Taxation in an intertemporal general equilibrium model of a small open economy

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This paper presents a computable general equilibrium model of a small open economy, similar to the Auerbach–Kotlikoff model. Domestic and foreign goods are imperfect substitutes, whereas domestic and foreign assets are perfectly substitutable. We investigate the effects of partial switches in the choice of tax base from capital or wage income taxation to consumption taxation. It is found that reductions in capital income tax rates may lead to less capital accumulation at home, even though these reductions are welfare improving. A reduction of corporate income taxes gives best results in this respect. Terms of trade effects generally dominate the efficiency gains of a switch of tax base.

Keywords: Computable general equilibrium model; Taxation; Terms of trade

Since World War II the view on the role of taxation in the performance of the economy has changed fundamentally. In the 1950s and 1960s taxes were mainly considered as an instrument of demand management. Nowadays the distortionary effects of taxes on supply and demand decisions are widely recognized, and the tax system is considered an important determinant of the growth potential of economies.

The acceleration in the process of European integration in the last decade has been an important factor in this increase in interest in the effects of different modes of taxation. The completion of the internal market and the transition towards a monetary union render the European economies increasingly interdependent (for a general assessment of EMU see Goodhart [11]). This strengthens tax competition between European countries and may induce further tax harmonization, limiting the extent to which tax policies can serve as an instrument of national economic policy. Currently, the most topical example is the harmonization of value-added taxes (see Frenkel *et al* [10], Perraudin and Pujol [18]), but the issue extends to all taxes on internationally mobile goods and services.

Intertemporal general equilibrium models in several ways provide a suitable instrument for analysing the impact of tax policies. These models explicitly consider the behaviour of economic subjects on a micro-economic level, and they incorporate the notions of rationality and forward looking behaviour. Because of their explicit reliance on utility maximization, general equilibrium models allow the evaluation of the welfare consequences of various policies. In particular, the effects on future economic developments of saving and investment decisions are fully discounted, allowing for an assessment of the long-term impact of taxes.

Much of the interest in the long-term effects of taxation can be traced to Summers [22], who examined the consequences of capital income taxation in a lifecycle model with overlapping generations. He concluded that the intertemporal substitution effects of capital income taxation would most probably render this form of taxation unattractive, compared

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with other choices of tax base. Summers considered only the steady-state effects, however, and ignored possible costs of transition to a new equilibrium. Auerbach and Kotlikoff [2] extended his approach by constructing a general equilibrium model and incorporating rational expectations. Auerbach and Kotlikoff [3] endogenized labour supply and accounted for installation costs of investment. The conclusion that can be drawn from these models corroborates Summers's initial findings.

These analyses all apply to a closed economy, however, and their conclusions do not necessarily generalize to an open economy. First, in an open economy the competitive nature of international capital markets makes domestic interest rate movements largely exogenous. This removes the direct link between savings and investment, and the extent to which the correlation between savings and investment, observed by Feldstein and Horioka [9], can be expected to exist also in a world with perfect capital mobility depends *inter alia* on the substitutability of domestic and foreign goods (Bovenberg [6]). In a small open economy the incidence of capital income taxes may therefore fall entirely on labour, if arbitrage equates the *net* rates of return at home and abroad. Bovenberg [5], however, points out that with costs of adjustment, existing physical capital is immobile between countries, so that after tax differences in rentals affect investment flows only at a finite rate. A capital income tax therefore partly acts as a lump sum tax on existing capital, and the welfare effects depend on the transition path.

Second, the treatment of capital income before taxes is essential information to solve the Harberger incidence problem for an open economy. Most of the studies dealing with this problem have assumed that the source principle applies, which equalizes net rates of return. However, the spread of double taxation agreements leads to a predominance of the residence principle as far as interest income is concerned (see Sinn [20]). So, if the domestic capital stock is largely owned by domestic residents, equality of gross rates of return of the capital stock across countries should result. This assumption is used by Söderlind [21], and by Keuschnigg [16], who uses a two-country model.

Third, as pointed out by Lipton and Sachs [17], with heterogeneous tradable goods terms of trade effects become an important equilibriating mechanism that may transfer part of the welfare gains of tax changes to foreign countries. This point was investigated by Perraudin and Pujol [18] in a model of the French economy including both capital flows and foreign goods. Their conclusions are not substantially different from those of Auerbach and Kotlikoff, but they underestimate the openness of the French economy by excluding imports of raw materials and investment goods from their model.

This paper present a general equilibrium model of a small open economy, modelled after the Dutch economy which extends existing general equilibrium models of small open economies in a number of respects. First, we include a fully developed model of the firm, with an endogenous financial structure, as in Auerbach [1]. This enables us to study the effects of changes in corporation based capital income taxes, as well as the effects of capital gains or losses on equity by households due to unexpected tax changes. Second, we incorporate imports of raw materials and investment goods in the model, thus increasing the import content of domestic production and the effect of changes in the terms of trade. Third, we attempt to make a step towards an analysis of an *optimal* change in the tax structure by comparing balanced budget tax reforms with tax smoothed reforms. We apply these elements to an analysis of the relative efficiency of both labour income and several forms of capital income taxation versus consumption taxation.

The structure of the paper is as follows. The next section discusses the modelling of the household sector, domestic firms, the government and the foreign sector. The third section discusses the calibration of the model. A number of simulation results are then presented, and the last section offers some conclusions.

The model

The model contains a domestic good and a foreign good. Both commodities can be used for consumption as well as investment. There are four sectors: households, firms, government and the foreign sector. Households have fixed finite lives. Every period a generation of households dies and a new generation is born. This implies that at any time there exist several overlapping generations of households. These generations choose an optimal combination of goods and leisure on the basis of a pure lifecycle model without bequests. This specification allows us to examine the intergenerational redistribution that may result from tax policies.

Firms produce the domestic good using labour, capital and imported raw materials, subject to a constant returns to scale production function. The capital good is composed of domestic as well as foreign investment goods. Capital formation is subject to internal adjustment costs and is financed by retained earnings, issuing of debt and new shares. Investment and employment are determined so as to maximize the present value of the firm. Ownership of the firm is assumed to be purely domestic. We include the effects of corporate taxation in the model by distinguishing between corporate income tax, dividend taxation and interest income taxation. The financial structure is endogenous in our model through agency costs. Capital costs are also affected by the dividend policy pursued by the firm. We compare the consequences of either of the existing views of dividend policy (Poterba and Summers [19]).

The government imposes taxes (wage taxes, capital income taxes, consumption taxes and profit taxes) and distributes the proceeds as interest on government debt, expenditure on domestic goods and transfers to households. A possible budget deficit is bond financed and subject to an intertemporal budget constraint. Interaction with the foreign sector consists of trade and capital flows. The capital account mirrors the current account and it involves only government debt, so that gross rates of return are equalized, according to the residence principle. The price of foreign goods serves as numeraire.

We present the equations for each sector in turn, and conclude with the market equilibrium conditions.

The household sector

Households are distinguished by time of birth. Each household has a fixed, finite, lifetime, lasting T_0 periods, so that a household born in period t_0 has a planning horizon of $T = T_0 + t_0 - t$ periods in period t. Each household can supply an amount of labour $0 \leqslant l \leqslant l_{max}$ per period. In addition, households receive income from their financial assets, that consist of bonds D_H and equity of domestic firms V. It is assumed that both assets are perfectly substitutable and offer the same rate of return r_H. The last source of income is lump sum transfers made by the government, Tf. The decision problem for the household is to find a utility maximizing plan for its supply of labour and consumption of the domestically produced good and the imported good, subject to the lifetime budget constraint. To avoid secular shifts in labour supply in the face of steadily rising real wages, it is assumed that the preference for leisure declines over generations at the same pace as labour saving technical progress.[1] In addition it is assumed that the preference for leisure of each individual household grows with its age. We do not assume any bequest motives, so that households start without any financial assets, and leave no financial assets upon their decease. Households born before period $t = 1$ have already accumulated some assets at $t = 1$, however. We assume that the initial distribution of both bonds and equity is uniform over generations. Let

$A(t, t_0)$ = value of assets of household of generation t_0

$s_h(t_0)$ = share of generation t_0 in total private wealth at $t = 1$, $\sum_{\tau=2-T_0}^{1} s_h(\tau) = 1$

