Tariff and tax reform: dynamic implications*

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Abstract

In an endogenously growing small open economy with a capital good and a consumption good, we characterize the optimal combination of an import tariff and consumption taxes under the revenue neutrality constraint. Focusing on the case in which the economy imports the capital good, we obtain two main results. First, consumption of the capital good is distorted more than the consumption good at the optimum. Second, the optimal tariff rate is positive, implying that free trade is not optimal even for a small open economy with no market failure.

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1 Introduction

Under pressure from the GATT/WTO, governments in developing countries have been reducing tariffs. To compensate for the resulting loss in government revenue, they have been mainly relying on indirect taxes, such as value-added taxes. According to the World Bank (2002), in low- and middle-income countries, the share of taxes on international trade in total current revenue fell from 17% to 9%, and the share of taxes on goods and services rose from 26% to 36% during the period 1990-1999. The share of taxes on income, profits, and capital gains, plus social security taxes, which are regarded as direct taxes, remained at 22% over the same period.

How, then, should the government coordinate tariff and tax reform while maintaining government revenue? Michael et al. (1993), Abe (1995), Hatzipanayotou et al. (1994), and Keen and Ligthart (2002) tackled this problem by formulating static general equilibrium trade models. Michael et al. (1993) identified conditions under which revenue-neutral substitution of consumption taxes for import tariffs raises welfare. In an economy with a public good, Abe (1995) demonstrated that a combination of tariff and tax changes that neutralizes direct price effects on the household budget constraint raises government revenue and hence welfare. Hatzipanayotou et al. (1994) and Keen and Ligthart (2002) took a simpler approach: they showed that lowering import tariffs and raising consumption taxes on the corresponding imports, with consumer prices unchanged, raises both welfare and government revenue.[1] The rise in welfare results from an improvement in production efficiency because of the tariff reduction. On the other hand, the rise in government revenue comes from an increase in the tax base; the tax base of an import tariff is consumption minus production, whereas that of a consumption tax is consumption. Hatzipanayotou et al. (1994) and Keen and Ligthart (2002) differ from Michael et al. (1993) and Abe (1995) in that the sizes of tariff and tax changes do not depend on the pre-reform equilibrium values of the endogenous variables.

Although the static literature on tariff and tax reform under a revenue constraint gives powerful policy recommendations, it overlooks the dynamic aspects of tariff and tax reform. Most developing countries import several types of equipment for investment, which has a central role in the growth process (e.g., Eaton and Kortum, 2001; Caselli and Wilson, 2004). In this situation, changes in the relative price of capital goods to consumption goods, often caused by changes in trade barriers, affect the incentives for investment and thus economic growth (e.g., De Long and Summers, 1991; Lee, 1993; Eaton and Kortum, 2001). Tariff and tax reform is surely one of the causes of such changes in the relative price. The dynamic implications of expanding consumption taxes have been analyzed by macroeconomists: Jones et al. (1993) and Gómez (2003), among others, showed numerically that replacing income taxes with consumption taxes raises both the growth rate and welfare by encouraging savings. However, the tax reform they studied is more appropriate to developed countries, where direct taxes are the main source of government revenue. The purpose of this paper is to examine analytically how tariff and tax reform affects the welfare and government revenue of a developing

[1] Hatzipanayotou et al. (1994) dealt with a uniform reduction in import tariffs and an offsetting increase in consumption taxes, whereas Keen and Ligthart (2002) generalized their scheme to arbitrary tariff reductions and offsetting tax changes.

country in a dynamic general equilibrium model.

We develop a two-good, one-factor endogenous growth model of a small open economy. Following Baxter (1992) and Kaneko (2000), we assume that a capital good (called good 1) is either invested or consumed, whereas a consumption good (called good 2) is only consumed. Each good is produced from capital, which is an aggregate of physical and human components. In the sense that technology exhibits constant returns to aggregate capital, this model is in line with the AK models of endogenous growth and taxation (e.g., Eaton, 1981; Rebelo, 1991). Our model can be viewed as the limit of Baxter's (1992) neoclassical model, with the factor share of capital approaching unity, or as the steady state of Kaneko's (2000) two-capital model.[2] The advantage of our one-capital model is that we may focus on the steady state to obtain an exact analytical solution of tariff and tax reform.

Our dynamic framework dramatically changes the implications of tariff and tax reform in static models. This is mainly because the tax base of the tariff on the capital good in our dynamic model is larger than that in static models. First, investment adds to the import of the capital good. Second, the minus term (i.e., production) disappears because of complete specialization. As the tax base of the tariff on the capital good is consumption plus investment, lowering the tariff and raising the corresponding consumption tax in a consumer-price-neutral way usually decreases government revenue through a decrease in the tax base. As a corollary, if the government wants to maintain government revenue, then it has to raise the consumption tax by more than the fall of the tariff rate. We focus on the welfare effect of the revenue-neutral tariff and tax reform, and characterize the optimal tariff and tax structure under the revenue neutrality constraint.

