Revenue-neutral tariff reform and growth in a small open economy*

Takumi Naito†
Tokyo Institute of Technology

July 9, 2002

Abstract

Formulating a two-final-good, two-input, small open endogenous growth model, we analyze the growth effect of revenue-neutral tariff reform. We find that the growth effect of tariff reform depends on the pattern of trade and the elasticities of substitution between inputs and between consumption of final goods. When the economy specializes in the capital good, the revenue-neutral substitution of a tariff on the imported final good for a tariff on the foreign intermediate good always raises the growth rate. However, when the economy specializes in the consumption good, the revenue-neutral tariff reform may raise or lower the growth rate.

JEL classification: F43; H20

Keywords: Revenue-neutral tariff reform; Small open endogenous growth model; Elasticity of substitution

†Department of Social Engineering, Tokyo Institute of Technology, 2-12-1 O-okayama, Meguro-ku, Tokyo 152-8552, Japan. Tel.: +81-3-5734-3194; fax: +81-3-5734-3613; e-mail: tnaito@soc.titech.ac.jp.

1 Introduction

To finance a targeted amount of expenditure, the government must collect revenue from various sources. In developing economies, tariffs on imports of final and intermediate goods contribute to a non-negligible part of government revenue. The World Bank (2001) reports that taxes on international trade accounted for about 17% of total current revenue on average in low- and middle-income economies in 1990. On the other hand, the two types of tariffs have different effects on resource allocation. In fact, the two types of tariffs are differentiated. According to the latest cross-country data provided by the World Bank (2001), the absolute value of the difference between the mean tariff rate on manufactured products (roughly representing final goods) and that on primary products (roughly representing intermediate goods) is about 3.8% on average,[1] whereas the mean tariff rate on all products is about 13.4%.

We examine how a tariff structure designed to achieve a fixed amount of revenue affects the growth of a small open economy. Osang and Pereira (1996) constructed a small open endogenous growth model with physical and human capital and a foreign consumption good, a foreign investment good, and a foreign intermediate good (which they called "the technology good") to assist human capital accumulation. Using a numerical method, they showed that the revenue-neutral substitution of a tariff on the investment good for a tariff on the intermediate good *always* raises the growth rate.[2] This result contrasts with the following intuition: revenue-neutral substitution of one tariff for another in total may have an ambiguous effect on the growth rate since both the investment good and the intermediate good are essential for economic growth.[3] To explore such a possibility in as simple a setup as we can, this paper presents an analytically tractable model with general functional forms.

We develop a two-final-good, two-input, small open endogenous growth model. Each of the two final goods, a capital good (e.g. machine) and a consumption good (e.g. food), is produced from domestic capital (e.g. machine installed for production) and a foreign intermediate good (e.g. raw material). Since the price of the foreign intermediate good is given, the economy completely specializes in the sector that offers the higher rental rate of capital. Our model can be seen as a hybrid of Lee (1993, section 3) and Kaneko (2000): In Lee (1993), a single final good is produced from capital and a foreign intermediate good. In Kaneko (2000), a capital good and a consumption good are produced from domestic physical and human capital.[4]

Our main results are summarized as follows. First, when the economy specializes in the capital good, the revenue-neutral substitution of a tariff on the imported final good for a tariff on the foreign intermediate good always raises the growth rate. Second, however, when the economy specializes in the consumption good, the revenue-neutral tariff reform may raise or lower the growth rate, depending on the elasticities of substitution between inputs and between consumption of final goods. Noting that the rate of return to capital is equal to the rental rate, divided by the domestic price of the capital good, less the depreciation rate, these results

[1] This might be an imperfect measure of the difference between the two types of tariffs. Manufactured products include some kinds of intermediate goods, while some types of final goods are categorized as primary products. This measure should be seen as an approximation.

[2] In a model with endogenous labor supply, capital externalities, and international borrowing and lending, Osang and Turnovsky (2000) numerically demonstrated that the revenue-neutral substitution of a tariff on a consumption good for a tariff on an investment good always raises the growth rate.

[3] The actual data also reveals that there is no tendency for the direction of tariff substitution: the World Bank (2001) provides data on mean tariff rates in the latest two available periods in 71 countries or regions. Three countries or regions substitute tariffs on manufactured products for tariffs on primary products, whereas eight countries or regions do the opposite.

[4] Our model differs from Kaneko (2000) in two respects. First, in Kaneko (2000), the reason for complete specialization is that the relative price of the services of physical and human capital is determined by the no-arbitrage condition between them. Second, the engine of sustained growth in Kaneko (2000) is the reproducibility of human capital, while in this paper and in Lee (1993) it is the unlimited availability of the foreign intermediate good.

follow from two sources. First, lowering the tariff rate on the foreign intermediate good raises the rental rate by raising the relative scarcity of capital in the operating sector, whereas raising the tariff rate on the imported final good does not affect the rental rate since the imported sector is not operating. Second, if and only if the economy specializes in the consumption good, raising the tariff rate on the imported final good raises the domestic price of the capital good.

The main difference between the results in this paper and those in the previous literature is due to the more flexible pattern of trade in this paper. In Osang and Pereira (1996), the pattern of trade is fixed by Armington-type consumption and production structures. This paper, in contrast, allows for the variable pattern of trade.

The rest of this paper is organized as follows. Section 2 formulates the model. Section 3 examines the determination of patterns of specialization and prices. Sections 4 and 5 analyze the growth effects of revenue-neutral tariff reform when the economy specializes in the capital good and the consumption good, respectively. Section 6 investigates the welfare effect. Section 7 concludes by discussing policy implications and directions for further research.

2 The model

Consider a small open economy with two final goods, the capital good (called good 1; the numeraire) and the consumption good (good 2). The capital good is invested for capital accumulation[5] or consumed, while the consumption good is only consumed. In sector $j (j = 1, 2)$, firms produce good j from domestically-owned capital[6] and the imported foreign intermediate good under constant returns to scale and perfect competition. Infinitely-lived households lend capital to domestic firms, consume the final goods, and save for accumulating capital under perfect foresight. The absence of international borrowing and lending implies that the rate of return to capital is endogenously determined and that trade is balanced in each period. The government sets the ad-valorem tariff rates on imports of final and intermediate goods permanently and redistributes the tariff revenue to households. The prices of the two final goods and the foreign intermediate good are given and constant in the world market. Because of constant free-trade prices and permanent tariffs, domestic prices are also constant over time.

2.1 Firms

In sector j, the representative firm maximizes its profit, subject to the production function $Y_j = F_j(K_j, M_j)$, where Y_j, K_j, and M_j are output, demand for capital, and demand for the foreign intermediate good, respectively. It is assumed that $F_j(\cdot)$ is increasing, concave, linear homogeneous, and differentiable. Cost minimization implies that

$$\begin{aligned} K_j/M_j &= k_j(r/p_M); k_j'(\cdot) < 0, \\ c_j(r, p_M) &= r a_{Kj}(r, p_M) + p_M a_{Mj}(r, p_M), \end{aligned} \tag{1}$$

[5] We assume away adjustment costs for investment, because its presence will not affect the qualitative relationship between the tariff structure and the growth rate.

[6] We define capital in a broad sense to include human capital. Consequently, trade in the capital good is interpreted not only trade in machines but also trade in higher education. With only one kind of capital, we can focus on steady-state analysis, as seen later.

where k_j, r, p_M, c_j, and a_{ij} are the ratio of capital to foreign intermediate good, the rental rate of capital, the price of the foreign intermediate good, the unit cost of good j, and the unit requirement for input $i(i = K, M)$, respectively. The unit cost function $c_j(\cdot)$ is increasing, concave, linear homogeneous, and differentiable. Given the price of good j, p_j, the first-order condition for profit maximization is

$$p_j \leq c_j(r, p_M), Y_j \geq 0, Y_j(p_j - c_j(r, p_M)) = 0. \tag{2}$$

The third equation in (2) means that the firm always makes zero profit.