The composition of asset holdings is given by:

$$A(t, t_0) = D_H(t, t_0) + V(t, t_0) \tag{1}$$

$$A(t_0, t_0) = 0 \tag{2}$$

$$D_H(1, t_0) = s_h(t_0) D_H(1) \qquad 2 - T_0 \leqslant t_0 \leqslant 1 \tag{3}$$

$$V(1, t_0) = s_h(t_0) V(1) \qquad 2 - T_0 \leqslant t_0 \leqslant 1 \tag{4}$$

and each household is subject to the following budget constraint:

$$\sum_{\tau=t}^{t+T-1} R_h(\tau, t) \sum_{i=0}^{2} p_{c_i}(\tau) c_i(\tau, t_0) \leqslant W_h(t, t_0) \tag{5}$$

where W_h denotes lifetime wealth, c_0 is the consumption of leisure, c_i, $i = 1, 2$, denotes consumption of good i, p_{c_0} is the price of leisure, p_{c_i}, $i = 1, 2$, denotes consumption prices and R_h is the compounded discount rate:

$$W_h(t, t_0) \equiv \sum_{\tau=t}^{t+T-1} R_h(\tau, t)(p_{c_0}(\tau) l_{max} + Tf(\tau, t_0)) + A(t, t_0) \tag{6}$$

$$R_h(\tau, t) \equiv \prod_{s=t}^{\tau} (1 + r_H(s))^{-1} \tag{7}$$

$$c_0(t, t_0) \equiv l_{max} - l(t, t_0) \tag{8}$$

$$p_{c_0}(t) \equiv (1 - t_l(t)) p_l(t) \tag{9}$$

$$p_{c_i}(t) = (1 + t_c(t)) p_i(t) \tag{10}$$

t_c is an indirect tax rate, levied on consumption goods on a producer prices basis. The net return on assets r_H consists of the after tax real interest rate, r, plus the change in domestic prices, against which government bonds are indexed:

$$r_H(t) = (1 - t_k(t))(r(t) + \pi_1(t)) \tag{11}$$

$$\pi_i(t) = p_i(t+1)/p_i(t) - 1 \qquad i = 1, 2 \tag{12}$$

π_2 is the general rate of inflation and π_1 the change

[1] The alternative would be to assume complete separability between leisure and consumption: see King, Plosser and Rebelo [15].

in the real exchange rate. The utility function is time separable and weakly separable in leisure and the two consumption goods:

$$U(t, t_0) = \left(1 - \frac{1}{\gamma}\right)^{-1} \sum_{\tau=t}^{t+T-1} (1+\beta)^{t-\tau} \times u(c_0(\tau, t_0), c_1(\tau, t_0), c_2(\tau, t_0))^{1-1/\gamma} \quad (\gamma > 0) \qquad (13)$$

$$u(c_0, c_1, c_2) = [\theta_0(c_0(1+\alpha)^{t_0}(1+v)^{t_0-t})^{-\rho_1} + c^{-\rho_1}]^{-1/\rho_1} \qquad (14)$$

$$c = [\theta_1 c_1^{-\rho_2} + \theta_2 c_2^{-\rho_2}]^{-1/\rho_2} \qquad (15)$$

γ is the intertemporal elasticity of substitution, α is the preference drift away from leisure over households, and v is the preference shift towards leisure for an individual household. The household seeks a maximum of Equation (13) with respect to c_0, c_1, c_2, subject to the budget constraint (5) and the leisure constraint $c_0(\tau, t_0) \leqslant l_{max}$. Denote the discounted shadow price of leisure by $\mu(\tau, t_0)$. Define

$$p_{c0}^*(\tau, t_0) = \mu(\tau, t_0) + p_{c0}(\tau)(1+\alpha)^{-t_0}(1+v)^{\tau - t_0} \qquad (16)$$

$$p_c(\tau) = [\theta_1^{\sigma_2} p_{c_1}(\tau)^{1-\sigma_2} + \theta_2^{\sigma_2} p_{c_2}(\tau)^{1-\sigma_2}]^{1/(1-\sigma_2)} \qquad (17)$$

$$p_u^*(\tau, t_0) = [\theta_0^{\sigma_1} p_{c0}^*(\tau, t_0)^{1-\sigma_1} + p_c(\tau)^{1-\sigma_1}]^{1/(1-\sigma_1)} \qquad (18)$$

where $\sigma_i = 1/(1+\rho_i)$, $i = 1, 2$ are the elasticities of substitution between leisure and consumption, and between consumption of the two goods respectively. The optimal consumption plan of households is as follows:

$$u^*(\tau, t_0) = \left(p_u^*(\tau, t_0) \frac{R_h(\tau, t)}{(1+\beta)^{t-\tau}}\right)^{-\gamma} \times \left(\frac{W_h(t, t_0) + \sum_{s=t}^{T+t-1} \mu(s, t_0) l_{max} R_h(s, t)}{\sum_{s=t}^{T+t-1} (p_u^*(s, t_0) R_h(s, t))^{1-\gamma} (1+\beta)^{-\gamma(s-t)}} \right) \qquad (19)$$

$$c_0^*(\tau, t_0) = (1+\alpha)^{-t_0}(1+v)^{t-t_0} \theta_0^{\sigma_1} \left(\frac{p_{c0}^*(\tau, t_0)}{p_u^*(\tau, t_0)}\right)^{-\sigma_1} \times u^*(\tau, t_0) \qquad (20)$$

$$c^*(\tau, t_0) = \left(\frac{p_c(\tau)}{p_u^*(\tau, t_0)}\right)^{-\sigma_1} u^*(\tau, t_0) \qquad (21)$$

$$c_i^*(\tau, t_0) = \theta_i^{\sigma_2} \left(\frac{p_{c_i}(\tau)}{p_c(\tau)}\right)^{-\sigma_2} c^*(\tau, t_0) \quad i = 1, 2 \qquad (22)$$

It appears from Equation (19) that consumption is only homogeneous in full income if the household does not plan to retire from the labour market (in that case, $\mu(\tau, t_0)$ is identically zero in τ).

Aggregate consumption, labour supply and transfers can be found by aggregating over all existing households:

$$c_i^*(t) = \sum_{\tau=t-T_0+1}^{t} gen(\tau) c_i^*(t, \tau) \qquad (23)$$

$$L^s(t) = \sum_{\tau=t-T_0+1}^{t} gen(\tau)(l_{max} - c_0^*(t, \tau)) \qquad (24)$$

$$Tf(t) = \sum_{\tau=t-T_0+1}^{t} gen(\tau) Tf(t, \tau) \qquad (26)$$

where $gen(\tau)$ is the size of generation τ. Total population is equal to

$$Pop(t) = \sum_{\tau=t-T_0+1}^{t} gen(\tau) \qquad (26)$$

Firms

There is one representative firm in the model, which uses raw materials M, capital K and labour L to produce one homogeneous good y. The capital good is a composite of domestic investment goods and imported investment goods. Production is subject to internal adjustment costs on gross investment (I). Input markets, the output market and the capital market are perfectly competitive. Financing of new investments can be done either by issuing new shares, by issuing debt, or by using internal funds. The use of debt entails a principal–agent problem, because of possible conflicts of interest between bondholders and shareholders. Shareholders may be induced to adopt riskier investment projects if the firm is more highly leveraged. We assume that this leads to a loss of efficiency in the aggregate, because a brankruptcy may involve a loss of productive capital, as the capital goods cannot be freely reallocated to new activities in the face of adjustment costs. We therefore assume that a higher debt–equity ratio induces a higher depreciation rate of capital. An alternative way to model agency costs is given in Auerbach [1] and Hayashi [13]. In these models the borrowing rate increases with the leverage of the firm. In a model without uncertainty, the risk premium that is associated with this higher borrowing rate *must* be compensated for by a real cost, in terms of a loss of resources, however. We choose to model this cost as a loss of capital goods. The firm maximizes its market value, subject to an arbitrage condition for its rate of return. The model is as follows:

$$y(t) = F[M(t), K(t), L(t), t] - C\left(\frac{I(t)}{K(t)}\right)I(t) \tag{27}$$

$$\Pi(t) = p_1(t)y(t) - p_m(t)M(t) - p_l(t)L(t) - (r(t) + \pi_1(t))B(t) \tag{28}$$

$$T_b(t) = t_b(t)\left(\Pi(t) - \sum_{i=1}^{2} cr(t)p_i(t)I_i(t) - \sum_{i=1}^{2} \sum_{\tau=t-T_D+1}^{t} S(t-\tau)p_i(\tau)I_i(\tau)\right) \tag{29}$$

$$Div(t) = \Pi(t) - T_b(t) - \sum_{i=1}^{2} p_i(t)I_i(t) + B(t+1) - B(t) + VN(t) \tag{30}$$

$$Div(t) \geqslant \chi(\Pi(t) - T_b(t) - p_I(t)\delta(b(t))K(t)) \tag{31}$$

$$VN(t) \geqslant 0 \tag{32}$$

$$I(t) = G[I_1(t), I_2(t)] \tag{33}$$

$$K(t+1) = I(t) + (1 - \delta(b(t))K(t) \tag{34}$$

$$b(t) = B(t)/(p_I(t)K(t)) \tag{35}$$

$$r_d(t)V(t) = (1 - t_d(t))Div(t) + (1 - t_v(t))(V(t+1) - V(t) - VN(t)) \tag{36}$$

$$F[M, K, L, t] = (\zeta_m M^{-\rho_h} + \zeta_h H[K, L, t]^{-\rho_h})^{-1/\rho_h} \tag{37}$$