The welfare effect of revenue-neutral tariff and tax reform consists of three parts: the growth effect, the income effect, and the substitution effect. First, a reduction in the tariff on the capital good fosters investment and growth, bringing about more consumption in the future. Second, the increase in investment leaves less income for consumption in the present. We show that the growth effect on welfare is always stronger than the income effect as long as the pre-reform tariff rate is positive. Third, a rise in the consumer price of the capital good as a result of the revenue-neutral tariff and tax reform increases the distortion, and hence tends to lower welfare if the pre-reform relative consumer price is distorted against the capital good. Conversely, a rise in the consumer price of the capital good decreases the distortion, and hence tends to raise welfare if the pre-reform relative consumer price is distorted against the consumption good. The optimal tariff and tax structure must balance out the three effects. Since the first two effects combine to be positive, we conclude that consumption of the capital good should be distorted more than the pure consumption good at the optimum. We also show that the optimal tariff cannot be zero, because the income effect cancels out the growth effect, leaving only the substitution effect, as the tariff rate approaches zero.

The remainder of this paper is organized as follows. Section 2 formulates the model. Section 3 examines the effects of the revenue-neutral tariff and tax reform when the economy imports the capital good. Section 4 concludes.

[2]Barro and Sala-i-Martin (1995) interpreted the AK model in a similar way.

2 The model

2.1 Firms

The representative firm in sector j ($j = 1, 2$) maximizes its profit $\Pi_j = p_j Y_j - rK_j$, subject to the production function $Y_j = A_j K_j$, where p_j is the producer price of good j; Y_j is the output; r is the rental rate of capital; K_j is the demand for capital; and A_j is the marginal product of capital. The first-order condition for profit maximization is:

$$p_j A_j - r \leq 0, K_j \geq 0, K_j(p_j A_j - r) = 0. \tag{1}$$

The last equation in (1) means that the firm always makes zero profit.

2.2 Households

The representative household maximizes its utility $U = \int_0^\infty \exp(-\rho t)(C(t)^{1-\theta} - 1)/(1-\theta)dt$, $C(t) = V(C_1(t), C_2(t))$, where ρ is the subjective discount rate; C is the index of consumption; θ is the elasticity of marginal instantaneous utility, which becomes the inverse of the elasticity of intertemporal substitution; C_j is consumption of good j; and t denotes time. We omit the time variables where no confusion arises. It is assumed that the consumption index function $V(\cdot)$ is increasing, concave, linearly homogeneous, and differentiable. The flow budget constraint is:

$$p_1(t)(\dot{K}(t) + \delta K(t)) = r(t)K(t) + T(t) - E(t), E(t) = q_1(t)C_1(t) + q_2(t)C_2(t), \tag{2}$$

where K is the capital stock; δ is the depreciation rate; T is the lump-sum transfer from the government; E is the value of expenditure; q_j is the consumer price of good j; and a dot over a variable denotes differentiation with respect to t (e.g., $\dot{K}(t) \equiv dK(t)/dt$). Note two things about the domestic prices when the economy imports good 1. First, the price of investing in a unit of new capital is one plus the tariff rate. Second, the price of consuming a unit of good 1 exceeds the price of investment by the consumption tax rate. The above problem contains both static and dynamic maximization problems, so we solve the two problems, stage by stage. In the first stage, given E, we choose C_1 and C_2 to maximize C subject to the "static" budget constraint $E = q_1 C_1 + q_2 C_2$. The first-order condition for maximization of C is $V_1(C_1, C_2)/V_2(C_1, C_2) = q_1/q_2$, where $V_j(\cdot) \equiv \partial V(\cdot)/\partial C_j$. Since $V(\cdot)$ is linearly homogeneous, this condition is rewritten as:

$$C_1/C_2 = c(q_1/q_2); c'(\cdot) < 0, \tag{3}$$

where c is the consumption demand for good 1 relative to good 2. From this equation and the "static" budget constraint, we obtain $C_1 = [c/(q_1 c + q_2)]E$, $C_2 = [1/(q_1 c + q_2)]E$, and $C = E/e(q_1, q_2)$, where e is the amount of expenditure needed to obtain a unit of the consumption index. The unit expenditure function

$e(\cdot)$ is increasing, concave, linearly homogeneous, and differentiable. In the second stage, we substitute the last expression for C into the utility function and choose the time path of $E(t)$ to maximize U subject to Eq. (2). This results in the following Euler equation:

$$\gamma_E(t) = (1/\theta)(r(t)/p_1(t) - \delta - \rho), \tag{4}$$

where $\gamma_{subscript}$ denotes the growth rate of the subscript (e.g., $\gamma_E(t) \equiv \dot{E}(t)/E(t)$), and the transversality condition $0 = \lim_{t\to\infty} \exp(-\int_0^t (r(s)/p_1(s) - \delta)ds)K(t)$. Note that the rate of return to capital is $r/p_1 - \delta$; an additional unit of capital yields rental r, which buys r/p_1 units of the capital good for investment. Since δ units of the capital good must replace the depreciated capital, only $r/p_1 - \delta$ units of it add to the capital stock. Assume that the growth rate of E is positive, but not so high as to yield unbounded utility: $\gamma_E(t) > 0$, $\rho > (1-\theta)\gamma_E(t) \forall t$.

