Import Tariff in a Two-Country Endogenous Growth Model with International Technology Spillover[+]

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Abstract

We develop a two-country (Home and Foreign) by two-good (consumption good and investment good) by one factor (capital) endogenous growth model with international technology spillover to study the relationship between import tariff and economic growth and welfare. First, we show that there exists a unique balanced growth path (BGP) with both countries being incompletely specialized. Second, unlike the past literature, we don't need to make an assumption such that the growth rates between countries are identical in a BGP. Third, a higher import tariff may boost (reduce) the rate of economic growth when the foreign (domestic) country has absolute advantage in the investment good. Finally, a higher import tariff may also raise welfare under some parameter spaces.

Keywords: two-country endogenous growth model, knowledge spillover, import tariff

JEL Classification: F13, F43, O41.

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1. Introduction

Innumerable articles and volumes have been published to extend the Ramsey-type endogenous growth model, such as Romer (1986) and Lucas (1988), to various directions. However, there are only few contributions that extend these models to a two-country or multi-country economy to reexamine the trade issues and the long-run growth rate jointly in an unified framework. This paper attempts to provide such a framework. We develop a two-country (Home and Foreign) by two-good (consumption good and investment good) by one factor (capital) endogenous growth model with international technology spillover to study the relationship between import tariff and economic growth and welfare.

There are two main results in this model. First, unlike the past literature, we don't need to make an assumption such that the growth rates between countries are identical in the balanced growth path (BGP). The main mechanism behind this is the international technology spillover that furthers the productivity in each country and correlates the long-run growth rates between countries. Following leaning by doing and knowledge spillover in Romer (1986), the international knowledge available to the firms is represented by the other country's total capital stock and firms between countries can access international knowledge at zero cost. When the growth rates between countries are different, it also implies different growth rates of capital between countries and then, through international knowledge spillover, the growth rates between countries will converge to be identical in a BGP.

For the existing literatures, they always assume no international difference in production technology and preference in the spirit of the Heckscher-Ohlin model to yield the identical long-run growth rates between countries. For example, Bond, Trask and Wang (2003) and Doi, Nishimura and Shimomura (2007) make the same assumption. The former develops a two-country by three-good by two-factor endogenous growth model to examine the static and dynamic version of the Heckscher-Ohlin hypothesis and the latter develops a two-country by two-good by two-factor endogenous growth model to discuss what jointly determines the long-run pattern of international trade and the long-run growth rate. Moreover, Farmer and Lahiri (2005) assume perfect international mobility of capital and identical preference to produce the same long-run growth rates in a two-country by two-good by two-factor endogenous growth model with human capital externality.

The second main result is that a higher import tariff may boost (reduce) the rate of economic growth when the foreign (domestic) country has absolute advantage in the investment good. The intuition behind this may be explained as follows. If Home import the consumption good, a higher tariff on this good leads to a higher domestic price of this good and thereby the firms reallocate resources to this sector. Hence, the rise in the supply of the consumption good in the world market lowers the international price of this good and then Foreign's firms reallocate resources to the investment sector. With diminishing marginal product of capital in the investment sector, the first effect results in a higher Home's growth rate and the latter effect results in a lower Foreign's growth rate. It also implies that Home's growth rate of capital (Home's investment) is greater than Foreign's. By international technology spillover, Foreign's firms absorb more knowledge than Home's so that Home's growth rate decreases and Foreign's growth rate increase. Eventually, the growth rates between the two countries will converge to be identical. When Foreign has absolute advantage in the investment good, the Foreign's speed of convergence is greater than Home's and then the new long-run two-country growth rate exceeds the original one. As a result, the growth rate rises as a higher tariff.

This result is consistent with ambiguous relationship between tariff and economic growth in the existing empirical literature. While some papers documented a negative relationship (e.g., Edwards, 1992; Lee, 1993 and Harrison, 1996), some papers found a positive relationship (e.g. O'Rourke, 2000; Irwin, 2002 and Yanikkaya, 2003). Recently, Clemens and Williamson (2004) have confirmed that high tariffs were associated with fast growth before World War II, but with slow growth thereafter. For theoretical papers, this result also echoes with Naito (2006b) in a two-sector endogenous growth model of a small open economy and Grossman and Helpman (1990) and Rivera-Batiz and Romer (1991) in a R&D endogenous growth model, although there are many studies that find a negative relationship (e.g. Jones and Manuelli, 1990; Easterly and Rebelo, 1993; Osang and Pereira, 1996; Ben-David and Loewy, 1998; Naito, 2006a). We also find that a higher tariff may raise welfare under some parameter spaces, which is consistent with the findings of Naito (2006a, 2006b) in a small-open economy.