$$H[K, L, t] = (\zeta_k K^{-\rho_y} + \zeta_l(L\exp(\alpha t))^{-\rho_y})^{-1/\rho_y} \tag{38}$$

$$G[I_1, I_2] = (\gamma_1 I_1^{-\rho_I} + \gamma_2 I_2^{-\rho_I})^{-1/\rho_I} \tag{39}$$

$$p_I(t) = (\gamma_1^{-\sigma_I} p_1(t)^{1-\sigma_I} + \gamma_2^{-\sigma_I} p_2(t)^{1-\sigma_I})^{1/(1-\sigma_I)} \tag{40}$$

$$\sigma_I = 1/(1 + \rho_I) \tag{41}$$

$$C(I/K) = \tfrac{1}{2}c_I I/K \tag{42}$$

$$\delta(b) = \delta_0 + \tfrac{1}{2}c_b b^2 \tag{43}$$

Π denotes the profits of the firm, T_b corporate taxes, Div the dividend payout, B the amount of debt, r_d the rate of return, t_d the tax rate on dividends, t_v the capital gains tax, and V the present value or market value of the firm. VN denotes issues of new shares. It is assumed that repurchasing of shares by the firm is prohibited (Equation (32)). The production structure incorporates weak separability of raw materials from capital and labour (Equations (37), (38)). Accumulation of new capital goods incurs adjustment costs through production losses (Equation (27)). Capital goods are an amalgam of domestically produced goods (I_1) and imported investment goods (I_2) (Equation (33)). The depreciation rate depends on the leverage ratio b ie the ratio of debt versus the replacement value of capital (Equation (43)).[2] The economic depreciation rate δ may deviate from the depreciation scheme of capital for tax purposes, $S(\cdot)$, used in Equation (29). Financing of investment expenditures through internal funds is restricted by a pay out condition on dividends (Equation (31)). Debt is issued as one-period bonds at a real interest rate of $r(t)$. Equation (36) defines the rate of return to the firm's assets. The rate of return on equity is linked to the net return on bonds via an arbitrage condition:

$$r_d(t) = r_H(t) \tag{44}$$

Forward solution of Equation (36) yields Equation (45):

$$V(t) = \sum_{\tau=t}^{\infty} R_f(\tau, t)\left\{\frac{1 - t_d(\tau)}{1 - t_v(\tau)} Div(\tau) - VN(\tau)\right\} \tag{45}$$

$$R_f(\tau, t) \equiv \prod_{s=t}^{\tau}\left(1 + \frac{r_d(s)}{1 - t_v(s)}\right)^{-1} \tag{46}$$

For foreign investors, the net return on financial claims deviates from that of domestic investors if tax rates differ and if the residence principle of taxation applies, as we assume. This implies that foreign stockholders discount future revenues differently from domestic investors, which would create a problem of shareholder unanimity if foreign investors were to invest in

[2] An alternative would be to use the debt–equity ratio, as in Hayashi [13]. We refrained from doing that for computational reasons.

domestic firms. To avoid this, we assume that foreign investment is only in bonds (see section below on the foreign sector).

The firm seeks a production and investment plan that maximizes its market value. The first-order conditions for this problem are presented in Broer and Westerhout [7]. Since labour and raw materials are flexible inputs, their marginal product equals their market price. For investment, we can derive the following q-theoretic relation:

$$c_I \frac{I(\tau)}{K(\tau)} = [q(\tau) - \lambda_I(\tau)/p_I(\tau)]/ [(\lambda_B(\tau) - \chi\lambda_D(\tau))(1 - t_b(\tau))p_1(\tau)/p_I(\tau)] \quad (47)$$

where

$$q(\tau) = \lambda_K(\tau)/p_I(\tau) \quad (48)$$

$$\lambda_I(\tau) = p_I(\tau)[\lambda_B(\tau) - (\lambda_B(\tau) - \chi\lambda_D(\tau)) \times t_b(\tau)(cr(\tau) + depr(\tau))] \quad (49)$$

$$\begin{aligned}\lambda_K(t) &= \sum_{\tau=t+1}^{\infty} \Bigg\{(\lambda_B(\tau) - \chi\lambda_D(\tau))(1 - t_b(\tau)) \\ &\times\left(\frac{\partial F}{\partial K(\tau)} + \left(\frac{I(\tau)}{K(\tau)}\right)^2 C'\left(\frac{I(\tau)}{K(\tau)}\right)\right) + p_I(\tau)b(\tau) \\ &\times\left\{\lambda_B(\tau - 1)\left(1 + \frac{r_d(\tau)}{1 - t_v(\tau)}\right) - \lambda_B(\tau)(1 + (1 - t_b(\tau))r(\tau))\right\} \\ &+ \chi p_I(\tau)\lambda_D(\tau)(\delta(b(\tau)) + (1 - t_b(\tau))r(\tau)b(\tau)\Bigg\} \\ &(1 - \delta)^{\tau - t}R_f(\tau, t)\end{aligned} \quad (50)$$

Investment is positive if the marginal value of capital (λ_K) is larger than its net cost of purchase (λ_I). The marginal value of capital consists of, first, the present value of the increase in production resulting from an additional unit of capital. This unit of capital both increases gross production and diminishes adjustment costs. Second, the reduction in the rate of deterioration caused by the lower leverage resulting from a larger capital base can be expressed in terms of the interest rate difference of retentions (r_d) and debt ($(1 - t_b)r$). Finally, the third term in (50) represents the return to a relaxation of the dividend pay out restriction, caused by higher depreciation deductions and interest payments. The shadow price of debt (λ_B), used to value marginal returns to investment in (50), also depends on the mode of finance. Suppose, as usually, that $t_v \leqslant t_d$ and $(1 - t_k)/(1 - t_v) < 1 - t_b$. It then follows from the first-order conditions that there are three financing regimes, ranked by increasing costs of debt (for a similar result in a slightly different model, see Auerbach [1] and Hayashi [13]). In the first regime, investment is financed by retained profits and, for a growing firm, debt issues ($\lambda_D = 0, \lambda_B = (1 - t_d)/(1 - t_v)$). In the second regime, retained profits are exhausted and the firm uses debt as the sole marginal source of funds ($\lambda_D = \lambda_B - (1 - t_d)/(1 - t_v), (1 - t_d)/(1 - t_v) < \lambda_B < 1$)). In the third regime, the costs of debt have risen sufficiently to make equity finance a viable option, and the firm uses both debt and equity as means of additional financing ($\lambda_B = 1$, $\lambda_D = 1 - (1 - t_d)/(1 - t_v)$). Debt financing will therefore always be one of the sources of funds. It derives its attractiveness from the higher rate of taxation of corporate profits as against interest income (which defines the rate of return in Equation (44)). The optimal debt–capital ratio is determined by:

$$\begin{aligned}\delta'(b(\tau)) &= \left\{\lambda_B(\tau - 1)\left(1 + \frac{r_d(\tau)}{1 - t_v(\tau)}\right) - (\lambda_B(\tau) - \chi\lambda_D(\tau)) \times (1 + (1 - t_b(\tau))(r(\tau) + \pi_1(t))) - \lambda_B(\tau)\right\}\Big/ \\ &(q(\tau) - \chi\lambda_D(\tau))\end{aligned} \quad (51)$$

If $\lambda_B(\tau) = \lambda_B(\tau - 1)$ and $\lambda_D(\tau) = 0$, the term between braces can be simplified. In that case, it follows that $B(\tau) > 0$ if f$(1 - t_k)/(1 - t_v) > (1 - t_b)$.

It is also possible to derive a q-theoretic relation between the marginal value of capital, q, and its average value, Q, for the leveraged firm. Define

$$V_D(t) = \sum_{\tau=t-T_D+1}^{t-1} \sum_{i=1}^{2} p_i(\tau)I_i(\tau) \cdot \sum_{s=t}^{\tau+T_D-1} \lambda_B(s)t_b(s)S(s - \tau)R_f(s - 1, t) \quad (52)$$

$$Q(t) \equiv \left(V(t) + \frac{1 - t_d(t)}{1 - t_v(t)}B(t)\right)\Big/(p_I(t)K(t)) \quad (53)$$

then

$$q(t) = \frac{p_I(t + 1)}{p_I(t)}\left\{Q(t + 1) - \frac{V_D(t + 1)}{p_I(t + 1)K(t + 1)}\right\} \quad (54)$$

(see Broer and Westerhout [7] for a derivation). Equation (54) restates the result of Hayashi [12] relating marginal q to Tobin's average q for the case of a partially debt financed firm. Note the difference in timing, which results from the fact that investment results in additions to the capital stock with a lag of one period.