2.3 Patterns of specialization

The production structure in this model is similar to that in the Ricardian model. Given producer prices, suppose that $p_1 A_1 > p_2 A_2$; that is, the value of the marginal product of capital is higher in sector 1 than in sector 2. Then, households lend all of their capital to firms in sector 1, with the rental rate given by $r = p_1 A_1$. As a result, the economy specializes completely in good 1.

By the same logic, if $p_1 A_1 < p_2 A_2$, then the economy specializes completely in good 2 with $r = p_2 A_2$.

Suppose that domestic prices are such that the economy should specialize in good 1, the capital good. The tariff is then imposed on good 2, the consumption good. Since the tariff and the consumption tax on good 2 have the same tax base (i.e., consumption) because of specialization, lowering the tariff and raising the consumption tax, with government revenue unchanged, implies offsetting tariff and tax changes, and has no effect on resource allocation.[3]

2.4 The case of specialization in the consumption good

Let p_j^* denote the world price of good j, and let us normalize p_1^* to unity. Suppose that $A_1 < p_2^* A_2$; that is, the economy specializes in good 2, the consumption good, in free trade. Then, the government imposes the tariff on the import of good 1, the capital good. Let $\tau_1(\geq 0)$, $t_1(\geq 0)$, and $t_2(\geq 0)$ denote the permanent specific tariff rate on good 1, the consumption tax rate on good 1, and the consumption tax rate on good 2, respectively. The domestic prices are given by $p_1 = 1 + \tau_1$, $p_2 = p_2^*$, $q_1 = 1 + \tau_1 + t_1$, and $q_2 = p_2^* + t_2$. Assume that τ_1 always satisfies $(1+\tau_1)A_1 < p_2^* A_2$ so that the pattern of specialization should be unchanged. Assuming a balanced budget in each period, the government budget constraint is:

[3] If we add a labor-leisure choice as per Osang and Turnovsky (2000), then independent changes in the tariff and the consumption tax on good 2 could affect the growth rate. However, as long as the tariff and the consumption tax cover the same tax base, their revenue-neutral changes still have no growth effect.

$$T = \tau_1(C_1 + \dot{K} + \delta K) + t_1 C_1 + t_2 C_2. \tag{5}$$

From Eqs. (1), (2), (5), and the capital market clearing condition $K_2 = K$, we obtain the trade balance; that is, the value of imports matches the value of exports at world prices:

$$C_1 + \dot{K} + \delta K + p_2^* C_2 = p_2^* Y_2. \tag{6}$$

We now examine the dynamics of the economy. From Eq. (6), the evolution of K is governed by $\dot{K}(t) = p_2^* Y_2(t) - \delta K(t) - C_1(t) - p_2^* C_2(t) = (p_2^* A_2 - \delta)K(t) - [(c + p_2^*)/(q_1 c + q_2)]E(t)$. This equation and the Euler equation (4), together with the initial condition and the transversality condition, constitute the dynamic system. This system can be combined into the following single linear differential equation with respect to $\kappa \equiv K/E : \dot{\kappa} = (p_2^* A_2 - \delta - \gamma_E)\kappa - (c + p_2^*)/(q_1 c + q_2)$. Note that $p_2^* A_2 - \delta - \gamma_E \geq p_2^* A_2/(1+\tau_1) - \delta - \gamma_E > 0$, where the last inequality is equivalent to the condition for bounded utility: $\rho > (1-\theta)\gamma_E$. Let κ^* be the steady-state value of κ such that $\dot{\kappa} = 0$. Because of linearity, κ^* is unique. Since the dynamics of κ are unstable, κ must jump to κ^* in the initial period and stay there forever in order for the economy to grow at a positive rate and to satisfy the transversality condition. Therefore, K grows at the same constant rate as E :

$$\gamma_E = \gamma_K = (1/\theta)[p_2^* A_2/(1+\tau_1) - \delta - \rho] \equiv \gamma(\tau_1). \tag{7}$$

We know from Eq. (7) that the growth rate rises as the tariff rate on the capital good falls: $\gamma'(\tau_1) = (1/\theta)[-p_2^* A_2/(1+\tau_1)^2] < 0$. The essential reason for the negative relationship between the tariff rate and the growth rate is that the economy imports the capital good from abroad. An additional unit of capital yields A_2 units of the consumption good, which are exchanged for $p_2^* A_2$ units of the capital good in the world market. However, this can buy only $p_2^* A_2/(1+\tau_1)$ units of the capital good for investment, since the government raises its domestic import price to $p_1 = 1 + \tau_1$.