2.2 Households

Given the initial capital stock $K(0)$, the representative household maximizes its discounted sum of utility $U = \int_0^\infty \exp(-\rho t) \ln C(t) dt$, where ρ is the subjective discount rate, and the index of instantaneous consumption $C = C(C_1, C_2)$ is assumed to be increasing, concave, linear homogeneous, and differentiable. The budget constraint is

$$\begin{gathered} p_1(t)(\dot{K}(t) + \delta K(t)) = r(t)K(t) + T(t) - E(t), \qquad (3) \\ E = p_1 C_1 + p_2 C_2, \end{gathered}$$

where δ, T, E, and C_j are the depreciation rate, the lump-sum transfer, the value of expenditure, and consumption of good j, respectively, and a dot over a variable represents differentiation with respect to time t. Note that p_1 equals unity in free trade but it does not when a tariff is imposed on good 1. The above problem is broken down into two stages. First, given E, we choose C_1 and C_2 to maximize C subject to $E = p_1 C_1 + p_2 C_2$. Second, making use of the result in the first stage, we choose the time path of $E(t)$ to maximize U subject to Eq. (3). Solving the first stage of the problem, we get

$$C_1/C_2 = d(p_1/p_2); d'(\cdot) < 0, \tag{4}$$

$$\begin{gathered} C_1 = [d(\cdot)/(p_1 d(\cdot) + p_2)]E, C_2 = [1/(p_1 d(\cdot) + p_2)]E, \qquad (5) \\ C = E/e(p_1, p_2), \end{gathered}$$

where d and e are the ratio of consumption of good 1 to good 2 and the amount of expenditure for obtaining a unit of the consumption index, respectively. The unit expenditure function $e(\cdot)$ is increasing, concave, linear homogeneous, and differentiable. Substituting the last expression for C into the utility function, we set up the present-value Hamiltonian:

$$H \equiv \exp(-\rho t)(\ln E - \ln e(p_1, p_2)) + \lambda[(rK + T - E)/p_1 - \delta K],$$

where λ is the value of a unit of the capital good at time t measured in terms of utility at time 0. The first-order conditions for utility maximization are

$$\exp(-\rho t)(1/E) - \lambda/p_1 = 0, \tag{6}$$

$$\lambda(r/p_1 - \delta) = -\dot{\lambda}, \tag{7}$$

$$\lim_{t\to\infty} \lambda(t)K(t) = 0. \tag{8}$$

From Eqs. (6) and (7), we get the Euler equation:

$$\dot{E}(t)/E(t) = r(t)/p_1(t) - \delta - \rho. \tag{9}$$

Assume that δ and ρ are sufficiently small that $r(t)/p_1(t) > \delta + \rho \forall t$.

2.3 Equilibrium

The capital market clears if

$$K_1 + K_2 = K. \tag{10}$$

From the zero-profit condition (2) and the dynamic budget constraint (3), we obtain

$$p_1(C_1 + \dot{K} + \delta K - Y_1) + p_2(C_2 - Y_2) + r(K_1 + K_2 - K) + p_M(M_1 + M_2) = T. \tag{11}$$

Substituting Eq. (10) and the corresponding government budget constraint into Eq. (11), we obtain the trade balance.

3 Patterns of specialization and prices

Let $p_1^*(\equiv 1), p_2^*$, and p_M^* denote the prices of good 1, good 2, and good M in free trade, respectively. The domestic prices p_1, p_2, and p_M may deviate from the free-trade prices, as specified later. In Fig. 1, curve $c_1(r, p_M) = p_1$ (or $c_2(r, p_M) = p_2$) represents the unit cost of good 1 (or 2) that equals its domestic price. The figure is drawn under the assumption that good 1 is capital-intensive.[7]

If the domestic price of good M is relatively high, say at p_M, then the equilibrium occurs at point A, with r the equilibrium rental rate, and the economy completely specializes in good 1, the K-intensive sector. This is because at that point firms in sector 1 break even with a positive level of production while those in sector 2 shut down since the unit cost at that point exceeds the price. (cf. Eq. (2)) Conversely, if the domestic price of good M is relatively low, then the economy specializes in good 2, the M-intensive sector. To summarize the argument, let $\overline{p}_M$ be the threshold level of p_M at which both final goods are produced given p_1 and p_2.[8] If and only if $p_M > (or <)\overline{p}_M$, the economy specializes in good 1 (or 2).

By similar reasoning, in the case that good 1 is foreign intermediate good-intensive, the economy specializes in good 2 (or 1) if and only if $p_M > (or <)\overline{p}_M$. (To see this, just reverse $c_1(\cdot) = p_1$ and $c_2(\cdot) = p_2$ in Fig. 1.) Hence we arrive at the following proposition.

[7] The absolute value of the slope of the unit cost curve of good j is given by $-dp_M/dr|_{dc_j=0} = (\partial c_j(\cdot)/\partial r)/(\partial c_j(\cdot)/\partial p_M) = a_{Kj}(\cdot)/a_{Mj}(\cdot) = k_j(\cdot)$.
Fig. 1 shows that $k_1(r/p_M) > k_2(r/p_M) \forall r/p_M$.

[8] $\overline{p}_M$ and $\overline{r}$, the threshold level of r, are implicitly defined by $c_1(\overline{r}, \overline{p}_M) = p_1$ and $c_2(\overline{r}, \overline{p}_M) = p_2$.

Proposition 1 *A small open economy completely specializes in the good which intensively uses the relatively cheap input.*

As far as our small open economy is concerned, the input intensity ranking is of little importance to dynamics. From now on, therefore, we focus on the case that good 1 is capital-intensive.

Next, we consider the effect of changes in the domestic prices on the rental rate. Suppose that in Fig. 1 the domestic price of good M falls to p'_M for whatever reason. Then the equilibrium moves to point A′, with the rental rate rising to r'. The economic intuition behind this result is simple. When the domestic price of good M falls, firms buy it more in the world market. Then capital, the supply of which is limited domestically, becomes relatively more scarce. The rise in the rental rate reflects this rise in scarcity.

On the other hand, the change in the price of the imported final good in any direction (e.g. rising to p'_2 in Fig. 1) affects only the specialization threshold, but not the rental rate. This is because input substitution occurs only in the operating sector.

When the domestic price of good M is so low that the economy specializes in good 2, we can easily draw a similar figure to Fig. 1 to obtain the same results. To sum up:

Lemma 2 *As long as the pattern of specialization is preserved,*

1. *a fall in the price of the foreign intermediate good raises the rental rate;*
2. *any change in the price of the imported final good does not affect the rental rate.*

4 Revenue-neutral tariff reform: specialization in the capital good

Suppose that the economy specializes in good 1 in free trade. Then the government can impose tariffs on good 2 and good M. Let $\tau_2(>0)$ and $\tau_M(>0)$ denote the permanent ad-valorem tariff rates on good 2 and good M, respectively. From now on, assume that the imposition of tariffs never changes the patterns of specialization in free trade. The domestic prices are given by $p_1 = 1, p_2 = (1+\tau_2)p_2^*$, and $p_M = (1+\tau_M)p_M^*$. Assuming a balanced budget in each period, the government budget constraint is

$$T = \tau_2 p_2^* C_2 + \tau_M p_M^* M_1. \tag{12}$$

From Eqs. (10), (11), and (12), we obtain the trade balance:

$$C_1 + \dot{K} + \delta K + p_2^* C_2 + p_M^* M_1 = Y_1. \tag{13}$$

Before analyzing revenue-neutral tariff reform, we examine the dynamics of the tariff-ridden economy. Noting from Eqs. (1) and (5) that M_1/K_1 and C_2/E are constant, and that the entire capital is employed in sector 1, Eqs. (3) and (12) imply that

$$\dot{K}(t) = (r + \tau_M p_M^* k_1(\cdot)^{-1} - \delta)K(t) - [1 - \tau_2 p_2^*/(p_1 d(\cdot) + p_2)]E(t).$$

Given $K(0)$, Eqs. (7), (8), (9), and this expression constitute the dynamic system. It is easy to verify that both E and K grow at the same constant rate in any period, implying that the economy is always in the steady state:[9]

[9] This can be verified in the same way as Barro and Sala-i-Martin (1995, pp. 142–143).

$$\dot{E}(t)/E(t) = \dot{K}(t)/K(t) = r - \delta - \rho \equiv \gamma_1, \tag{14}$$

where γ_j is the steady-state growth rate when the economy specializes in good j.

Following Osang and Pereira (1996), we define the *revenue-neutral tariff reform* as changing the tariff rates on the foreign intermediate good and the imported final good with the present value of tariff revenue unchanged. Two things are noted. First, in our model the present value of tariff revenue is unchanged if and only if the tariff revenue in the initial period is unchanged. This is because T grows at the rate $r - \delta - \rho$ and is discounted at the rate $r - \delta$. Even if the growth rate of T, say, rises because of the rise in r as a result of the revenue-neutral tariff reform, it is offset by the rise in the market discount rate. Following on from this fact, we only need to consider revenue neutrality in the initial period.[10] Second, even under revenue neutrality, lowering (or raising) τ_M does not always imply raising (or lowering) τ_2. As the tariff revenue involves endogenous variables, the volumes of imports, we must take account of the general equilibrium feedback effects.

Our calculation of revenue-neutral tariff reform proceeds as follows. First, given $\widehat{\tau}_M \equiv d\tau_M/\tau_M$ and $\widehat{\tau}_2 \equiv d\tau_2/\tau_2$, where a hat over a variable represents the rate of change, we express the rates of change in all endogenous variables as functions of $\widehat{\tau}_M$ and $\widehat{\tau}_2$. Next, we impose the revenue neutrality condition to obtain $\widehat{\tau}_2$ as a function of $\widehat{\tau}_M$.