Additional insight into the impact of the financial structure on capital costs can be obtained from the steady-state solution of the model. In a steady state the real growth rate (ψ), the tax rates and the rates of inflation are constant ($\pi_2 = \pi_1 = \pi$). The steady-state relations are:

$$\lambda_B^* = (1 - t_d)/(1 - t_v) + \lambda_D^* \tag{55}$$

$$(\lambda_B^* - 1)VN^* = 0 \tag{56}$$

$$\lambda_D^*(Div^* - \chi(\Pi^* - T_b^* - p_I^*\delta^* K^*)) = 0 \tag{57}$$

$$\lambda_I^* = p_I^*(\lambda_B^* - (\lambda_B^* - \chi\lambda_D^*)t_b(cr + depr^*)) \tag{58}$$

$$\lambda_K^* = (\lambda_I^* + (\lambda_B^* - \chi\lambda_D)(1 - t_b)p_1^* c_I(\psi + \delta(b^*))) \tag{59}$$

$$q^* = \lambda_K^*/p_I^* \tag{60}$$

$$\delta'(b^*) = \left[\lambda_B^* \frac{1 - t_k}{1 - t_v} - (\lambda_B^* - \chi\lambda_D^*)(1 - t_B)\right] \cdot (r^* + \pi^*)/(q^* - \chi\lambda_D^*) \tag{61}$$

$$I^* = K^*(\psi + \delta(b^*)) \tag{62}$$

$$p_1^*\left(\frac{\partial F}{\partial K} - \tfrac{1}{2}c_I(\psi + \delta)^2\right) = p_k^* \tag{63}$$

$$p_1^* \frac{\partial F}{\partial M} = p_m \tag{64}$$

$$p_1^* \frac{\partial F}{\partial L} = p_l^* \tag{65}$$

where p_k^* is the equilibrium user price of capital:

$$p_k^* = p_I^*\left\{q^*\left(\frac{1 + r_d^*/(1 - t_v)}{1 + \pi^*} + \delta(b^*) - 1\right) - b^*(r^* + \pi)\left(\lambda_B^* \frac{1 - t_k}{1 - t_v} - (\lambda_B^* - \chi\lambda_D^*)(1 - t_b)\right) - \chi\delta(b^*)\lambda_D^*\right\} \Big/ \{(\lambda_B^* - \chi\lambda_D^*)(1 - t_b)\} \tag{66}$$

Note that the net interest rate on debt appears in this equation with a weight equal to the leverage rate. If dividend payments are not restricted ($\lambda_D = 0$ or $\chi = 0$), b^* and p_K are independent of λ_B and therefore the marginal source of finance affects capital costs only through the debt-capital ratio b^*. This implies that dividend taxes have no effect on capital costs or the capital stock. The corporate tax rate influences capital costs both because investment is generally not fully deductible against profits, if $cr + depr < 1$, and because it acts upon the financial structure of the firm, by changing the desired debt-capital ratio. A higher amount of debt lowers after tax capital costs, and will induce the firm to choose a higher level of capital intensity than it would in a world without debt. The total impact of corporate taxation on investment is therefore ambiguous. The conditions under which corporate taxes do not affect the user costs of capital are $cr + depr = 1$ (full deductibility of depreciation), $c_I = 0$, $\lambda_D = 0$, and $b = 0$ (no debt finance).

The consequences of the financial structure for investment decisions also depend on the treatment of dividend payments. We distinguish the following cases (see Poterba and Summers [19]):

(i) $\chi = 0$: this case represents the new view of dividend taxes, where the timing of dividends is not important, because only their capitalized value matters. It follows from (66) that the level of dividend taxes does not distort investment decisions, to that there is no problem of double taxation (of course, intertemporal substitution caused by expected changes in dividend taxes may still lead to a loss of efficiency).

(ii) $\chi > 0$: this case represents the classical view, where the firm is compelled to maintain a stable flow of dividend payments eg to signal its profitability. In this case, if the restriction is binding ($\lambda > 0$), dividend taxes do distort capital costs. This effect is represented by the separate role of the shadow price of dividends in (66), which depends positively on the dividend tax rate t_d, and enters marginal investment costs (λ_I).

Of course, dividend taxes will in any case influence the market value of the firm and thereby asset positions of households.

The government

Government behaviour is largely exogenous in the model. The restrictions imposed are that the government adjusts its taxes or expenditure to meet its budget constraint and that it keeps the real level of per capita transfers constant. We also assume that government consumption consists of domestic goods only. The accumulation of debt of the government is the difference between expenditure and income plus nominal capital gains as a result of the indexation of debt on the domestic price level:

$$D(t+1) = D(t) + G(t) + Tf(t) + (r(t) + \pi_1(t))D(t) - T_T(t) \quad (67)$$

where $G(t)$ is government consumption and $T_T(t)$ are total tax receipts:

$$T_T(t) = T_b(t) + t_l(t)p_l(t)L(t) + t_k(t)r(t) D_H(t) + B(t) + t_k(t)Div(t) + t_v(t)(V(t+1) - V(t) - VN(t)) + \frac{t_c(t)}{1+t_c(t)}\left\{\sum_{i=1}^{2} p_{c_i}(t)c_i(t) + p_{c_1}(t)g(t)\right\} \quad (68)$$

where g denotes the volume of government consumption. Real transfers per capita (Tv) are exogenous, nominal transfers are given by:

$$Tf(t) = Tv(t)Pop(t)p_1(t)$$

The intertemporal budget constraint requires that the present value of government debt be zero eventually:

$$\lim_{t\to\infty} D(t)\prod_{\tau=1}^{t}(r(\tau) + p_1(\tau+1)/p_1(\tau))^{-1} = 0$$

Using this condition leads to the following forward solution of Equation (67):

$$D(t) + \sum_{\tau=t}^{\infty} R_g(\tau,t)(G(\tau) + Tf(\tau)) = \sum_{\tau=t}^{\infty} R_g(\tau,t)T_T(\tau) \quad (69)$$

where

$$R_g(\tau,t) \equiv \prod_{s=t}^{\tau}\left(r(s) + \frac{p_1(s+1)}{p_1(s)}\right)^{-1} \quad (70)$$

The government chooses a time path of one or more of its instruments to satisfy Equation (69). This choice is exogenous in the model. We consider two special cases of Equation (69) in the simulations, the first being that the government adjusts one of its taxes so as to maintain a constant real debt per capita:

$$D(t+1) = D(t)Pop(t+1)/Pop(t)p_1(t+1)/p_1(t) \quad (\forall t \geq 1) \quad (71)$$

This rule satisfies the budget constraint provided that the growth rate of the population is less than the before tax rate of interest. The second option that we consider is that the government reacts to fluctuations of its deficit by choosing a constant level of its tax instruments, such that real debt per capita is constant in the steady state:

$$\lim_{t\to\infty} (D(t+1)/D(t) - Pop(t+1)/Pop(t)p_1(t+1)/p_1(t)) = 0 \quad (72)$$

This represents a policy of tax smoothing, where the government deficit may deviate from zero in the short run (Barro [4]). Though the general conditions for uniform taxation given by Deaton [8] are not satisfied over time in this model, it is still plausible that a policy aimed at avoiding the excess burden of intertemporal substitution is welfare improving. Long-run debt per capita, and indeed the position of the steady state, depends on the transition path.

The foreign sector

By analogy with the model for domestic consumers, we assume that goods produced at home and abroad are imperfect substitutes. We do not explicitly consider the choice problem for foreigners but simply assume that foreign demand for domestic goods is given by:

$$e(t) = e_0(t)(p_1(t)/p_2(t))^{-\varepsilon} \quad (73)$$

As we shall see below, this formulation has implications for welfare analysis, similar to those of a monopoly. Note however that domestic firms cannot exploit this monopoly, but sell at marginal costs to domestic consumers and foreigners alike. The accumulation of foreign claims on the home country is determined by the current account:

$$A_e(t+1) = p_2(t)(c_2(t) + I_2(t)) - p_1(t)e(t) + \left(r(t) + \frac{p_1(t+1)}{p_1(t)}\right)A_e(t) \quad (74)$$

$(r(t) + p_1(t+1)/p_1(t))A_e(t)$ is net factor income to foreigners under the residence principle of income taxation. It is assumed that foreigners invest only in government bonds, so that factor income does not include dividend payments. The budget constraint of the foreign country is again given by a transversality condition:

$$\lim_{t\to\infty} A_e(t)\prod_{\tau=1}^{t}(r(\tau) + p_1(\tau+1)/p_1(\tau)) = 0$$

which results in the following intertemporal restriction:

$$\sum_{\tau=t}^{\infty} R_g(\tau,t)p_1(\tau)e(\tau) - A_e(t)$$
$$= \sum_{\tau=t}^{\infty} R_g(\tau,t)(p_2(\tau)(c_2(\tau)+I_2(\tau))) \quad (75)$$

Equilibrium

Market equilibrium is given by

$$L(t) = L^s(t) \quad (76)$$

$$y(t) = c_1(t) + I_1(t) + g(t) + e(t) \quad (77)$$

$$A(t) + A_e(t) = V(t) + B(t) + D(t) \quad (78)$$

$$r(t) + p_1(t+1)/p_1(t) = r_e(t) + p_2(t+1)/p_2(t) \quad (79)$$

Equation (76) defines labour market equilibrium, Equation (77) equilibrium on the domestic goods market, Equation (78) defines equilbrium on the domestic bonds market and Equation (79) is the arbitrage condition for the international capital market under the residence principle of taxation. Claims of residents on the government are given by $A(t) - V(t)$ and claims of foreigners on the government by $A_e(t)$. If $A_e(t) < 0$, this is interpreted as domestic holdings of foreign bonds. One of the Equations (76)-(79) is redundant by Walras's law.