Substituting Eq. (7) back into Eq. (6) and rearranging the terms, we have:

$$C_1 + p_2^* C_2 = (p_2^* A_2 - \delta - \gamma)K. \tag{8}$$

From Eq. (8) and the relative demand function (3), C_2, C_1, and C are solved as $C_2 = [1/(c+p_2^*)](p_2^* A_2 - \delta - \gamma)K$, $C_1 = [c/(c+p_2^*)](p_2^* A_2 - \delta - \gamma)K$, and

$$C = C_2 V(c,1) = [V(c,1)/(c+p_2^*)](p_2^* A_2 - \delta - \gamma)K. \tag{9}$$

Substituting Eq. (7) back into Eq. (5), we have $T = \tau_1(C_1 + \gamma K + \delta K) + t_1 C_1 + t_2 C_2$. Since we know from the above expressions that C_1 and C_2 are also linear in K, T also grows at the same rate as E and $K : T(t) = T(0)\exp(\gamma t)$. Integrating the flow budget constraint (2) with respect to t, and imposing the transversality condition, we obtain the intertemporal budget constraint: $(1+\tau_1)K(0) + G = \int_0^\infty E(t)\exp(-[p_2^* A_2/(1+\tau_1) - \delta]t)dt$, where $G \equiv \int_0^\infty T(t)\exp(-[p_2^* A_2/(1+\tau_1) - \delta]t)dt$ is the present value of government revenue, our criterion for revenue changes.[4] Using $T(t) = T(0)\exp(\gamma t)$ and remembering that $p_2^* A_2/(1+\tau_1) - \delta > \gamma$, G is rewritten as:

$$G = T(0)/[p_2^* A_2/(1+\tau_1) - \delta - \gamma] = T(0)/[\rho - (1-\theta)\gamma], \tag{10}$$

where we use the fact that $p_2^* A_2/(1+\tau_1) - \delta - \gamma = \rho - (1-\theta)\gamma$.

Since we have shown that C is also linear in K, we have $C(t) = C(0)\exp(\gamma t)$. Substituting this into the utility function, integrating it with respect to t, and remembering the condition for bounded utility, we obtain:

$$U = [1/(1-\theta)]\{C(0)^{1-\theta}/[\rho - (1-\theta)\gamma] - 1/\rho\} : \theta \neq 1; \tag{11}$$

$$U = (1/\rho)(\ln C(0) + \gamma/\rho) : \theta = 1.$$

3 Revenue-neutral tariff and tax reform

3.1 Analytical results

To consider the effect of substituting the consumption tax for the import tariff on the capital good, we change τ_1 and t_1, but not t_2. Our tariff and tax reform has three main effects: the growth effect, the income effect, and the substitution effect. For the growth effect, a reduction in the tariff on the capital good raises the growth rate of government revenue and the consumption index (cf. Eq. (7)), and thus affects the present value of government revenue and welfare. The income effect is a consequence of the growth effect. A rise in the growth rate decreases the income for consumption (cf. Eq. (8)), and hence, decreases consumption of both goods. For the substitution effect, a change in the consumer price of the capital good affects relative demand (cf. Eq. (3)), which alters consumption of the two goods in opposite directions. Consumption changes in the initial period caused by the income and the substitution effects influence the present value of government revenue and welfare. Since the growth and the income effects depend on τ_1, whereas the substitution effect depends on $\tau_1 + t_1$, we can rewrite Eqs. (10) and (11) as functions of τ_1 and $\tau_1 + t_1$:

$$G = G(\tau_1, \tau_1 + t_1), \tag{12}$$

$$U = U(\tau_1, \tau_1 + t_1). \tag{13}$$

[4] In their analysis of revenue-neutral tariff reform in a dynamic model, Osang and Pereira (1996) claimed that revenue neutrality in the present-value sense is more appropriate than revenue neutrality in each period. They also assumed a balanced budget in each period similar to our Eq. (5).

We examine the properties of $G(\tau_1, \tau_1 + t_1)$ and $U(\tau_1, \tau_1 + t_1)$ in turn.