Let us examine the supply side first. Lemma 2 implies that $\widehat{r}$ is determined by logarithmically differentiating $1 = c_1(r, (1+\tau_M)p_M^*)$:

$$\widehat{r} = -[(1-\theta_1)/\theta_1][\tau_M/(1+\tau_M)]\widehat{\tau}_M, \tag{15}$$

where $\theta_1 \equiv r a_{K1}/c_1$ is the input share of capital in sector 1 (determined at the pre-reform equilibrium). Logarithmically differentiating Eq. (1) and the first-order conditions for cost minimization, we obtain

$$\widehat{a}_{K1} - \widehat{a}_{M1} = -\sigma_1(\widehat{r} - \widehat{p}_M),$$
$$0 = \theta_1\widehat{a}_{K1} + (1-\theta_1)\widehat{a}_{M1},$$

where $\sigma_1 \equiv -k_1' \cdot (r/p_M)/k_1 (> 0)$ is the elasticity of substitution between inputs in sector 1 (determined at the pre-reform equilibrium). Solving these for $\widehat{a}_{K1}$ and $\widehat{a}_{M1}$ and substituting Eq. (15) into them, we obtain

$$\widehat{a}_{K1} = [(1-\theta_1)/\theta_1]\sigma_1[\tau_M/(1+\tau_M)]\widehat{\tau}_M,$$
$$\widehat{a}_{M1} = -\sigma_1[\tau_M/(1+\tau_M)]\widehat{\tau}_M.$$

Logarithmically differentiating Eq. (10): $a_{K1}Y_1 = K$ and noting that K is predetermined and thus

[10] The dynamic budget constraint and the transversality condition imply that the present value of expenditure from time 0 to infinity equals the capital stock at time 0 and the present value of tariff revenue $\int_0^\infty T(t)\exp(-(r-\delta)t)dt$. Since the tariff revenue grows at the rate $r-\delta-\rho$, we have $T(t) = T(0)\exp((r-\delta-\rho)t)$. Combining these equations, we get $\int_0^\infty T(t)\exp(-(r-\delta)t)dt = T(0)/\rho$. Note that the logarithmic form of the instantaneous utility function greatly simplifies the analysis: if the elasticity of intertemporal substitution were not unity, then the present value of tariff revenue would depend not only on the initial tariff revenue but also directly on the rental rate, which would make the problem of revenue-neutral tariff reform analytically intractable.

cannot be changed instantaneously in each period, we obtain

$$\widehat{Y}_1 = -\widehat{a}_{K1} = -[(1-\theta_1)/\theta_1]\sigma_1[\tau_M/(1+\tau_M)]\widehat{\tau}_M.$$

$\widehat{M}_1$ is derived by logarithmically differentiating $M_1 = a_{M1}Y_1$:

$$\widehat{M}_1 = \widehat{a}_{M1} + \widehat{Y}_1 = -(\sigma_1/\theta_1)[\tau_M/(1+\tau_M)]\widehat{\tau}_M. \tag{16}$$

Next, we consider the demand side. Substituting $\dot{K}$ from Eq. (14) into Eq. (13), we obtain $C_1 + (r-\rho)K + p_2^* C_2 + p_M^* M_1 = Y_1$. Logarithmically differentiating this, we obtain[11]

$$\begin{aligned} s_1^1\widehat{C}_1 + s_2^1\widehat{C}_2 &= \widehat{Y}_1 - s_M^1\widehat{M}_1 - \theta_1\widehat{r} \\ &= (1-\theta_1)[1-(\sigma_1/\theta_1)\tau_M/(1+\tau_M)][\tau_M/(1+\tau_M)]\widehat{\tau}_M, \end{aligned} \tag{17}$$

where $s_1^1 \equiv C_1/Y_1, s_2^1 \equiv p_2^*C_2/Y_1$, and $s_M^1 \equiv p_M^*M_1/Y_1$ are the shares of consumption of good 1, consumption of good 2, and import of good M in the amount of output, respectively, all evaluated at the free-trade prices, and a superscript "1" means that the economy specializes in good 1. Note that the quantity variables in these shares are determined at the pre-reform equilibrium. Eq. (17) states that the amount of expenditure evaluated at the free-trade prices $C_1 + p_2^*C_2$ positively correlates with τ_M if and only if $1 > (\sigma_1/\theta_1)\tau_M/(1+\tau_M)$, that is, if and only if the change in $\dot{K} + \delta K$ is larger in absolute value than the net change in $Y_1 - p_M^*M_1$. From this and the relative demand (4), $\widehat{C}_1$ and $\widehat{C}_2$ are solved as

$$\begin{aligned} \widehat{C}_2 &= \frac{1-\theta_1}{s_1^1+s_2^1}\left(1-\frac{\sigma_1}{\theta_1}\frac{\tau_M}{1+\tau_M}\right)\frac{\tau_M}{1+\tau_M}\widehat{\tau}_M - \frac{s_1^1}{s_1^1+s_2^1}\sigma_d\frac{\tau_2}{1+\tau_2}\widehat{\tau}_2, \\ \widehat{C}_1 &= \widehat{C}_2 + \sigma_d[\tau_2/(1+\tau_2)]\widehat{\tau}_2, \end{aligned} \tag{18}$$

where $\sigma_d \equiv -d' \cdot (p_1/p_2)/d (> 0)$ is the elasticity of substitution between consumption of final goods (determined at the pre-reform equilibrium).

In the initial period, logarithmically differentiating Eq. (12) and imposing that $\widehat{T}(0) = 0$, we obtain the revenue neutrality condition:

$$0 = (1-\mu_1)(\widehat{\tau}_2 + \widehat{C}_2(0)) + \mu_1(\widehat{\tau}_M + \widehat{M}_1(0)),$$

where $\mu_1 \equiv \tau_M p_M^* M_1(0)/T(0)$ is the share of a tariff on good M in total tariff revenue (determined at the pre-reform equilibrium). Substituting Eqs. (16) and (18) into the revenue neutrality condition, we get

$$\begin{aligned} 0 &= (1-\mu_1)\left(1-\frac{s_1^1}{s_1^1+s_2^1}\sigma_d\frac{\tau_2}{1+\tau_2}\right)\widehat{\tau}_2 \\ &+ (1-\mu_1)\frac{1-\theta_1}{s_1^1+s_2^1}\left(1-\frac{\sigma_1}{\theta_1}\frac{\tau_M}{1+\tau_M}\right)\frac{\tau_M}{1+\tau_M}\widehat{\tau}_M \\ &+ \mu_1\left(1-\frac{\sigma_1}{\theta_1}\frac{\tau_M}{1+\tau_M}\right)\widehat{\tau}_M. \end{aligned} \tag{19}$$

[11] We use $1-\theta_1 = p_M a_{M1}/c_1 = (1+\tau_M)p_M^* a_{M1}/1$ to get $1-\theta_1-s_M^1 = [\tau_M/(1+\tau_M)](1-\theta_1)$.

In the first row in the right-hand side of Eq. (19), the second term in the second parenthesis represents the substitution effect in consumption. The second row shows the income effect in consumption: consumption of good 2 changes since the amount of expenditure evaluated at the free-trade prices changes. (cf. Eq. (17)) The second term in parenthesis in the third row is the substitution effect in inputs. Eq. (19) implies that the direction of revenue-neutral tariff reform depends on the sizes of σ_d and σ_1 in the following way:

1.

$$0 < \sigma_d < [(s_1^1 + s_2^1)/s_1^1](1+\tau_2)/\tau_2, \tag{20}$$

$$0 < \sigma_1 < \theta_1(1+\tau_M)/\tau_M : \tag{21}$$

—$\tau_M \downarrow \rightarrow \tau_2 \uparrow$.

2. $\sigma_d > [(s_1^1 + s_2^1)/s_1^1](1+\tau_2)/\tau_2, 0 < \sigma_1 < \theta_1(1+\tau_M)/\tau_M$: $\tau_M \downarrow \rightarrow \tau_2 \downarrow$.
3. $0 < \sigma_d < [(s_1^1 + s_2^1)/s_1^1](1+\tau_2)/\tau_2, \sigma_1 > \theta_1(1+\tau_M)/\tau_M$: $\tau_M \downarrow \rightarrow \tau_2 \downarrow$.
4. $\sigma_d > [(s_1^1 + s_2^1)/s_1^1](1+\tau_2)/\tau_2, \sigma_1 > \theta_1(1+\tau_M)/\tau_M$: $\tau_M \downarrow \rightarrow \tau_2 \uparrow$.

In case 1 and case 4, τ_M and τ_2 move in opposite directions. In case 2 and case 3, revenue-neutrality implies uniform tariff changes. Case 1 is much more likely than the other three cases for conventional values of the pre-reform tariff rates around 20%. In this case, the two substitution effects are not so strong as to dominate the direct effects of tariff changes on tariff revenue and the amount of expenditure evaluated at the free-trade prices positively correlates with τ_M. We call case 1 the normal case.

Now we are ready to analyze the growth effect of revenue-neutral tariff reform. Note that the term $r - \delta$ in the far right-hand side in Eq. (14) represents the rate of return to capital: it shows how many units of the capital good accrue to the owners of capital when they invest in an additional unit of capital. When the economy specializes in the capital good, an additional unit of capital yields $r = \partial F_1(\cdot)/\partial K_1$ units of the capital good. In this pattern of specialization, the rate of return to capital equals the rental rate less the depreciation rate. Therefore, in all of the four cases, Lemma 2 implies the following proposition.

