | | -0.395 | 2 |
| Namibia | 35 | 0 | 0 | 1.184 | 1.508 | | | 1.209 | 0.070 | 0.433 | 0.002 | 1.587 | 0.172 | 1.058 | 0.005 | | | | -0.426 | 2 |
| Netherlands | 25.5 | 25.5 | 0 | 1.148 | 1.436 | 0.823 | -4.743 | 1.163 | 0.044 | 0.266 | 0.001 | 1.486 | 0.115 | 0.700 | 0.004 | 0.863 | 4.859 | -4.502 | -0.414 | 1 |
| Norway | 28 | 28 | 0 | 1.432 | 2.177 | | | 1.461 | 0.068 | 0.401 | 0.003 | 2.275 | 0.148 | 0.872 | 0.007 | | | | -0.378 | 2 |
| New Zealand | 33 | 0 | 0 | 1.551 | 2.451 | | | 1.594 | 0.090 | 0.528 | 0.004 | 2.589 | 0.184 | 1.081 | 0.008 | | | | -0.378 | 3 |
| Oman | 30 | 30 | 0 | 8.594 | 21.312 | | | 9.127 | 0.202 | 0.980 | 0.028 | 23.218 | 0.287 | 1.397 | 0.040 | | | | -0.253 | 7 |
| Panama | 30 | 30 | 10 | 2.081 | 3.503 | | | 2.189 | 0.170 | 0.998 | 0.008 | 3.821 | 0.292 | 1.714 | 0.014 | | | | -0.371 | 5 |
| Peru | 30 | 30 | 0 | 3.952 | 7.917 | | | 4.202 | 0.206 | 1.140 | 0.015 | 8.683 | 0.310 | 1.722 | 0.022 | | | | -0.327 | 6 |
| Philippines | 35 | 10 | 0 | 2.381 | 4.349 | | | 2.482 | 0.139 | 0.800 | 0.008 | 4.666 | 0.236 | 1.359 | 0.013 | | | | -0.357 | 4 |
| Poland | 19 | 19 | 19 | 1.181 | 1.502 | | | 1.201 | 0.058 | 0.358 | 0.002 | 1.567 | 0.142 | 0.880 | 0.004 | | | | -0.430 | 2 |
| Portugal | 26.5 | 25 | 20 | 0.996 | 0.988 | | | 1.012 | 0.051 | 0.319 | 0.001 | 1.037 | 0.161 | 1.004 | 0.004 | | | | -0.436 | 1 |
| Paraguay | 10 | 10 | 5 | 1.454 | 2.331 | | | 1.464 | 0.022 | 0.131 | 0.001 | 2.367 | 0.051 | 0.297 | 0.002 | | | | -0.380 | 0 |
| Saudi Arabia | 20 | 20 | 5 | 4.538 | 10.311 | | | 4.680 | 0.103 | 0.536 | 0.010 | 10.812 | 0.159 | 0.829 | 0.016 | | | | -0.293 | 4 |
| Senegal | 25 | 25 | 10 | 2.568 | 4.747 | | | 2.680 | 0.143 | 0.818 | 0.008 | 5.095 | 0.237 | 1.356 | 0.014 | | | | -0.351 | 5 |
| Serbia | 10 | 10 | 0 | 1.087 | 1.293 | | | 1.090 | 0.010 | 0.061 | 0.000 | 1.305 | 0.031 | 0.189 | 0.001 | | | | -0.422 | 0 |
| Slovak Republic | 19 | 19 | 0 | 1.335 | 1.952 | | | 1.350 | 0.039 | 0.235 | 0.001 | 2.006 | 0.090 | 0.546 | 0.003 | | | | -0.405 | 1 |
| Slovenia | 22 | 22 | 0 | 1.045 | 1.145 | | | 1.054 | 0.027 | 0.169 | 0.001 | 1.174 | 0.085 | 0.524 | 0.003 | | | | -0.430 | 0 |
| Sweden | 28 | 28 | 0 | 1.069 | 1.205 | 0.786 | -5.855 | 1.084 | 0.046 | 0.287 | 0.001 | 1.253 | 0.131 | 0.809 | 0.004 | 0.900 | 14.455 | -5.619 | -0.431 | 1 |
| Thailand | 30 | 30 | 10 | 2.406 | 4.255 | | | 2.537 | 0.177 | 1.015 | 0.010 | 4.644 | 0.294 | 1.681 | 0.017 | | | | -0.351 | 5 |
| Tunisia | 30 | 30 | 0 | 1.751 | 2.835 | | | 1.816 | 0.122 | 0.724 | 0.005 | 3.034 | 0.228 | 1.353 | 0.010 | | | | -0.385 | 4 |
| Turkey | 20 | 20 | 0 | 3.843 | 8.398 | 1.935 | 16.068 | 3.943 | 0.085 | 0.457 | 0.007 | 8.744 | 0.135 | 0.724 | 0.012 | 2.050 | 5.918 | 16.493 | -0.310 | 3 |
| Ukraine | 25 | 25 | 25 | 1.066 | 1.179 | | | 1.090 | 0.076 | 0.480 | 0.002 | 1.251 | 0.198 | 1.248 | 0.005 | | | | -0.452 | 2 |
| Uruguay | 25 | 25 | 0 | 1.739 | 2.934 | | | 1.778 | 0.074 | 0.427 | 0.004 | 3.063 | 0.144 | 0.833 | 0.007 | | | | -0.367 | 3 |
| United States | 35 | 35 | 10.5 | 1.001 | 1.003 | 0.758 | -6.728 | 1.025 | 0.079 | 0.499 | 0.002 | 1.072 | 0.222 | 1.401 | 0.005 | 0.993 | 30.938 | -7.017 | -0.451 | 2 |
| Venezuela | 34 | 34 | 0 | 2.426 | 4.320 | | | 2.561 | 0.181 | 1.031 | 0.011 | 4.724 | 0.300 | 1.709 | 0.018 | | | | -0.346 | 5 |
| South Africa | 29 | 14.5 | 0 | 1.379 | 2.035 | 0.929 | -1.781 | 1.404 | 0.060 | 0.358 | 0.002 | 2.117 | 0.132 | 0.792 | 0.005 | 0.948 | 1.960 | -1.712 | -0.396 | 2 |
| Zimbabwe | 30.9 | 20 | 0 | 1.412 | 2.174 | | | 1.439 | 0.064 | 0.374 | 0.003 | 2.270 | 0.145 | 0.843 | 0.007 | | | | -0.368 | 2 |

Initial taxes are for the base year 2008 and are reduced by 10%. Time horizon is 30 years, 2008 - 2037. $U$ gives an approximation for the discounted utility. $\overline{g}_z^{t-t'}$ gives the average growth rate of the variable $z$ between $t$ and $t'$. $\lambda$ is the country specific convergence parameter. Gap Close indicates the number of years until 99% of the gap between the base line output and the new steady-state output is closed. $\hat{y}$, $\hat{k}$ and $\hat{c}$ are measured in units of effective labor.