Proposition 1 *The present value of government revenue G depends on the tariff on good 1 τ_1 and the consumption tax on good 1 t_1 in the following way.*[5]

1. *Holding $\tau_1 + t_1$ fixed, G is increasing in τ_1, if the elasticity of intertemporal substitution is smaller than or equal to unity, and if τ_1 is sufficiently small at the pre-reform equilibrium.*
2. *Holding τ_1 fixed, G is increasing in $\tau_1 + t_1$, if either of the following holds:*
   - *(a) consumption of good 1 is distorted less than good 2 at the pre-reform equilibrium;*
   - *(b) consumption of good 1 is distorted more than good 2, and the elasticity of intratemporal substitution is sufficiently small, at the pre-reform equilibrium.*

The first statement in Proposition 1 implies that consumer-price-neutral tariff and tax reform (i.e., $d\tau_1 < 0$, $dt_1 = -d\tau_1 > 0$) normally decreases the present value of government revenue. Consumer-price-neutral tariff and tax reform affects the present value of government revenue through three channels. First, in view of Eq. (10), the growth effect works negatively on G if $\theta > 1$, that is, the elasticity of intertemporal substitution is smaller than unity. Second, the income effect also decreases G by reducing the initial government revenue from consumption. Third, the reform directly decreases the initial tariff revenue from the import of the capital good used for investment, but indirectly increases the revenue through an increase in investment. If the direct effect outweighs the indirect effect, which is the case when the pre-reform tariff rate is not so high, then G decreases because the tax base shrinks during the reform.

The second statement in Proposition 1 simply means that a rise in the consumption tax rate normally increases the present value of government revenue. The tax increase directly increases initial government revenue from consumption, but indirectly affects that revenue through the substitution of good 2 for good 1. When the direct and the indirect effects work in opposite directions, we must impose an upper bound on the elasticity of intratemporal substitution in consumption to have the normal property. Proposition 1 implies that the government normally has to raise the consumption tax by more than the rate of the fall in the tariff in order to keep the present value of government revenue unchanged.

It can be verified that the sufficient conditions for the normal shape of $G(\tau_1, \tau_1 + t_1)$ are likely to be satisfied for plausible parameter values. Moreover, even if all of the sufficient conditions are not satisfied, it is possible that the normal properties hold. Indeed, the normal case applies in most of our numerical experiments in section 3.2. From now on, we focus on the normal case.[6]

The properties of $U(\tau_1, \tau_1 + t_1)$ are clearer than those of $G(\tau_1, \tau_1 + t_1)$.

Proposition 2 *Welfare U depends on the tariff on good 1 τ_1 and the consumption tax on good 1 t_1 in the following way.*[7]

[5] The proof is available on the author's website <http://www.soc.titech.ac.jp/˜naito/>.

[6] The other less usual cases are briefly discussed on the author's website <http://www.soc.titech.ac.jp/˜naito/>.

[7] The proof is available on the author's website <http://www.soc.titech.ac.jp/˜naito/>.

1. *Holding $\tau_1 + t_1$ fixed, U is decreasing in τ_1 if and only if τ_1 is positive at the pre-reform equilibrium. A change in τ_1 has no effect on U if and only if the pre-reform τ_1 is zero.*

2. *Holding τ_1 fixed, U is decreasing in $\tau_1 + t_1$ if and only if consumption of good 1 is distorted more than good 2 at the pre-reform equilibrium, or U is increasing in $\tau_1 + t_1$ if and only if consumption of good 1 is distorted less than good 2 at the pre-reform equilibrium. A change in $\tau_1 + t_1$ has no effect on U if and only if the pre-reform tariff and tax structure is nondistortionary.*

The first statement in Proposition 2 implies that consumer-price-neutral tariff and tax reform unambiguously raises welfare. The reform raises welfare by increasing future consumption, but it lowers welfare by decreasing present consumption. It can be shown that the former always outweighs the latter as long as the pre-reform tariff rate is positive. The second statement in Proposition 2 means that a change in the consumer price of good 1 lowers welfare if the price change enlarges the consumption distortion.

Having obtained the forms of $G(\tau_1, \tau_1+t_1)$ and $U(\tau_1, \tau_1+t_1)$, we can graphically examine the optimal tariff and tax structure under the revenue neutrality constraint in the (τ_1, τ_1+t_1)-plane. In Fig. 1, only the region above the 45° line is feasible, since we do not allow for negative tariff and taxes. The horizontal broken line with a height of t_2/p_2^* represents the set of the uniform, nondistortionary tariff and tax structure, because $(1 + \tau_1 + t_1)/(p_2^* + t_2) = 1/p_2^*$ along this line. Let point A denote the pre-reform tariff and tax structure. In the normal case described in Proposition 1, the revenue neutrality constraint is drawn as the downward-sloping curve GG′ passing through point A. The inverted C-shaped curves represent indifference curves. From Proposition 2, they are downward sloping above the horizontal broken line, upward sloping below the horizontal broken line, vertical on the horizontal broken line, and horizontal on the vertical axis. In the region above the horizontal broken line, welfare rises as one moves down and to the left. Conversely, in the region below the horizontal broken line, welfare rises as one moves up and to the left. Consumer-price-neutral tariff and tax reform is expressed as a horizontal leftward shift. It unambiguously raises welfare, but fails to keep government revenue from falling.