Proposition 3 *When a small open economy specializes in the capital good, lowering the tariff rate on the foreign intermediate good and changing the tariff rate on the consumption good, with tariff revenue unchanged, raises the growth rate.*

5 Revenue-neutral tariff reform: specialization in the consumption good

5.1 Analytical results

Suppose that the economy specializes in good 2. The domestic prices are then given by $p_1 = 1 + \tau_1, p_2 = p_2^*$, and $p_M = (1+\tau_M)p_M^*$, where $\tau_1(>0)$ is the permanent ad-valorem tariff rate on good 1. The government budget constraint and the trade balance are respectively given by

$$T = \tau_1(C_1 + \dot{K} + \delta K) + \tau_M p_M^* M_2, \tag{22}$$

$$C_1 + \dot{K} + \delta K + p_2^* C_2 + p_M^* M_2 = p_2^* Y_2. \tag{23}$$

In the same way as in section 4, we can verify that

$$\dot{E}(t)/E(t) = \dot{K}(t)/K(t) = r/(1+\tau_1) - \delta - \rho \equiv \gamma_2. \tag{24}$$

The major difference between this section and the previous section is that here the rate of return to capital, the term $r/(1+\tau_1) - \delta$ in the far right-hand side in Eq. (24), depends not only on the rental rate, but also on the tariff rate on good 1. When the economy specializes in the consumption good, an additional unit of capital yields $\partial F_2(\cdot)/\partial K_2$ units of the consumption good, which are exchanged for $r = p_2^* \partial F_2(\cdot)/\partial K_2$ units of the capital good in the world market. However, to get a unit of the capital good, households must pay $1+\tau_1$ units of it, $100 \times \tau_1\%$ of which are collected by the government. Therefore, $r/(1+\tau_1) - \delta$ units of the capital good accrue to households. The difference between Eq. (14) and Eq. (24) is due to whether capital good is produced at home or bought from abroad.[12]

The above point creates one ambiguity in the growth effect of revenue-neutral tariff reform. Suppose that τ_M and τ_1 move in the opposite directions under revenue neutrality. Then we can not immediately tell whether $r/(1+\tau_1)$ rises or falls as a result of lowering τ_M, since r and τ_1 move in the same direction. Hence we must explicitly solve for $\widehat{\tau}_1/\widehat{\tau}_M$ to obtain the sign of $[r/\widehat{(1+\tau_1)}]/\widehat{\tau}_M$.

The rates of change in the supply-side variables are calculated in the same way as in section 4, except that the figure "1" is replaced by "2". The analogous expression to Eq. (17) is

$$\begin{aligned} s_1^2 \widehat{C}_1 + s_2^2 \widehat{C}_2 &= \widehat{Y}_2 - s_M^2 \widehat{M}_2 - \frac{\theta_2}{1+\tau_1}\left(\widehat{r} - \frac{\tau_1}{1+\tau_1}\widehat{\tau}_1\right) \\ &= -(1-\theta_2)\frac{\sigma_2}{\theta_2}\frac{\tau_M}{1+\tau_M}\frac{\tau_M}{1+\tau_M}\widehat{\tau}_M \\ &\quad - \frac{\theta_2}{1+\tau_1}\left(-\frac{1-\theta_2}{\theta_2}\frac{\tau_M}{1+\tau_M}\widehat{\tau}_M - \frac{\tau_1}{1+\tau_1}\widehat{\tau}_1\right), \end{aligned} \tag{25}$$

where $s_1^2 \equiv C_1/(p_2^* Y_2), s_2^2 \equiv p_2^* C_2/(p_2^* Y_2), s_M^2 \equiv p_M^* M_1/(p_2^* Y_2)$. From Eqs. (25) and (4), we obtain

$$\begin{aligned} \widehat{C}_1 &= -\frac{1-\theta_2}{s_1^2+s_2^2}\frac{\sigma_2}{\theta_2}\frac{\tau_M}{1+\tau_M}\frac{\tau_M}{1+\tau_M}\widehat{\tau}_M \\ &\quad + \frac{\theta_2/(1+\tau_1)}{s_1^2+s_2^2}\left(\frac{1-\theta_2}{\theta_2}\frac{\tau_M}{1+\tau_M}\widehat{\tau}_M + \frac{\tau_1}{1+\tau_1}\widehat{\tau}_1\right) \\ &\quad - \frac{s_2^2}{s_1^2+s_2^2}\sigma_d\frac{\tau_1}{1+\tau_1}\widehat{\tau}_1, \\ \widehat{C}_2 &= \widehat{C}_1 + \sigma_d[\tau_1/(1+\tau_1)]\widehat{\tau}_1. \end{aligned} \tag{26}$$

The revenue neutrality condition is

[12]This is a general feature of two-sector models of the type described by Kaneko (2000).

$$0 = (1-\mu_2)\left[\widehat{\tau}_1 + \frac{s_1^2}{1-s_2^2-s_M^2}\widehat{C}_1(0) + \frac{\theta_2/(1+\tau_1)}{1-s_2^2-s_M^2}\left(\widehat{r} - \frac{\tau_1}{1+\tau_1}\widehat{\tau}_1\right)\right]$$
$$+ \mu_2(\widehat{\tau}_M + \widehat{M}_2(0)),$$

where $\mu_2 \equiv \tau_M p_M^* M_2(0)/T(0)$. Substituting Eq. (26) and the analogous expressions to Eqs. (15) and (16) into the revenue neutrality condition, we get

$$\begin{aligned}
0 = {} & (1-\mu_2)\left(1 - \frac{s_1^2}{1-s_2^2-s_M^2}\frac{s_2^2}{s_1^2+s_2^2}\sigma_d\frac{\tau_1}{1+\tau_1}\right)\widehat{\tau}_1 \\
& + (1-\mu_2)\frac{s_1^2}{1-s_2^2-s_M^2}\left[-\frac{1-\theta_2}{s_1^2+s_2^2}\frac{\sigma_2}{\theta_2}\frac{\tau_M}{1+\tau_M}\frac{\tau_M}{1+\tau_M}\widehat{\tau}_M\right. \\
& \left. + \frac{\theta_2/(1+\tau_1)}{s_1^2+s_2^2}\left(\frac{1-\theta_2}{\theta_2}\frac{\tau_M}{1+\tau_M}\widehat{\tau}_M + \frac{\tau_1}{1+\tau_1}\widehat{\tau}_1\right)\right] \\
& - (1-\mu_2)\frac{\theta_2/(1+\tau_1)}{1-s_2^2-s_M^2}\left(\frac{1-\theta_2}{\theta_2}\frac{\tau_M}{1+\tau_M}\widehat{\tau}_M + \frac{\tau_1}{1+\tau_1}\widehat{\tau}_1\right) \\
& + \mu_2\left(1 - \frac{\sigma_2}{\theta_2}\frac{\tau_M}{1+\tau_M}\right)\widehat{\tau}_M. \qquad (27)
\end{aligned}$$

In the right-hand side of Eq. (27), the first and fifth rows are similar to the first and third rows respectively in Eq. (19). The second and third rows represent the income effect in consumption: not only the change in τ_M but also the change in τ_1 affect the amount of expenditure evaluated at the free-trade prices. (cf. Eq. (25)) The fourth row reflects the direct effect of the change in investment on tariff revenue. Multiplying both sides of Eq. (27) by $(1-s_2^2-s_M^2)(s_1^2+s_2^2)(1+\tau_1)\theta_2(1+\tau_M)^2$ and rearranging the terms, we can solve the equation for $\widehat{\tau}_1/\widehat{\tau}_M$:

$$\begin{aligned}
\widehat{\tau}_1/\widehat{\tau}_M &= -\phi_M/\phi_1; \qquad (28) \\
\phi_M &\equiv -(1-\mu_2)(1-\theta_2)\tau_M[s_1^2(1+\tau_1)\sigma_2\tau_M + s_2^2(1+\tau_M)\theta_2] \\
&\quad + (1-s_2^2-s_M^2)(s_1^2+s_2^2)(1+\tau_1)(1+\tau_M)\mu_2 \\
&\quad \times [\theta_2(1+\tau_M) - \sigma_2\tau_M], \\
\phi_1 &\equiv \theta_2(1+\tau_M)^2(1-\mu_2) \\
&\quad \times \{(1-s_2^2-s_M^2)(s_1^2+s_2^2)(1+\tau_1) - s_1^2 s_2^2\sigma_d\tau_1 - s_2^2[\theta_2/(1+\tau_1)]\tau_1\}.
\end{aligned}$$

As in section 4, the direction of revenue-neutral tariff reform depends on σ_d and σ_2 in the following manner:

1.

$$0 < \sigma_d < \overline{\sigma}_d \Leftrightarrow \phi_1 > 0, \tag{29}$$
$$0 < \sigma_2 < \overline{\sigma}_2 \Leftrightarrow \phi_M > 0; \tag{30}$$
$$\overline{\sigma}_d \equiv \frac{1 - s_2^2 - s_M^2}{s_1^2}\frac{s_1^2 + s_2^2}{s_2^2}\frac{1+\tau_1}{\tau_1} - \frac{\theta_2/(1+\tau_1)}{s_1^2},$$
$$\overline{\sigma}_2 \equiv \frac{-(1-\mu_2)(1-\theta_2)\tau_M s_2^2 + (1 - s_2^2 - s_M^2)(s_1^2 + s_2^2)(1+\tau_1)\mu_2(1+\tau_M)}{(1+\tau_1)[(1-\mu_2)(1-\theta_2)s_1^2\tau_M + (1 - s_2^2 - s_M^2)(s_1^2 + s_2^2)(1+\tau_M)\mu_2]} \times \theta_2 \frac{1+\tau_M}{\tau_M} :$$

—$\tau_M \downarrow \rightarrow \tau_1 \uparrow$.