Simulation procedure

In the absence of analytical solutions, we have to perform numerical simulations to investigate the consequences of various tax policies. This requires choosing parameter values and values for the predetermined variables. Crucial parameters such as substitution elasticities have been assigned values that agree with estimates in the literature (for a detailed discussion of the calibration procedure we refer to Broer and Westerhout [7]). Scale parameters and exogenous variables are chosen in a way that makes the initial steady-state solution of the model resemble the Dutch economy as closely as possible around the year 1989. Due to the stylized nature of the model this attempt can only be partially successful eg unemployment, government employment, and foreign direct investment are excluded from the model. The parameter values chosen are:

$\gamma = 0.25$	$\sigma_1 = 0.9$	$\sigma_2 = 0.5$	$\beta = 0.015$
$\nu = 0.015$	$l_{max} = 1.0$	$\alpha = 0$	
$\sigma_y = 0.5.02$	$\sigma_I = 0.8$	$\sigma_h = 0.5$	$\delta_0 = 0.045$
$\delta_1 = 0.003$	$c_I = 10.0$	$\varepsilon = -2.0$	

The values of the exogenous variables are:

$p_2 = 1.0$	$p_m = 1.0$	$e_0 = 9.4$	$r_e = 0.055$
$g = 60$	$cr = 0.0$	$t_h = 0.35$	$t_c = 0.25$
$t_l = 0.25$	$t_d = 0.25$	$t_k = 0.25$	$t_r = 0.0$
$gen = 0.5$	$\psi = 0.01$		

To investigate the consequences of changes in government policy we compute the effects of changes in a number of instruments on the solution path of the model, in deviation from the initial steady-state path. To allow for convergence to a new steady state, we solve the model for 200 periods, in which case the terminal values are within a few percent of the new equilibrium and the cut off point has a negligible effect on the solution in the first 60 periods.

Results

In this section we investigate the effects of switching from various forms of income taxation to consumption taxation. The discussion of whether to tax income or expenditure is an old one (for a survey, see Kay [14]). In a lifecycle perspective, a capital income tax puts a burden on future consumption, while a consumption tax or a wage tax places the burden on current consumption. Thus capital income taxation distorts the choice between consumption in different periods, while consumption and wage taxes distort the choice between leisure and consumption per period. The relative efficiency of the various tax regimes will depend on the supply elasticities of labour and savings and on the size of the relevant tax base. Based on the results of Auerbach and Kotlikoff, the general presumption would be that consumption taxation is more efficient than wage taxation and that a capital income tax is least efficient. As pointed out in the introduction, this conclusion may need modification in case of an open economy. Furthermore, in a model that includes financial aspects of investment, the various forms that capital income taxation can take may influence its efficiency ranking.

Wage taxation

The first measure we analyse is a reduction in the wage tax rate (t_l), financed by an increase in the indirect tax rate (t_c), sufficient to keep the level of real government debt per capita constant. Table 1 presents the results for our small open economy. The constant debt policy does not introduce intergenerational income effects. Still, the tax reform is not neutral between generations. For individual households, a proportional consumption tax is equivalent to a wage tax plus a lump sum tax on existing assets. The

Table 1. Effects of a 1% decrease in the rate of wage income taxation, financed by an increase in indirect taxes to keep real government debt per capita at a constant level.

Endogenous variable[a]	Year 1	2	3	4	5	10	30	60	∞
t_c (Δ%)	1.73	1.62	1.60	1.59	1.58	1.52	1.40	1.32	1.27
b (Δ%)	0.03	−0.02	−0.01	−0.01	−0.01	0.00	0.01	0.00	0.00
c_1 (%)	−0.26	−0.19	−0.18	−0.16	−0.14	−0.07	0.10	0.22	0.32
c_2 (%)	−0.31	−0.25	−0.23	−0.21	−0.20	−0.13	0.06	0.22	0.34
l_1 (%)	0.13	0.14	0.14	0.15	0.15	0.16	0.13	0.08	0.04
l_2 (%)	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.08
e (%)	0.20	0.21	0.21	0.22	0.23	0.24	0.15	0.02	−0.09
y_1 (%)	0.05	0.08	0.09	0.10	0.11	0.14	0.13	0.08	0.04
L_d(%)	0.16	0.18	0.18	0.18	0.19	0.18	0.14	0.08	0.03
k (%)	0.00	0.02	0.03	0.04	0.06	0.09	0.12	0.08	0.05
m (%)	0.01	0.03	0.04	0.04	0.06	0.10	0.08	0.08	0.08
p_1 (%)	−0.10	−0.10	−0.11	−0.11	−0.11	−0.12	−0.08	−0.01	0.04
p_l (%)	−0.29	−0.30	−0.30	−0.29	−0.28	−0.25	−0.13	−0.01	0.09
A_e (%)	−0.10	−0.21	−0.31	−0.40	−0.50	−0.99	−2.72	−4.21	−5.41
V (%)	0.02	0.06	0.05	0.05	0.05	0.04	0.05	0.09	0.08
CV^b (%)	−0.006	−0.009	−0.011	−0.013	−0.015	−0.023	−0.048	−0.067	−0.081
CV^c (%)	−0.001	0.003	0.008	0.013	0.018	0.044	0.146		

[a] Δ% = percentage point changes; % = percentage increase in lifetime resources needed (CV); percentage increase in benchmark value in other cases.
[b] For this entry, the time index corresponds to the year in which the household was born.
[c] For this entry, the time index corresponds to one minus the year in which the household was born.

balanced budget reduction in the wage tax therefore places a lump sum burden on older generations, while younger generations profit.

The income effect of the tax change decreases consumption of both goods and leisure of older generations. For new born generations the income effect of the transfer tends to raise consumption and lower labour supply. Since the consumption tax has a broader base, after tax wages will shift by more than consumer prices, which will induce a substitution effect towards increased labour supply for younger generations as well. The result is an increase in overall labour supply, which depresses real wages and raises capital productivity. Both investment and production therefore increase. The growth of product supply is not matched by an increase in domestic demand and it therefore leads to a surplus on the current account and a deterioration of the terms of trade (p_1). The accumulation of claims against foreigners during the transition period must necessarily bring about an increase of domestic consumption that creates a deficit on the trade balance in later years which causes the terms of trade to sway back. The intertemporal trade which results from the increase in net domestic savings, brings a welfare gain to foreigners, because domestic households as a whole sacrifice part of their consumer surplus as a result of the initial increase in net exports.

This transfer abroad implies that the switch is not necessarily welfare improving for the home country, as it would be for a closed economy (see Auerbach and Kotlikoff [3]). The last two rows of Table 1 show the compensating variations necessary to restore the original levels of utility, of new born and existing generations respectively, expressed as a percentage of lifetime resources. An intergenerational redistribution effect is apparent, but the compensating transfers are only a small fraction of lifetime resources. The present value of these transfers is slightly positive (0.3% of GNP), indicating a net welfare loss. This suggests that the efficiency gains are dominated by the loss of consumer surplus.

The existence of such a surplus is a consequence of the heterogeneity of domestic and foreign goods, which is confirmed by the moderate price elasticities found in empirical studies of export demand. We can calculate the size of this rent fairly easily. Because foreign income does not enter the export demand equation,[3] the compensating income variation for foreigners can be calculated directly from the Marshallian consumer surplus (for the general case, see Vartia [23]). Denote the export demand function (Equation (73)) as $e(p_1)$. The income transfer at time t, implicit in changing the domestic price level from $p_1^{(1)}(t)$ to $p_1^{(2)}(t)$, is

$$CV_e(t) = -\int_{p_1^{(1)}}^{p_1^{(2)}} e(p_1)\,\mathrm{d}p_1$$

$$= -\frac{1}{1-\varepsilon}\left(p_1^{(2)}e(p_1^{(2)}) - p_1^{(1)}e(p_1^{(1)})\right)$$

[3] The implicit assumption is that variations in the domestic price level have a negligible income effect for foreign consumers.