We first identify the first-best optimum without the revenue neutrality constraint as a reference point. This optimum is at point F: $(0, t_2/p_2^*)$, where the growth rate is maximized and the consumption distortion is eliminated. The most remarkable feature of the first-best optimum is that free trade is optimal for a small open economy even in a dynamic framework.

In fact, the government must seek the optimal tariff and tax structure subject to the revenue neutrality constraint GG′. At point A, the indifference curve is steeper than curve GG′. In this case, the government can raise welfare by lowering τ_1 and raising τ_1+t_1 along the constraint. The second-best optimum is attained at point B, where the indifference curve is tangent to the revenue neutrality constraint.[8] The optimal tariff and tax structure is characterized in the following proposition.

Proposition 3 *Suppose that, as defined in Eqs. (12) and (13), the present value of government revenue G*

[8]The second-order condition is that $d^2(\tau_1 + t_1)/d\tau_1^2|_{dU=0} < d^2(\tau_1 + t_1)/d\tau_1^2|_{dG=0}$.

and welfare U are given by $G(\tau_1, \tau_1 + t_1)$ and $U(\tau_1, \tau_1 + t_1)$, where τ_1 and t_1 are the tariff on good 1 and the consumption tax on good 1, respectively. In the normal case that $\partial G/\partial \tau_1 > 0$ and $\partial G/\partial(\tau_1 + t_1) > 0$, if the revenue-constrained optimal tariff and tax structure exists at an interior point above the 45° line in the $(\tau_1, \tau_1 + t_1)$-plane, then it must satisfy the following features.

1. *The indifference curve is tangent to the revenue neutrality constraint.*

2. *Consumption of good 1 is distorted more than good 2.*

Interestingly, the optimal tariff and tax structure under the revenue neutrality constraint distorts consumption of good 1 relative to good 2. This is because, at the optimum, the marginal benefit of trade liberalization through more consumption in the future is equal to its marginal cost through more consumption distortion. A fall in τ_1 raises welfare because the growth effect outweighs the income effect. On the other hand, to keep G unchanged, the government has to raise $\tau_1 + t_1$, which in turn changes welfare through the substitution effect. The latter welfare change can be negative, implying a welfare cost of trade liberalization, if and only if $\tau_1 + t_1 > t_2/p_2^*$, that is, consumption of good 1 is distorted more than good 2. At the optimum, the sum of the two welfare changes should be zero.

Another remarkable characteristic of the second-best optimum, compared with the first-best one, is that the corner solution with free trade is impossible.

Proposition 4 *The revenue-constrained optimal tariff rate is positive.*

Suppose that the government implements tariff and tax reform from point A to the northwest along curve GG′ in Fig. 1. As the tariff and tax structure approaches point G on the vertical axis, the marginal benefit of trade liberalization approaches zero, because the negative income effect cancels out the positive growth effect (cf. Proposition 2). Therefore, it is optimal for the government not to liberalize trade completely.

The difference between the second-best and the first-best results is attributable to the existence of the revenue neutrality constraint. Without the revenue neutrality constraint, the government can now choose t_1 independently of τ_1. This implies that the economy need not bear a welfare cost, or even benefit, from the substitution effect. Thus, free trade is optimal in the first-best situation. On the contrary, the government subject to the revenue neutrality constraint has to raise $\tau_1 + t_1$ along with trade liberalization, which necessarily incurs a welfare cost through more consumption distortion. Hence, free trade is not optimal even for a small open economy with no market failure.

3.2 Numerical results

To verify our analytical results and to quantify the optimal tariff and tax structure under the revenue neutrality constraint, we conduct numerical experiments for several sets of parameters. Suppose that the consumption index function has the CES form: $C = V(C_1, C_2) = [bC_1^{(\sigma_c-1)/\sigma_c} + (1-b)C_2^{(\sigma_c-1)/\sigma_c}]^{\sigma_c/(\sigma_c-1)}$ for $\sigma_c \neq 1$; and $C = V(C_1, C_2) = C_1^b C_2^{1-b}$ for $\sigma_c = 1$.