A necessary condition for this case to exist is

$$0 < \overline{\sigma}_d \Leftrightarrow \frac{1}{1+\tau_1}\frac{\tau_1}{1+\tau_1} < \frac{1 - s_2^2 - s_M^2}{\theta_2}\frac{s_1^2 + s_2^2}{s_2^2}, \tag{31}$$
$$0 < \overline{\sigma}_2 \Leftrightarrow \frac{1}{1+\tau_1}\frac{\tau_M}{1+\tau_M} < \frac{1 - s_2^2 - s_M^2}{1-\theta_2}\frac{s_1^2 + s_2^2}{s_2^2}\frac{\mu_2}{1-\mu_2}, \tag{32}$$

which we assume.[13]

2. $\sigma_d > \overline{\sigma}_d (\Leftrightarrow \phi_1 < 0), 0 < \sigma_2 < \overline{\sigma}_2 (\Leftrightarrow \phi_M > 0)$: $\tau_M \downarrow \rightarrow \tau_1 \downarrow$.

3. $0 < \sigma_d < \overline{\sigma}_d (\Leftrightarrow \phi_1 > 0), \sigma_2 > \overline{\sigma}_2 (\Leftrightarrow \phi_M < 0)$: $\tau_M \downarrow \rightarrow \tau_1 \downarrow$.

4. $\sigma_d > \overline{\sigma}_d (\Leftrightarrow \phi_1 < 0), \sigma_2 > \overline{\sigma}_2 (\Leftrightarrow \phi_M < 0)$: $\tau_M \downarrow \rightarrow \tau_1 \uparrow$.

In case 2 and case 3, τ_M and τ_1 move in the same direction under revenue neutrality. Then Eq. (24) and Lemma 2 readily imply that uniform tariff reduction raises the growth rate. In case 1 and case 4, τ_M and τ_1 move in the opposite directions. Noting that $\overline{\sigma}_d$ and $\overline{\sigma}_2$ are similar to the far right-hand sides of Eqs. (20) and (21) respectively, for conventional values of the pre-reform tariff rates around 20%, case 1 is much more likely than the other three cases. From now on, therefore, we focus on case 1, the normal case.[14]

Our final task is to determine the sign of $[r/\widehat{(1+\tau_1)}]/\widehat{\tau}_M = \widehat{r}/\widehat{\tau}_M - [\tau_1/(1+\tau_1)]\widehat{\tau}_1/\widehat{\tau}_M$. From Eq. (28) and the analogous expression to Eq. (15), we get

[13] The violation of either Eq. (31) or Eq. (32) or both would only exclude some of the four cases here, so no further examination would be needed.

[14] Case 4 can be similarly analyzed, except that the sign of ϕ_1 in (33) is opposite that in case 1.

$$\begin{aligned}
&\widehat{r}/\widehat{\tau}_M - [\tau_1/(1+\tau_1)]\widehat{\tau}_1/\widehat{\tau}_M \\
&\quad = -[(1-\theta_2)/\theta_2]\tau_M/(1+\tau_M) + [\tau_1/(1+\tau_1)]\phi_M/\phi_1 \\
&\quad = \psi/[(1+\tau_1)\phi_1]; \qquad (33)\\
&\psi \equiv \psi_0 + \psi_d\sigma_d - \psi_2\sigma_2, \\
&\psi_0 \equiv (1+\tau_1)(1+\tau_M)(1-s_2^2-s_M^2)(s_1^2+s_2^2) \\
&\quad \times [-(1-\mu_2)(1+\tau_1)(1-\theta_2)\tau_M + \tau_1\mu_2\theta_2(1+\tau_M)], \\
&\psi_d \equiv (1+\tau_1)(1+\tau_M)(1-\mu_2)s_1^2 s_2^2 \tau_1(1-\theta_2)\tau_M > 0, \\
&\psi_2 \equiv \tau_1\tau_M(1+\tau_1) \\
&\quad \times [(1-\mu_2)(1-\theta_2)s_1^2\tau_M + (1-s_2^2-s_M^2)(s_1^2+s_2^2)(1+\tau_M)\mu_2] \\
&\quad > 0.
\end{aligned}$$

The second row in Eq. (33) shows that the revenue-neutral substitution of τ_1 for τ_M raises (or lowers) the growth rate if and only if the direct effect of lowering τ_M on r is larger (or smaller) in absolute value than the effect of tariff replacement. The following proposition gives the necessary and sufficient conditions for each result.

Proposition 4 *When a small open economy specializes in the consumption good, suppose that Eqs. (31) and (32) hold and that the pair of elasticities lies in the set* $\Sigma \equiv \{(\sigma_d, \sigma_2) | 0 < \sigma_d < \overline{\sigma}_d, 0 < \sigma_2 < \overline{\sigma}_2\}$. *Then a line* $\psi_0 + \psi_d\sigma_d - \psi_2\sigma_2 = 0$ *always separates* Σ *into two regions:* $\Sigma^- \equiv \{(\sigma_d, \sigma_2) | (\sigma_d, \sigma_2) \in \Sigma \wedge \psi_0 + \psi_d\sigma_d - \psi_2\sigma_2 < 0\}$, *and* $\Sigma^+ \equiv \{(\sigma_d, \sigma_2) | (\sigma_d, \sigma_2) \in \Sigma \wedge \psi_0 + \psi_d\sigma_d - \psi_2\sigma_2 > 0\}$. *If and only if the pair of elasticities lies in* Σ^- *(or* Σ^+*), lowering the tariff rate on the foreign intermediate good and raising the tariff rate on the capital good, with tariff revenue unchanged, raises (or lowers) the growth rate.*

Proof. Fig. 2 illustrates the sign of $\psi = \psi_0 + \psi_d\sigma_d - \psi_2\sigma_2$, so let us first see how this figure is drawn. First of all, the actual values of σ_d and σ_2 are located at point A: (σ_d, σ_2). Its location generally depends on the pre-reform equilibrium prices, and hence, the pre-reform tariff rates. When the consumption index function and the production functions are of the CES form, the location of point A is parametrically given. Next, we calculate $\overline{\sigma}_d, \overline{\sigma}_2, \psi_0, \psi_d$, and ψ_2. They also depend on the pre-reform tariff rates. Moreover, they depend on the actual values of σ_d and σ_2, as the CES examples below suggest. That is, if point A moves, then $\overline{\sigma}_d, \overline{\sigma}_2, \psi_0, \psi_d$, and ψ_2 also change. Fig. 2 is given in the case that the actual values of σ_d and σ_2 are smaller than $\overline{\sigma}_d$ and $\overline{\sigma}_2$ respectively at the pre-reform equilibrium. Finally, having determined ψ_0, ψ_d, and ψ_2 at the pre-reform equilibrium, we construct a reference line $\psi_0 + \psi_d\sigma_d - \psi_2\sigma_2 = 0$. This has the slope $\psi_d/\psi_2 (> 0)$, vertical intercept ψ_0/ψ_2, and horizontal intercept $-\psi_0/\psi_d$. Note that any point (σ_d, σ_2) on this line does not correspond with the actual values of σ_d and σ_2.

We show that if point A lies in Σ, then line $\psi_0 + \psi_d\sigma_d - \psi_2\sigma_2 = 0$ divides Σ into Σ^- and Σ^+. From Fig. 2, this is true if and only if

$$\psi_0/\psi_2 < \overline{\sigma}_2, \qquad (34)$$

$$-\psi_0/\psi_d < \overline{\sigma}_d. \qquad (35)$$

It is easy to verify that Eqs. (34) and (35) are equivalent to Eqs. (31) and (32) respectively, both of which hold by assumption.

If point A lies in Σ^- (or Σ^+), then at the very point $\psi = \psi_0 + \psi_d\sigma_d - \psi_2\sigma_2 < (or >)0$. This and Eq. (33) imply the desired result. ■

Fig. 2 indicates that the revenue-neutral substitution of τ_1 for τ_M is more likely to raise the growth rate, the larger σ_2 is and the smaller σ_d is relative to the reference line: the larger σ_2 is, the more sensitive r is to the reduction in τ_M; and the smaller σ_d is, the less responsive C_1 is to the change in τ_1, so that the government needs to raise τ_1 by a lesser amount to keep tariff revenue unchanged.