Table 2. Effects of a 2 percentage point decrease in the rate of interest income taxation, financed by an increase in indirect taxes to keep real government debt per capita at a constant level.[a]

Endogenous variable	**Year** 1	**2**	**3**	**4**	**5**	**10**	**30**	**60**	∞
t_c (Δ%)	−15.44	0.95	0.95	0.94	0.94	0.91	0.76	0.59	0.45
b (Δ%)	0.06	10.83	10.80	10.78	10.75	10.68	10.57	10.53	10.50
c_1 (%)	7.69	−0.87	−0.89	−0.90	−0.90	−0.87	−0.57	−0.25	0.00
c_2 (%)	7.59	−1.01	−1.00	−0.99	−0.97	−0.86	−0.38	0.05	0.38
I_1 (%)	−0.49	−0.28	−0.32	−0.35	−0.38	−0.51	−0.78	−0.95	−1.08
I_2 (%)	−0.64	−0.50	−0.50	−0.49	−0.49	−0.49	−0.48	−0.47	0.48
e (%)	0.37	0.54	0.44	0.35	0.27	−0.07	−0.75	−1.19	−1.50
y_1 (%)	2.47	0.08	0.01	−0.05	−0.11	−0.33	−0.70	−0.90	−1.03
L_d (%)	3.56	−0.01	−0.03	−0.06	−0.09	−0.20	−0.50	0.71	0.86
k (%)	0.00	−0.08	−0.17	−0.24	−0.30	−0.53	−0.86	−1.00	−1.09
m (%)	1.68	−0.26	−0.28	−0.29	−0.31	−0.36	−0.42	−0.43	−0.44
p_1 (%)	−0.18	−0.27	−0.22	−0.18	−0.13	0.03	0.38	0.59	0.75
p_I (%)	−3.69	−0.45	−0.43	−0.41	−0.39	−0.26	0.19	0.55	0.81
A_e (%)	−0.18	1.50	1.01	0.54	0.08	−1.98	−7.90	−12.46	−16.09
V (%)	−0.14	−9.12	−9.08	−9.04	−9.00	−8.85	−8.59	−8.45	−8.33
CV^b (%)	0.007	0.049	0.046	0.043	0.040	0.024	−0.037	−0.088	−0.129
CV^c (%)	0.003	−0.001	−0.006	−0.009	−0.013	−0.031	−0.074		

[a] Δ% = Percentage point changes; % = percentage increase in lifetime resources needed (CV); percentage increase in benchmark value in other cases.
[b] For this entry, the time index corresponds to the year in which the household was born.
[c] For this entry, the time index corresponds to one minus the year in which the household was born.

Note that for $p_1^{(1)} < p_1^{(2)}$, the surplus is necessarily negative. It tends to zero for $\varepsilon \to \infty$. The total transfer is

$$CV_e = \sum_{t=0}^{\infty} CV_e(t) \prod_{s=0}^{t} (1 + r_s)^{-1}$$

which equals 1.5% of GNP in the case at hand. Apparently, this is larger than the efficiency gain obtained from switching to a broader tax base.

Capital income taxation

Capital income taxation can take several forms in our model. We distinguish interest income, dividend income, and corporate profits as possible tax bases. These sources of income are all treated separately under Dutch tax laws, and from a theoretical point of view their distortionary impact may differ considerably. In particular, the conclusions obtained by Summers and Auerbach and Kotlikoff concerning the negative welfare effects of savings taxation need to be reaffirmed for corporate income taxes. We present the consequences of a switch from each of these tax bases to consumption taxation in turn.

Interest income taxation. Interest income taxation represents the classical distortion between consumption in different periods. In an open economy, where the rate of interest is determined internationally, the channels through which this tax influences economic development are different from those of a closed economy. In this respect, the treatment of capital income before taxes is of importance as well. Under the residence principle, the tax rate of the country of residence of the investor determines the effective tax rate, whereas under the source principle the country where the income is generated is decisive. Generally, for income from interest and dividends the residence principle applies and for profit income the source principle. In our model the source principle does not play any role, because, like most authors, we exclude foreign investment in equity.

We present the results of a 2 percentage point decrease in the interest income tax rate in Tables 2 and 3. In Table 2, the tax change is effected as a balanced budget reform. The decrease in the interest income tax rate implies an increase in the desired leverage ratio of firms, as the gap between the net required return to capital and the net costs of debt grows. Firms will therefore immediately increase their amount of debt and distribute their excess cash flow to shareholders in the form of dividends. This leads to a substantial increase in dividend tax receipts in the first period, which allows the government to decrease the consumption tax rate by 15 percentage points. In the second year dividends return to a normal level and the consumption tax increases to maintain a constant deficit. This fluctuation in taxes causes strong intertemporal substitution effects in consumption in period 1, that initially somewhat obscure the increase

Table 3. Effects of a 2 percentage point decrease in the rate of interest income taxation, financed by a uniform increase in indirect taxes to create a constant equilibrium level of government debt per capita.[a]

Endogenous variable	Year 1	2	3	4	5	10	30	60	∞
t_c (Δ%)	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
b (Δ%)	0.12	10.79	10.77	10.75	10.74	10.67	10.58	10.53	10.50
c_1 (%)	−0.70	−0.69	−0.68	−0.67	−0.66	−0.61	−0.33	−0.08	0.07
c_2 (%)	−0.87	−0.84	−0.81	−0.78	−0.76	−0.62	−0.15	0.22	0.45
l_1 (%)	−0.12	−0.11	−0.15	−0.18	−0.22	−0.35	−0.69	−0.92	−1.07
l_2 (%)	−0.40	−0.36	−0.36	−0.36	−0.36	−0.37	−0.41	−0.44	−0.46
e (%)	0.70	0.62	0.53	0.44	0.36	0.04	−0.70	−1.21	−1.52
y_1 (%)	0.24	0.19	0.13	0.08	0.02	−0.18	−0.59	−0.86	−1.02
L_d (%)	0.24	0.22	0.18	0.15	0.12	−0.02	−0.40	−0.68	−0.85
k (%)	0.00	−0.03	−0.10	−0.15	−0.21	−0.40	−0.75	−0.96	−1.08
m (%)	−0.14	−0.14	−0.16	−0.17	−0.18	−0.24	−0.34	−0.40	−0.44
p_1 (%)	−0.35	−0.31	−0.26	−0.22	−0.18	−0.02	0.35	0.60	0.76
p_l (%)	−0.72	−0.67	−0.64	−0.60	−0.56	−0.40	0.15	0.57	0.84
A_e (%)	−0.36	−0.88	−1.38	−1.85	−2.31	−4.38	−10.23	−14.52	−17.33
V (%)	−0.61	−8.95	−8.92	−8.89	−8.86	−8.74	−8.51	−8.39	−8.32
D (%)	−0.35	−4.10	−3.97	−3.85	−3.73	−3.20	−1.66	−0.57	0.13
CV^b (%)	−0.002	−0.004	−0.007	−0.010	−0.013	−0.027	−0.073	−0.109	−0.132
CV^c (%)	−0.005	−0.008	−0.010	−0.013	−0.015	−0.025	−0.012		

[a] Δ% = percentage point changes; % = percentage increase in lifetime resources needed (CV); percentage increase in benchmark value in other cases.
[b] For this entry, the time index corresponds to the year in which the household was born.
[c] For this entry, the time index corresponds to one minus the year in which the household was born.

in the propensity to save. The lower interest income tax implies a higher net return on savings for households, which leads to a postponement of consumption. From period 2 onwards, savings do indeed increase. This does not cause a fall in the rate of interest, as it would in a closed economy, but rather an accumulation of foreign assets. The increase in savings is also reflected in an increase in net exports. In period 1, labour supply rises sharply as a result of intratemporal substituion, which raises production. In later periods labour supply falls, but net exports remain high initially because domestic consumption falls sharply. In the longer run net exports fall again, as households start to consume their assets, and the terms of trade improve. The increase in savings thus leads to a net export of capital instead of depressing interest rates. In this way households profit from the higher return to savings abroad by entering into intertemporal trade. The lower capital income tax rate increases the required rate of return to capital, however, which lowers the desired capital stock. Domestic asset accumulation therefore occurs exclusively in terms of foreign assets.

Welfare gains accrue both to older generations, which experience an increase in the value of their assets, and to generations born after $t = 18$, which profit from the reduction in foreign debt. Generations in between pay for the transition in terms of higher consumption taxes. Total welfare, measured as (minus) the present value of compensating variations, increases by 16.3 thousand million guilders equal to 4.8% of GNP in the base year. It is evident, however, from the fluctuations in the consumption tax rate that the tax policy of the government induces new intertemporal distortions in consumption that might be avoided by smoothing consumption tax changes.

We present the consequences of a once only adaptation of this tax rate in Table 3. The effect of this restriction on tax changes is that government debt is no longer constant during the transition. Even though this implies some intergenerational redistribution through the government budget, the compensating variations resulting from this reform are negative for all generations born after $t = -35$, with a total present value of −18.3 thousand million guilders. The tax smoothed reform therefore delivers higher welfare gains than the constant debt policy. Medium- and long-run effects for this tax change are similar to that of the balanced budget change, with as notable differences the response of labour supply, which remains positive for more periods, and foreign debt, which starts to decline immediately. Both effects reflect the income effect of the additional burden placed on existing generations as a result of the initial reduction in government debt. All except the eldest generations profit, however, from the reduction in intertemporal distortions.