The benchmark parameter values are chosen as follows. We use $\rho = 0.02$ and $\delta = 0.05$ following Barro and Sala-i-Martin (1995). In line with Jones et al. (1993) and Gómez (2003), we set $\theta = 2$. Since the empirical values of b and σ_c vary depending on goods classification, we choose $b = 0.5$ and $\sigma_c = 1$ as a theoretical benchmark. The initial capital stock is arbitrarily set to $K(0) = 10$ in order to obtain positive values for welfare. We use $A_1 = 0.1$, $A_2 = 0.2$, and $p_2^* = 1$. With these values, the relative producer price of the capital good to the consumption good becomes $p_1/p_2 = A_2/A_1 = 2$ in autarky, which is higher than $1/p_2^* = 1$ in free trade. Then the economy imports the capital good, with the domestic relative producer price $(1 + \tau_1)/p_2^*$ lying between those of free-trade and autarky. This is in accordance with the stylized fact reported by De Long and Summers (1991) and Eaton and Kortum (2001) that the relative price of capital goods to consumption goods is higher in developing countries importing capital goods than in developed countries exporting them. Finally, calculating the mean values for developing countries from the World Bank (2002) data, we set $\tau_1 = 0.15$ and $t_1 = t_2 = 0.1$ as the pre-reform tariff and consumption taxes.

The results of our simulations are summarized in Table 1 and Table 2. Table 1 displays the relationship between σ_c and the optimal tariff and tax structure, whereas Table 2 reports the optimal tariff and tax structure for different values of θ.[9] On the whole, we find three properties. First, in all of our experiments, we have $\partial G/\partial\tau_1 > 0$ and $\partial G/\partial(\tau_1+t_1) > 0$ between the pre-reform point and the optimal point.[10] Second, in all cases, the optimal tariff and tax structure exists uniquely in an interior point and satisfies $\tau_1 + t_1 > t_2/p_2^*$. For example, in the benchmark case that $\theta = 2$ and $\sigma_c = 1$, we obtain $\tau_1 = 0.098$ and $\tau_1+t_1 = 0.445527(> 0.1)$ at the optimum. Third, in six out of seven cases, lowering τ_1 and raising $\tau_1 + t_1$ from the pre-reform tariff and tax structure raises both the growth rate and welfare. This is in line with Osang and Turnovsky (2000, Table 5B), who showed numerically that lowering a tariff on a purely imported investment good and raising a tariff on a purely imported consumption good in a revenue-neutral way causes similar growth and welfare effects.

From Table 1, we see that the larger is σ_c, the higher is the optimal tariff. This is because σ_c, the elasticity of intratemporal substitution, determines the magnitude of the marginal cost of trade liberalization. If σ_c is large, then a rise in $\tau_1 + t_1$ caused by a fall in τ_1 induces more consumption substitution, which damages welfare severely. When $\sigma_c = 3$, the marginal cost of trade liberalization is so high that the optimal tariff is even higher than the pre-reform one.

Table 2 suggests that the optimal tariff falls as θ falls. This is because $1/\theta$, the elasticity of intertemporal substitution, governs the magnitude of the marginal benefit of trade liberalization. If $1/\theta$ is large, then a fall in τ_1 significantly raises the growth rate, and hence, welfare. However, as θ decreases and approaches unity from above, the optimal $\tau_1 + t_1$ is about 172%, which is impractical. The optimal tariff and tax structure can take realistic values only when θ is well above unity, which accords with the empirical evidence (e.g., Hall, 1988; Ogaki and Reinhart, 1998; Hahm, 1998).

[9] For $\theta = 0.5$, we change ρ to 0.08 so as to satisfy the condition for bounded utility.

[10] Only in the case where $\sigma_c = 1$ and $\theta = 0.5$, has the revenue neutrality constraint an upward-sloping section: $\partial G/\partial\tau_1 < 0$ and $\partial G/\partial(\tau_1 + t_1) > 0$ for $\tau_1 > 0.183$. However, the optimal tariff and tax structure is found outside this range of τ_1.

4 Concluding remarks

Most developing countries import capital goods. In those countries, it is important to consider how to substitute consumption taxes for import tariffs on the capital goods while maintaining government revenue. Our paper makes recommendations to solve this problem. First, the optimal tariff and tax structure under the revenue neutrality constraint must impose some distortion on consumption of the capital goods relative to pure consumption goods. Second, the optimal tariff rate is positive, which forms the limit of trade liberalization. Third, estimating both intratemporal and intertemporal elasticities of substitution is crucial to quantitative assessment of the optimal tariff and tax structure.

To examine the problems of tariff and tax reform analytically, this paper makes some restrictive assumptions. First, the existence of only one type of capital rules out transitional dynamics, which may in reality take a long time when the sizes of tariff and tax changes are large. Second, to focus on intratemporal trade, we assume away international borrowing and lending, which differs from reality. Third, although many developing countries depend heavily on imported capital goods, zero domestic production of the capital goods is unlikely. This paper should be seen as a benchmark case against which more realistic, policy-oriented papers can be compared in the future.