5.2 Numerical results

To confirm that the growth effect of revenue-neutral tariff reform can go either way in the realistic situation, we apply a numerical method. Suppose that the production function in sector j and the consumption index function have the CES form:

$$Y_j = F_j(K_j, M_j) = A_j[\alpha_j K_j^{(\sigma_j-1)/\sigma_j} + (1-\alpha_j)M_j^{(\sigma_j-1)/\sigma_j}]^{\sigma_j/(\sigma_j-1)};$$
$$\alpha_j \in (0,1), \sigma_j > 0,$$
$$C = C(C_1, C_2) = [\beta C_1^{(\sigma_d-1)/\sigma_d} + (1-\beta)C_2^{(\sigma_d-1)/\sigma_d}]^{\sigma_d/(\sigma_d-1)}; \beta \in (0,1), \sigma_d > 0.$$

With the Cobb-Douglas technology (i.e. $\sigma_j \to 1$), α_j equals the input share of capital. Following Lee (1993), we set $\alpha_1 = 5/6$ and $\alpha_2 = 5/7$.[15] The other parameter values are chosen so that the economy should specialize in good 2 and the resulting growth rate should take plausible values: $A_1 = 0.25, A_2 = 0.5, \beta = 0.5, \rho = 0.04, \delta = 0.04, p_2^* = 1, p_M^* = 1$, and $K(0) = 10$.

Let $\tau_M = 0.2$ and $\tau_1 = 0.2$ be the benchmark pre-reform tariff rates. Table 1 displays the numerical result for the benchmark values of elasticities $\sigma_d = 4$ and $\sigma_1 = \sigma_2 = 1.2$. The fact that $\overline{\sigma}_d$ and $\overline{\sigma}_2$ are larger than σ_d and σ_2 respectively implies that τ_M and τ_1 move in the opposite directions. The sign of $\psi/[(1+\tau_1)\phi_1]$ in Eq. (33) is negative, indicating that revenue-neutral substitution of τ_1 for τ_M raises the growth rate. The first to third columns in the lower half of Table 1 report that this is actually true: lowering τ_M to 0.19 with tariff revenue unchanged implies raising τ_1 to 0.202025, which raises γ from 0.075485 to 0.075522.

Table 2 shows the result when only $\sigma_d(= 8)$ is larger than its benchmark value. Although $\overline{\sigma}_d$ also changes, it is still larger than the new value of σ_d. Now the sign of $\psi/[(1+\tau_1)\phi_1]$ becomes positive, implying that revenue-neutral substitution of τ_1 for τ_M lowers the growth rate. The lower half of Table 2 states that lowering τ_M and raising τ_1 with tariff revenue unchanged actually lowers γ, while the reverse operation raises γ. Table 3 reports the result when only $\sigma_1 = \sigma_2(= 0.8)$ are smaller than their benchmark values. In this case also $\psi/[(1+\tau_1)\phi_1]$ becomes positive, and the growth effect of revenue-neutral tariff reform is qualitatively similar to that in Table 2.

In Table 4, where only $\tau_M(= 0.1)$ is lower than its benchmark value, the sign of $\psi/[(1+\tau_1)\phi_1]$ becomes positive. In Table 5, where only $\tau_1(= 0.1)$ is lower than its benchmark value, $\psi/[(1+\tau_1)\phi_1]$ is negative and lower than its benchmark value. The second row in Eq. (33) is useful in interpreting these results. The lower τ_M is, the smaller the first term $-[(1-\theta_2)/\theta_2]\tau_M/(1+\tau_M)$ is in absolute value. This implies that

[15] Using various data sources, Lee (1993) chose 0.4 or 0.2 as the ratio of the foreign intermediate good to GDP. In our model, GDP is given by $p_jY_j - p_M M_j = rK_j$ when the economy specializes in good j. Consequently, the ratio of the foreign intermediate good to GDP is $p_M M_j/(rK_j) = (1-\alpha_j)/\alpha_j$ in the Cobb-Douglas case. Equating this expression to 0.4 or 0.2, and remembering that good 1 is assumed to be capital-intensive, we obtain the values for α_1 and α_2.

the direct growth-enhancing effect of lowering τ_M becomes relatively small, thus raising the possibility that substituting τ_1 for τ_M lowers the growth rate. The lower τ_1 is, on the other hand, the smaller the second term $[\tau_1/(1+\tau_1)]\phi_M/\phi_1$ is. Consequently, the growth-reducing effect of replacing τ_M with τ_1 becomes relatively small, which makes the growth-enhancing effect of substituting τ_1 for τ_M stronger.

Finally, we examine how a rise in the input share of capital in sector 2 affects the growth effect of revenue-neutral tariff reform. Table 6 illustrates the result when α_2 rises from 5/7=20/28 to 3/4=21/28. As expected, $(1-\theta_2)/\theta_2$ is smaller than its benchmark value, since the economy needs less foreign intermediate good for production of good 2. Moreover, ϕ_M/ϕ_1 is also smaller than its benchmark value. This is because a rise in the input share of capital decreases μ_2, the share of a tariff on the foreign intermediate good in total tariff revenue. In view of Eq. (28), this decreases ϕ_M, the coefficient on $\widehat{\tau}_M$, while it increases ϕ_1, the coefficient on $\widehat{\tau}_1$. Therefore, the whole effect is ambiguous. In the present case, comparing Table 6 with Table 1, a decrease in $(1-\theta_2)/\theta_2$ is larger in absolute value than a decrease in ϕ_M/ϕ_1. This causes the first term in the second row in Eq. (33) to be relatively small in absolute value, and hence $\psi/[(1+\tau_1)\phi_1]$ becomes higher than its benchmark value. Although substituting τ_1 for τ_M still raises the growth rate, its effect is weaker than that in the benchmark case.

6 The welfare effect

Noting that $E(t) = E(0)\exp(\gamma t)$ and $C(t) = E(t)/e(p_1,p_2), U = \int_0^\infty \exp(-\rho t)\ln C(t)dt$ is rewritten as $U = (1/\rho)(\ln C(0) + \gamma/\rho)$. This implies that the welfare is increasing in the consumption index in the initial period and in the steady-state growth rate. We thus have to analyze the effect of revenue-neutral tariff reform on $C(0)$ in order to understand the whole welfare effect.

Suppose that the economy specializes in good 1 and that Eqs. (20) and (21) are satisfied. Consequently, lowering τ_M and raising τ_2 with tariff revenue unchanged raises γ. Its effect on $C(0)$ can be analyzed with the help of Fig. 3. Suppose that the government originally sets (τ_M, τ_2). Then the consumption point C is at the intersection of the world price line (with slope $-1/p_2^*$ and horizontal intercept B at which $C_1 = Y_1 - p_M^* M_1 - (r-\rho)K$) and the relative consumption line O$d(1/[(1+\tau_2)p_2^*])$. At point C, the absolute value of the slope of the indifference curve equals that of the budget line $1/[(1+\tau_2)p_2^*]$. Next, suppose that the government lowers τ_M and raises τ_2. In relation to the substitution effect, the rise in τ_2 shifts the relative consumption line in a clockwise manner to O$d(1/[(1+\tau_2')p_2^*])$, inducing households to substitute good 1 for good 2. In relation to the income effect, Eqs. (17) and (21) imply that the fall in τ_M shifts the world price line inward and in a parallel way (B→B′), forcing households to consume less of both goods. The result of these effects is that the consumption point moves to point C′, where the absolute value of the slope of the indifference curve equals $1/[(1+\tau_2')p_2^*]$. Since point C′ lies strictly inside the budget set associated with C, C is strictly directly revealed preferred to C′. Therefore, $C(0)$ falls as a result of growth-enhancing revenue-neutral tariff reform. Since γ rises but $C(0)$ falls, the whole welfare effect is ambiguous.

Table 7 displays the numerical result under parameter values used in subsection 5.2, except that the value of p_2^* is changed to 0.5 so that the economy should specialize in good 1. Revenue-neutral substitution of τ_2 for τ_M raises γ but lowers $C(0)$. The whole welfare effect is positive because the positive growth effect is larger in absolute value than the negative effect on $C(0)$. In this case, growth-enhancing revenue-neutral tariff reform is also welfare-enhancing.

When the economy specializes in good 2, the income effect is more complicated even if Eqs. (29) and (30) hold: the second term in the far right-hand side of Eq. (25) is positive (or negative) if and only if ψ is negative (or positive).

If $\psi < 0$, then lowering τ_M and raising τ_1 with tariff revenue unchanged raises γ. Although the substitution effect works against $C(0)$, the income effect is ambiguous from Eq. (25). Thus we cannot predict the direction of change in $C(0)$. Table 1, Table 5, and Table 6 numerically reveal that revenue-neutral substitution of τ_1 for τ_M also raises $C(0)$. This is because the income effect is positive and outweighs the negative substitution effect. Since both γ and $C(0)$ rise, revenue-neutral substitution of τ_1 for τ_M is both growth- and welfare-enhancing.