The results of a reduction in interest taxes in this model therefore deviate from those of a closed economy model as presented by Auerbach and

Table 4. Effects of a 5 percentage point decrease in the rate of dividend income taxation, financed by an increase in indirect taxes to keep real government debt per capita at a constant level.[a]

Endogenous variable	Year 1	2	3	4	5	10	30	60	∞
t_c (Δ%)	−0.11	0.14	0.18	0.21	0.25	0.39	0.73	0.95	1.09
b (Δ%)	−0.10	0.05	0.04	0.03	0.02	−0.01	−0.03	−0.01	0.01
c_1 (%)	0.71	0.55	0.50	0.45	0.41	0.21	−0.27	−0.63	−0.87
c_2 (%)	0.85	0.70	0.65	0.61	0.57	0.38	−0.17	−0.61	−0.93
I_1 (%)	−0.38	−0.40	−0.41	−0.42	−0.43	−0.45	−0.37	−0.23	−0.11
I_2 (%)	−0.16	−0.16	−0.17	−0.17	−0.17	−0.18	−0.20	−0.21	0.21
e (%)	−0.55	−0.58	−0.60	−0.62	−0.64	−0.66	−0.42	−0.05	0.24
y_1 (%)	−0.15	−0.22	−0.25	−0.28	−0.30	−0.38	−0.37	−0.23	−0.11
L_d (%)	−0.46	−0.51	−0.52	−0.52	−0.52	−0.52	−0.40	−0.22	−0.08
k (%)	0.00	−0.05	−0.09	−0.13	−0.16	−0.26	−0.33	−0.24	−0.15
m (%)	−0.04	−0.08	−0.09	−0.10	−0.12	−0.16	−0.21	−0.22	−0.21
p_1 (%)	0.28	0.29	0.30	0.31	0.32	0.33	0.21	0.03	−0.12
p_l (%)	0.82	0.84	0.83	0.81	0.79	0.71	0.36	0.02	−0.23
A_e (%)	0.32	0.61	0.88	1.15	1.42	2.77	7.26	10.90	13.58
V (%)	6.50	6.39	6.40	6.41	6.42	6.44	6.39	6.29	6.19
CV^b (%)	0.014	0.021	0.026	0.031	0.036	0.059	0.122	0.170	0.206
CV^c (%)	0.002	−0.010	−0.022	−0.035	−0.048	−0.116	−0.382		

[a] Δ% = percentage point changes; % = percentage increase in lifetime resources needed (CV); percentage increase in benchmark value in other cases.
[b] For this entry, the time index corresponds to the year in which the household was born.
[c] For this entry, the time index corresponds to one minus the year in which the household was born.

Kotlikoff [2], even though the welfare effects are similar. In their model, a switch from capital income taxation to consumption taxation leads to an increase in capital formation via a decrease in the interest rate caused by the larger supply of savings. In our model this is prevented by interest arbitrage through international capital flows and instead we find a strong improvement of the current account. The extra savings are invested abroad and their return is consumed mostly in terms of leisure. The trade balance therefore deteriorates in later years, balancing the additional factor income from abroad.

Dividend income taxation. Dividend income taxation, although similar to an interest tax from the household point of view, has completely different implications for savings. Its main effect is to decrease the market value of dividend payments, which acts as a lump sum tax on existing shareholders, while leaving future rates of return on assets unaffected. Only if firms are required to maintain a constant pay out ratio may dividend taxes influence capital costs (see above). The results of a 5 percentage point decrease in the dividend tax rate, compensated for by a balanced budget increase in consumption taxes, are presented in Table 4. The market value of the firm at once rises by 6.5% in reaction to the change, which presents a windfall profit to the elderly. Consumption of both goods and leisure therefore increases and investment falls as a result of the concomitant decrease in capital productivity. The result is a general decline in activity and a decrease in net exports that raises the terms of trade. In time, the intertemporal trade necessary to satisfy the external budget restriction (Equation (75)), brings down the terms of trade again. Welfare effects of this policy are positive, however, with a present value of compensating transfers of 1% of initial GNP as a result of the additional creaming off of the foreign consumer surplus by the private sector. The present value of this change in surplus is 4.2% of GNP. This presents another instance of a reversal of welfare effects caused by product differentiation in foreign trade, just as in the shift from wage taxation to consumption taxation analysed before. Some additional welfare gains result if the consumption tax rate is smoothed over time, but qualitative results are very similar.

Corporate income taxation. The last tax to be considered is the corporate income tax. The usual argument in favour of a reduction in corporate taxation is that it fosters investment. To the extent that this argument depends on an encouragement of domestic savings, it is of doubtful validity for a small open economy, as we have shown above. There is, however, another important aspect of corporate taxation in relation to the choice of financing of investment. High corporate tax rates encourage debt financing of investment expenditures, as the after tax costs of debt decrease with rising corporate tax rates, in view of the deductibility of interest payments. This increased leverage carries a social cost, as pointed out above, in the form of an overaccumulation of capital

Table 5. Effect of a 3 percentage point decrease in the corporate tax rate, financed by a uniform increase in indirect taxes to create a constant equilibrium level of government debt per capita.[a]

Endogenous variable	Year 1	2	3	4	5	10	30	60	∞
t_c (Δ%)	−0.08	−0.08	−0.08	−0.08	−0.08	−0.08	−0.08	−0.08	−0.08
b (Δ%)	−0.02	−1.64	−3.26	−4.89	−6.52	−14.74	−17.58	−17.57	−17.56
c_1 (%)	0.59	0.53	0.48	0.44	0.40	0.32	0.23	0.11	0.04
c_2 (%)	0.62	0.60	0.58	0.56	0.54	0.48	0.27	0.09	−0.02
I_1 (%)	−0.85	−0.84	−0.83	−0.80	−0.77	−0.61	−0.42	−0.31	−0.24
I_2 (%)	−0.80	−0.73	−0.67	−0.60	−0.55	−0.36	−0.35	−0.33	−0.32
e (%)	−0.12	−0.28	−0.40	−0.49	−0.56	−0.63	−0.19	0.06	0.21
y_1 (%)	0.08	−0.05	−0.14	−0.22	−0.28	−0.34	−0.07	0.06	0.14
L_d (%)	−0.45	−0.47	−0.47	−0.47	−0.47	−0.41	−0.22	−0.08	0.00
k (%)	0.00	−0.13	−0.23	−0.30	−0.36	−0.39	−0.14	−0.03	0.03
m (%)	−0.19	−0.20	−0.21	−0.21	−0.20	−0.17	−0.11	−0.08	−0.06
p_1 (%)	0.06	0.14	0.20	0.25	0.28	0.32	0.10	−0.03	−0.10
p_l (%)	0.52	0.52	0.51	0.51	0.50	0.46	0.21	0.00	−0.12
A_e (%)	0.05	−0.02	−0.04	−0.01	0.06	0.84	3.60	5.37	6.40
V (%)	4.64	5.71	6.77	7.84	8.91	14.24	16.01	15.98	15.95
D (%)	0.06	0.58	1.10	1.62	2.14	4.75	5.05	4.55	4.25
CV^b (%)	−0.058	−0.056	−0.054	−0.053	−0.052	−0.046	−0.027	−0.011	−0.002
CV^c (%)	−0.067	−0.076	−0.085	−0.094	−0.103	−0.151	−0.320		

[a] Δ% = percentage point changes; % = percentage increase in lifetime resources needed (CV); percentage increase in benchmark values in other cases.
[b] For this entry, the time index corresponds to the year in which the household was born.
[c] For this entry, the time index corresponds to one minus the year in which the household was born.

and an increased percentage of bankruptcies and capital depreciation.

The effects of a 3 percentage point decrease in the corporate tax rate, financed by a once only adjustment of indirect taxes, are presented in Table 5. An immediate consequence of the tax change is an increase in the market value of the firm. This presents a capital gain to existing shareholders, which stimulates consumption of both goods and leisure. As a result labour supply decreases and the marginal productivity of capital falls. A second consequence of the tax change is that the cost of debt rises and the desired debt–capital ratio falls. The desired decrease in the debt ratio is 17 percentage points, so that the change in financial structure cannot be paid for out of the current cash flow. Instead the firm withholds dividend payments for 11 years, to reach the new financial optimum. During this transition, the cost of funds is higher and investment is cut down. The increase in the cost of funds is, however, insufficient to induce the firm to issue new shares. From period 12 on, dividend payments are restored. Capital costs are now lower than in the benchmark case as a result of the smaller debt ratio, which lowers the depreciation rate by 0.04 percentage points, and the capital stock is gradually restored to its benchmark level. The amount of investment needed to sustain this capital stock is lower, though, so that consumption possibilities are larger, as is the taxable base of corporate income. This allows the government to lower the consumption tax, while maintaining a sustainable steady-state debt per capita.

The net result is thus a lowering of both tax rates, and welfare gains are bound to be substantial. The present value of compensating transfers amounts to 12% of GNP, which is to be attributed in large part to the reduction in agency costs following from the change in the financial structure of firms. Still, 20% of the beneficial effect is due to terms of trade changes, resulting from the withdrawal of labour supply.