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σ_c	pre-reform G	γ	U	optimal τ_1	$\tau_1 + t_1$	γ	U
3	4.31624	0.0519565	21.4788	0.153	0.237318	0.0517303	21.4808
2	4.37989	0.0519565	21.5353	0.138	0.297108	0.0528735	21.5522
1	4.44459	0.0519565	21.5929	0.098	0.445527	0.0560747	21.7482
0.5	4.47717	0.0519565	21.6218	0.057	0.596459	0.0596074	21.9648

Table 1: The optimal tariff and tax structure under the revenue neutrality constraint for different values of $\sigma_c : \theta = 2, t_2/p_2^* = 0.1, \tau_1 = 0.15, \tau_1 + t_1 = 0.25$.

θ	pre-reform G	γ	U	optimal τ_1	$\tau_1 + t_1$	γ	U
3	3.62158	0.0346377	8.09779	0.115	0.341475	0.0364574	8.13848
2	4.44459	0.0519565	21.5929	0.098	0.445527	0.0560747	21.7482
1	15.4658	0.103913	186.291	0.072	1.71987	0.116567	197.023
0.5^a	8.6615	0.0878261	5.86921	0.015	1.52118	0.134089	16.7588

Table 2: The optimal tariff and tax structure under the revenue neutrality constraint for different values of $\theta : \sigma_c = 1, t_2/p_2^* = 0.1, \tau_1 = 0.15, \tau_1 + t_1 = 0.25$. ^{a} Calculated with $\rho = 0.08$.

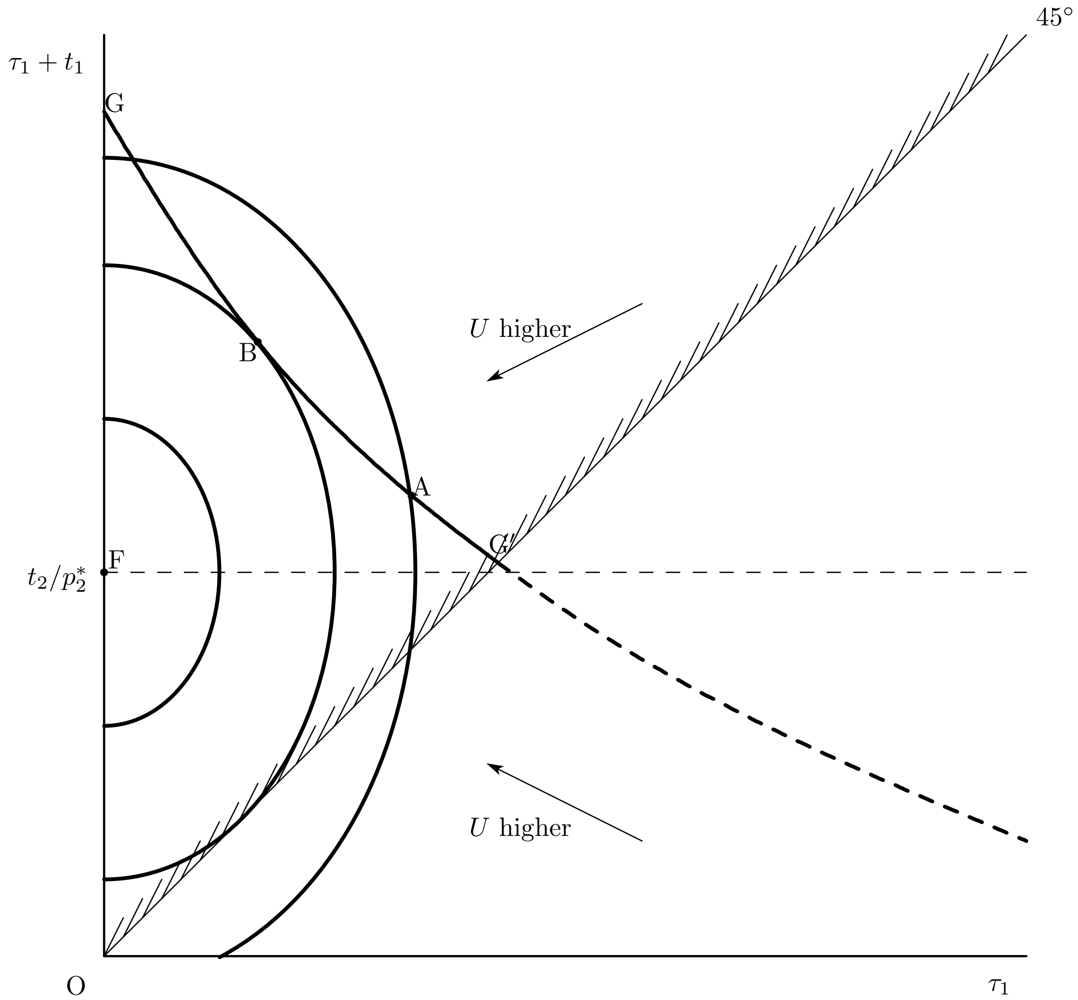

Fig. 1. The optimal tariff and tax structure under the revenue neutrality constraint.