If $\psi > 0$, then raising τ_M and lowering τ_1 with tariff revenue unchanged raises γ. In this case, the substitution effect positively affects $C(0)$. However, Eq. (25) implies that raising τ_M decreases the amount of expenditure evaluated at the free-trade prices. The direction of change in $C(0)$ is thus ambiguous. Table 2, Table 3, and Table 4 show that $C(0)$ and even U are lowered by the revenue-neutral substitution of τ_M for τ_1. This result reflects the fact that the negative income effect is stronger than the sum of positive growth and substitution effects. Here we face a trade-off between growth and welfare: growth-enhancing revenue-neutral tariff reform is welfare-reducing, and vice versa.

The results in this section are summarized as follows:[16]

Proposition 5 *Growth-enhancing revenue-neutral tariff reform is not always welfare-enhancing. It is actually welfare-reducing if and only if* $(1/\rho)d\gamma < -(1/C(0))dC(0)$.

7 Concluding remarks

The results obtained in this paper have some policy implications. First, the pattern of trade is crucial in judging the effect of revenue-neutral tariff reform on the growth rate. For example, if a developing economy exports machines, then the revenue-neutral substitution of tariffs on foods for tariffs on raw materials is likely to promote growth. On the other hand, if the economy exports foods, then we cannot immediately tell which tariffs should be substituted for the other to speed up growth. Second, in the case that the economy exports the consumption good, estimating the elasticities of substitution provides a useful guide to the direction of growth-enhancing revenue-neutral tariff reform. If and only if the installed machines and the raw materials are highly elastic in production, and the machines and the foods are not so elastic in consumption, the government should substitute the tariffs on the machines for the tariffs on the raw materials to enhance growth. Otherwise, it should go the other way around. Third, growth-enhancing revenue-neutral tariff reform is not always welfare-enhancing. We have shown that breaking down the welfare effect into growth, substitution, and income effects is useful in understanding the sources of welfare change.

The model in this paper is open to further research. First, to formulate an analytically tractable model, this paper makes some simplifying assumptions: there are no adjustment costs, no labor-leisure trade-offs, no international borrowing and lending, logarithmic utility, and so on. Relaxing these assumptions will make the model more realistic, although numerical methods will be more useful than analytical ones in that case. Second, our model is free from any kind of market failure. If we incorporate externality or public good, then it is interesting to see whether and in what case our policy recommendation will be valid.

[16]This proposition accords with Osang and Pereira (1996, Table 3).

Acknowledgements

I am grateful to Akihiko Kaneko, Ryoji Ohdoi, and two anonymous referees for their helpful comments and suggestions. All remaining errors are mine.

References

[1] Barro, R. J., Sala-i-Martin, X., 1995. Economic Growth. McGraw-Hill, New York.

[2] Kaneko, A., 2000. Terms of trade, economic growth, and trade patterns: a small open-economy case. Journal of International Economics 52, 169–181.

[3] Lee, J.-W., 1993. International trade, distortions, and long-run economic growth. IMF Staff Papers 40, 299–328.

[4] Osang, T., Pereira, A., 1996. Import tariffs and growth in a small open economy. Journal of Public Economics 60, 45–71.

[5] Osang, T., Turnovsky, S. J., 2000. Differential tariffs, growth, and welfare in a small open economy. Journal of Development Economics 62, 315–342.

[6] World Bank, 2001. World Development Indicators 2001. World Bank, Washington, DC.

$\overline{\sigma}_d$	$\overline{\sigma}_2$	$\psi/[(1+\tau_1)\phi_1]$	$(1-\theta_2)/\theta_2$	ϕ_M/ϕ_1
43.13553	4.066647	-0.00503	0.229514	0.199336
τ_M	τ_1	γ	$C(0)$	U
0.19	0.202025	0.075522	0.385173	23.34955
0.2	0.2	0.075485	0.385036	23.31766
0.21	0.19804	0.075443	0.384907	23.2832

Table 1: the growth and welfare effects of revenue-neutral tariff reform with specialization in good 2: $\sigma_d = 4, \sigma_1 = \sigma_2 = 1.2, \tau_M = 0.2, \tau_1 = 0.2$.

$\overline{\sigma}_d$	$\overline{\sigma}_2$	$\psi/[(1+\tau_1)\phi_1]$	$(1-\theta_2)/\theta_2$	ϕ_M/ϕ_1
54.71885	4.066647	0.000628	0.229514	0.233279
τ_M	τ_1	γ	$C(0)$	U
0.19	0.202375	0.075476	0.381105	23.05579
0.2	0.2	0.075485	0.380821	23.04245
0.21	0.19771	0.075486	0.380554	23.02561

Table 2: the growth and welfare effects of revenue-neutral tariff reform with specialization in good 2: $\sigma_d = 8, \sigma_1 = \sigma_2 = 1.2, \tau_M = 0.2, \tau_1 = 0.2$.

$\overline{\sigma}_d$	$\overline{\sigma}_2$	$\psi/[(1+\tau_1)\phi_1]$	$(1-\theta_2)/\theta_2$	ϕ_M/ϕ_1
24.11321	2.813458	0.010515	0.777172	0.840263
τ_M	τ_1	γ	$C(0)$	U
0.19	0.20858	0.010236	0.355474	-19.4602
0.2	0.2	0.010293	0.354813	-19.4711
0.21	0.191766	0.010331	0.354188	-19.4911

Table 3: the growth and welfare effects of revenue-neutral tariff reform with specialization in good 2: $\sigma_d = 4, \sigma_1 = \sigma_2 = 0.8, \tau_M = 0.2, \tau_1 = 0.2$.

$\overline{\sigma}_d$	$\overline{\sigma}_2$	$\psi/[(1+\tau_1)\phi_1]$	$(1-\theta_2)/\theta_2$	ϕ_M/ϕ_1
45.25495	7.42548	0.000685	0.234488	0.132012
τ_M	τ_1	γ	$C(0)$	U
0.09	0.20268	0.078642	0.373193	24.50957
0.1	0.2	0.078655	0.373005	24.50556
0.11	0.1974	0.078663	0.37282	24.49805

Table 4: the growth and welfare effects of revenue-neutral tariff reform with specialization in good 2: $\sigma_d = 4, \sigma_1 = \sigma_2 = 1.2, \tau_M = 0.1, \tau_1 = 0.2$.

$\overline{\sigma}_d$	$\overline{\sigma}_2$	$\psi/[(1+\tau_1)\phi_1]$	$(1-\theta_2)/\theta_2$	ϕ_M/ϕ_1
104.2408	4.436342	-0.00646	0.229514	0.34969
τ_M	τ_1	γ	$C(0)$	U
0.19	0.10178	0.089672	0.319188	27.49548
0.2	0.1	0.08962	0.319064	27.45336
0.21	0.09828	0.089563	0.318952	27.40877

Table 5: the growth and welfare effects of revenue-neutral tariff reform with specialization in good 2: $\sigma_d = 4, \sigma_1 = \sigma_2 = 1.2, \tau_M = 0.2, \tau_1 = 0.1$.

$\overline{\sigma}_d$	$\overline{\sigma}_2$	$\psi/[(1+\tau_1)\phi_1]$	$(1-\theta_2)/\theta_2$	ϕ_M/ϕ_1
47.75634	4.204838	-0.00464	0.189107	0.161243
τ_M	τ_1	γ	$C(0)$	U
0.19	0.20164	0.096342	0.403323	37.5131
0.2	0.2	0.096303	0.403219	37.4826
0.21	0.19841	0.096261	0.403121	37.44986

Table 6: the growth and welfare effects of revenue-neutral tariff reform with specialization in good 2: $\alpha = 3/4; \sigma_d = 4, \sigma_1 = \sigma_2 = 1.2, \tau_M = 0.2, \tau_1 = 0.2$.

τ_M	τ_2	γ	$C(0)$	U
0.19	0.20323	0.05072	0.343048	4.952817
0.2	0.2	0.050618	0.343808	4.944494
0.21	0.19686	0.050517	0.344549	4.93537

Table 7: the growth and welfare effects of revenue-neutral tariff reform with specialization in good 1: $\sigma_d = 4, \sigma_1 = \sigma_2 = 1.2, \tau_M = 0.2, \tau_2 = 0.2$.