Even though the reduction in the depreciation rate that causes these efficiency gains is rather modest, the beneficial effects of the corporate tax adjustment may be overstated. We consider two modifications of the model to investigate its sensitivity in this respect. First, under the old view of dividend payments, it is unrealistic to assume that firms can actually withhold dividend payments for a prolonged period, when they are in fact making a profit. This point is taken up in Table 6, which presents the results of a cut of the corporate tax rate, financed by a once only increase in the consumption tax rate, in case of a minimum dividend pay out of $\chi = 50\%$. Because of the pay out restriction, the initial drop in dividend taxes does not occur in this case. Short- and medium-term effects are very similar to the previous case. The transfer to older generations again causes consumption to rise and labour supply to fall. This decreases capital productivity and investment. In this case, however, the restriction on dividend pay outs distorts capital costs even in the

Table 6. Effects of a 3 percentage point decrease in the corporate tax rate in case of a required minimum dividend pay out ratio of 50%, financed by a uniform increase in indirect taxes to create a constant equilibrium level of government debt per capita.

Endogenous variable	Year 1	2	3	4	5	10	30	60	∞
t_c (Δ%)	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
b (Δ%)	−0.09	−0.22	−0.35	−0.48	−0.60	−1.16	−3.02	−5.07	−8.77
c_1 (%)	0.68	0.61	0.55	0.50	0.44	0.24	−0.18	−0.43	−0.50
c_2 (%)	0.81	0.77	0.73	0.69	0.65	0.49	0.01	−0.38	0.55
I_1 (%)	−0.88	−0.92	−0.95	−0.98	−1.00	−1.04	−0.88	−0.60	−0.40
I_2 (%)	−0.69	−0.68	−0.67	−0.66	−0.66	−0.63	−0.57	−0.52	−0.47
e (%)	−0.49	−0.60	−0.70	0.78	−0.85	−1.02	−0.77	−0.21	0.18
y_1 (%)	−0.13	−0.23	−0.32	−0.39	−0.45	−0.64	−0.60	−0.30	−0.05
L_d (%)	−0.77	−0.79	−0.80	−0.80	−0.81	−0.79	−0.53	−0.22	−0.04
k (%)	0.00	−0.13	−0.24	−0.33	−0.41	−0.68	−0.76	−0.51	−0.26
m (%)	−0.22	−0.25	−0.27	−0.29	−0.31	−0.36	−0.36	−0.29	−0.21
p_1 (%)	0.25	0.30	0.35	0.39	0.42	0.51	0.38	0.10	−0.09
p_I (%)	1.08	1.05	1.02	0.99	0.97	0.82	0.31	−0.14	−0.34
A_e (%)	0.37	0.47	0.59	0.74	0.91	1.97	6.57	10.31	11.43
V (%)	8.64	8.74	8.83	8.91	8.99	9.35	10.31	11.21	12.59
D (%)	0.25	−0.23	−0.73	−1.27	−1.84	−4.97	−16.55	−24.90	−22.03
CV^b (%)	−0.002	0.003	0.008	0.012	0.016	0.035	0.081	0.108	0.112
CV^c (%)	−0.018	−0.034	−0.051	−0.067	−0.084	−0.172	−0.505		

[a] Δ% = percentage point changes; % = percentage increase in lifetime resources needed (CV); percentage increase in benchmark value in other cases.
[b] For this entry, the time index corresponds to the year in which the household was born.
[c] For this entry, the time index corresponds to one minus the year in which the household was born.

long run, as the firm cannot achieve its optimal financial structure. This has a negative long-term effect on capital formation. The tax base of the government is also negatively affected by this inefficiency, and here the consumption tax rate has to increase to balance the steady-state budget. Because efficiency gains are largely absent, the consequences of the intergenerational transfer are more predominant, and the initial stimulus to consumption creates a deficit on the current account, that leads to terms of trade effects. Thus initial consumption increases even more, and later generations suffer. This is partially compensated for by a decline in government debt, which implies a transfer to new generations. Compensating variations would still have to go the new born, however, while the total welfare improvement drops to 8% of GNP.

Second, the assumed externality in capital formation may obscure the intrinsic efficiency gains or losses of the change of tax base. To judge this effect, we also computed the effects of this tax change in case of a fixed debt ratio, equal to the initial steady-state value (see Table 7). This case is very similar to the dividend tax reduction analysed previously. The primary effect is a transfer to older generations, by means of a capital gain on the market value of the firm. This stimulates consumption and reduces production and capital formation. Terms of trade effects cause a transfer to welfare from abroad (3% of initial GNP), so that the total welfare effect is positive, at 1% of GNP, even though the new born are worse off. Agency costs are therefore by far the most important determinant of the favourable consequences of corporate tax reductions.

Conclusion

In this paper we consider the consequences for a small open economy of switching from various forms of income taxation to consumption taxation. The paper emphasizes the role of the terms of trade in the allocation of production and the distribution of welfare gains of tax reforms between the home country and the foreign country. It is shown that the terms of trade effect may well dominate the pure efficiency gain of a tax reform for the home country. In case of a switch from wage taxation to consumption taxation, this leads to a small negative welfare effect, despite the broader tax base. Similarly, the effects of the lump sum transfer to existing stockholders that is implied by a switch from dividend taxation to consumption taxation are dominated by the positive welfare gains of the terms of trade improvement. A reduction in interest income taxes is also welfare improving; but unlike the case of a closed economy it does not foster investment, as the extra savings resulting from this measure are invested abroad. Substantial welfare gains are indicated by the model following a lowering of the corporate tax rate, as a result of a reduction in the externality associated with the agency costs of debt financing. In the absence of agency costs, a reduction

Table 7. Effect of a 3 percentage point decrease in the corporate tax rate in case of a fixed debt–capita ratio, financed by a uniform increase in indirect taxes to create a constant equilibrium level of government debt per capita.[a]

Endogenous variable	Year 1	2	3	4	5	10	30	60	∞
t_c (Δ%)	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
c_1 (%)	0.18	0.16	0.13	0.11	0.09	0.01	−0.18	−0.30	−0.38
c_2 (%)	0.26	0.24	0.22	0.21	0.19	0.12	−0.11	−0.29	−0.40
l_1 (%)	−0.28	−0.29	−0.30	−0.30	−0.31	−0.32	−0.24	−0.12	−0.05
l_2 (%)	−0.16	−0.15	−0.15	−0.15	−0.15	−0.15	−0.13	−0.10	−0.09
e (%)	−0.31	−0.34	−0.36	−0.38	−0.40	−0.43	−0.28	−0.05	0.10
y_1 (%)	−0.15	−0.18	−0.20	−0.22	−0.24	−0.28	−0.25	−0.13	−0.05
L_d (%)	−0.40	−0.40	−0.40	−0.40	−0.40	−0.38	−0.26	−0.12	−0.03
k (%)	0.00	−0.04	−0.07	−0.10	−0.12	−0.20	−0.22	−0.13	−0.07
m (%)	−0.10	−0.11	−0.11	−0.12	−0.12	−0.14	−0.14	−0.11	−0.09
p_1 (%)	0.15	0.17	0.18	0.19	0.20	0.21	0.14	0.02	−0.05
p_l (%)	0.60	0.59	0.57	0.56	0.54	0.47	0.23	0.02	−0.10
A_e (%)	0.15	0.24	0.33	0.43	0.53	1.10	3.25	5.01	6.04
V (%)	4.32	4.29	4.30	4.31	4.31	4.33	4.32	4.27	4.25
D (%)	0.15	−0.27	−0.66	−1.04	−1.43	−3.40	−10.10	−15.49	−18.91
CV^b (%)	0.022	0.024	0.026	0.028	0.030	0.039	0.062	0.078	0.088
CV^c (%)	0.015	0.007	−0.000	−0.008	−0.016	−0.056	−0.213		

[a] Δ% = percentage point changes; % = percentage increase in lifetime resources needed (CV); percentage increase in benchmark value in other cases.
[b] For this entry, the time index corresponds to the year in which the household was born.
[c] For this entry, the time index corresponds to one minus the year in which the household was born.

in the corporate tax rate has much the same effects as a reduction in dividend taxes. The incorporation of a required minimum pay out ratio of dividends raises capital costs, but does not affect the main conclusions in the cases investigated. Smoothing of the tax adjustment by the government raises welfare, but the effect is of second order compared with the efficiency gains and terms of trade effects of most tax reforms investigated.

A number of extensions to the model are possible. First, a non-tradables sector may be added. Second, a more elaborate treatment of international capital flows should include direct foreign investment and foreign portfolio investment in domestic firms. Third, extending the model to a multicountry setting would enable one to study game theoretical aspects of fiscal policy. A systematic exploitation of terms of trade effects, as might be recommended on the basis of the present analysis, would surely be met by retaliation from other countries. The resulting non-cooperative Nash equilibrium is then not Pareto efficient.

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