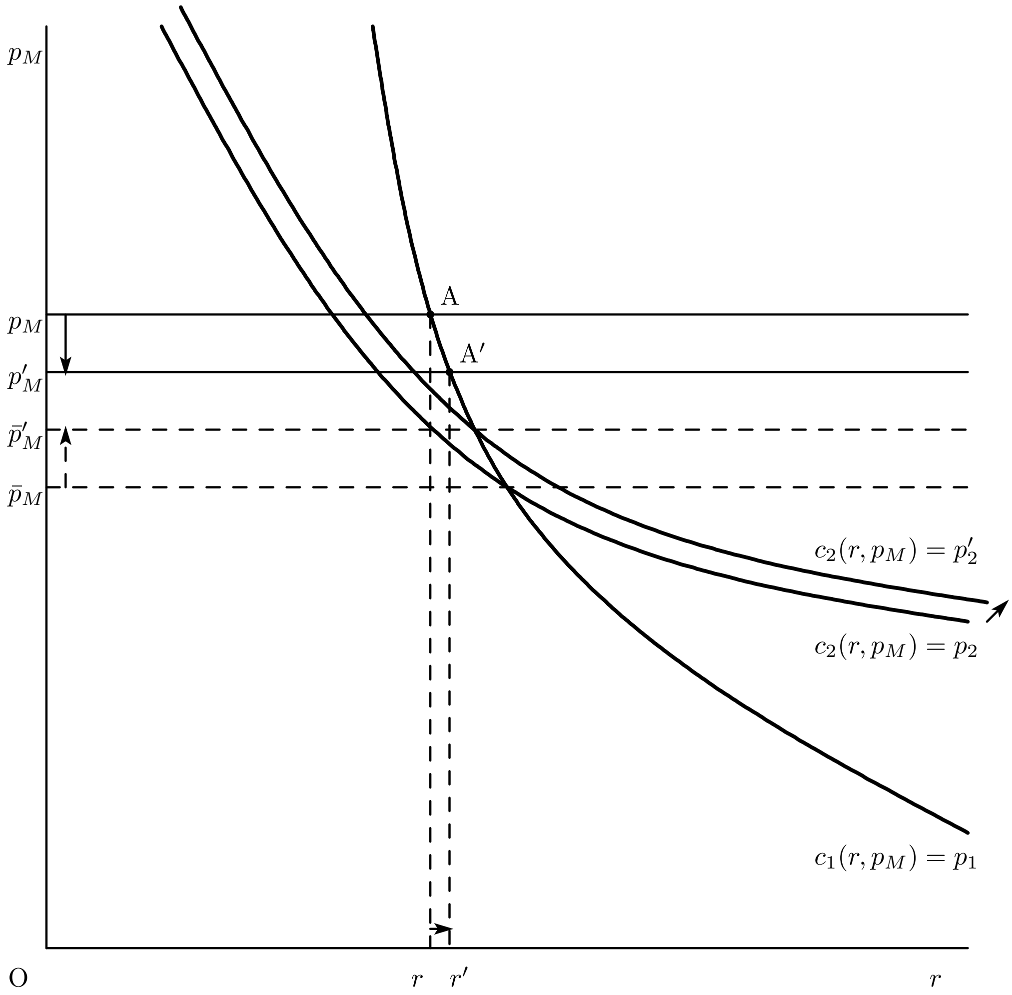

Fig. 1. Patterns of specialization and prices.

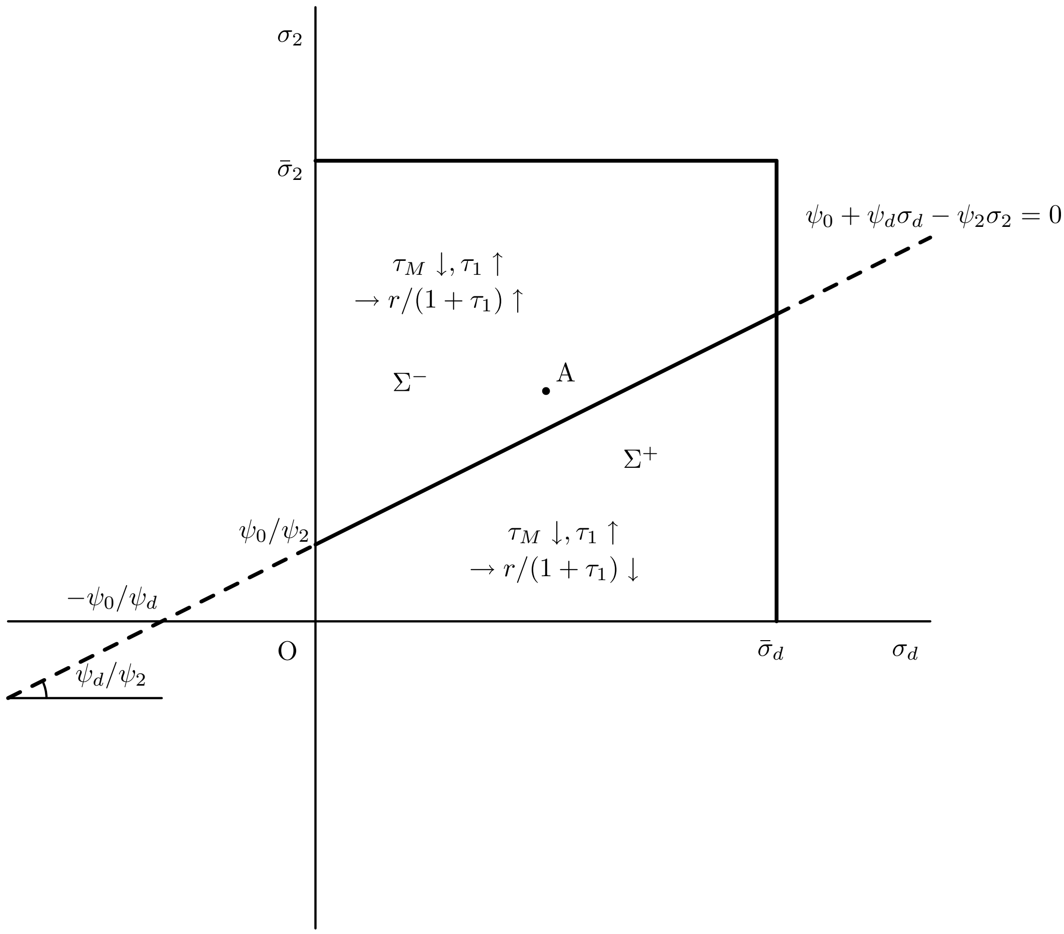

Fig. 2. Elasticities and the growth effect of revenue-neutral tariff reform with specialization in good 2.

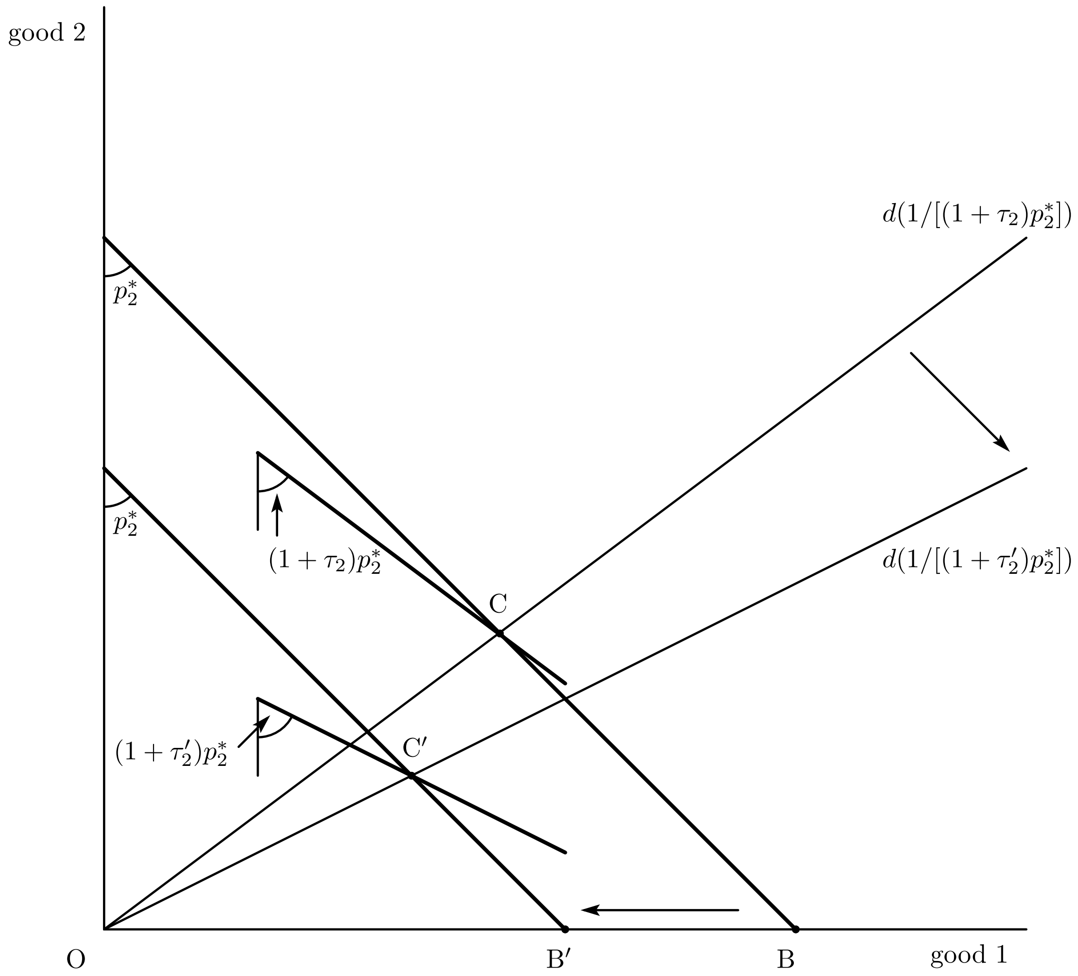

Fig. 3. The effect of lowering τ_M and raising τ_2 on $C(0)$ with specialization in good 1.