Finally, for the international technology spillover, a number of literatures have been employed to study empirically the importance though they do not differentiate between private-good knowledge spillover and public-good one. For example, Coe and Helpman (1995) estimate for their sample of 22 industrialized countries the shares for foreign R&D in the total elasticity effect are 60% in the 15 smaller countries and 20% in the G-7 countries. By contrast, Park (1995) in his analysis of aggregate data for ten OECD countries estimates that foreign R&D accounts for about two thirds of the total effect of R&D on productivity. Eaton and Kortum(1999) estimate that the part of productivity growth that is due to foreign R&D is between 74% and 89% in Germany, France, and the U.K.; it is around 65% for Japan, and about 40% for the United States presents results based on data for the G-5 countries around the year 1988. Keller (2002) estimates that between 1983 and 1995, the contribution of technology diffusion from G-5 countries is on average almost 90% of the total R&D effect on productivity in nine other OECD countries.

The structure of the paper is as follows. In section 2, we set up the basic model. In Section 3, we analyze the balanced growth path. In Section 4 and Section 5, we examine the relationship between import tariff and growth and welfare, respectively. Finally, some concluding remarks are made in Section 6.

2. The Basic Model

There are two countries (Home and Foreign) and two goods in each country: a pure consumption good and a pure investment good. There are two sectors to produce each good with capital as the only input. The capital may be thought of as a composite of various types of physical and human capital as outlined in Rebelo (1991). We introduce international technology spillover in this two-country economy, which furthers each country's productivity. The markets are competitive. Firms produce goods and make rental payments for capital input and distribute their profits to the households who own capital and firms. The households use the income to purchase the two goods. We also assume that the numbers of the households and firms are normalized to one, and thus each variable defined below expresses its aggregated value as well. Following the Oniki and Uzawa tradition, we assume that while the two goods are tradable, capital stock is not internationally mobile.

2.1. Firms

There are two sectors to produce each good with capital, k_i, as the only input. Following Romer (1986), the each firm's knowledge creation is a side product of investment, i.e. learning by doing, and the knowledge is a public good that any other firms can access at zero cost, i.e. knowledge spillover. We also assume that the knowledge spills over instantly across different countries.[1] For simplicity, abstracting from domestic knowledge spillover, the technological

[1] Although there is a lot of international technology diffusion whose marginal cost of using is not zero, we only focus on the public-good type for simplicity. The proportion of this kind of international technology spillover required the two-country equilibrium may be arbitrarily small and then this setup is reasonable.

knowledge available to the firm is just represented by the Foreign's total capital stock, k^*.[2] Thus, the production function of good i in the Home country is

$$y_i = a_i k_i^{1-\alpha} k^{*\alpha}, \quad i=1, 2. \tag{1}$$

where i=1 (resp. 2) corresponds to the consumption (resp. investment) good. Parameter a_i is the productivity coefficient in sector i and α measures the productivity of international technology spillover which is identical between the two sectors.

While the two sectors display decreasing returns at the private level, the sector exhibits constant returns at the social level due to an externality that is ignored by infinitesimal firms. An implication of decreasing private returns is positive profits. Unless the number of firms is fixed, we must assume that there is a fixed entry cost to determine the number of firms along the equilibrium paths. As is clear from below, the external effects and the degree of decreasing returns required for the two-country equilibrium may be arbitrarily small, and generate only a small amount of profits and thereby a small fixed cost of entry will be sufficient to deter new entrants. For simplicity, we assume that the profits are distributed back to the households who own these firms. This setup is also in line with Benhabib, et al (2000) and Mino (2001) in two-sector endogenous growth models with sector-specific externalities and Doi, Nishimura and Shimomura (2007) in a two-country by two-good by two-factor endogenous growth model with sector-specific externalities.

The full employment conditions are

$$k = k_1 + k_2, \tag{2}$$

where k is the total capital stock.

Suppose that the government in the Home country imposes an ad-valorem import tariff, denoted as τ, on the consumption goods and then the domestic prices of the pure consumption good become $p(1+\tau)$, where p is the price of consumption good in terms of the investment good. Given p, τ, and the rental rate of capital, r, if the Home country produces both goods simultaneously, the first-order conditions for the representative competitive firm in each sector are

$$(1-\alpha)p(1+\tau)\frac{y_1}{k_1} = r, \tag{3a}$$

[2] If the knowledge spillover is from both domestic firms and foreign firms, the externality can be written by a Cobb-Douglas form, $k^{1-\beta}k^{*\beta}$, where β is the share of international knowledge spillover. In this setting, the main results are the same. Therefore, we just retain the part of international knowledge spillover, k^*.

$$(1-\alpha)\frac{y_2}{k_2}=r, \tag{3b}$$

where r is also the interest rate if we assume that there is no depreciation of capital.

Suppose the Foreign has a similar production structure. Denote the variables with an asterisk as in the Foreign except the productivity of international technology spillover changes to η from α. Thus, the first-order conditions for the Foreign's representative firm are

$$(1-\eta)p\frac{y_1^*}{k_1^*}=r^*, \tag{4a}$$

$$(1-\eta)\frac{y_2^*}{k_2^*}=r^*, \tag{4b}$$

2.2 Households

The representative household earns factor income with $k(0)$ units of capital endowed initially, profit from the two firms and lump-sum transfer from the government. The household's budget constraint is

$$rk+\pi+T=p(1+\tau)c+I, \tag{5}$$

where $\pi=\pi_1+\pi_2=[p(1+\tau)y_1-rk_1]+(y_2-rk_2)$ is the profit from the two firms, T is the lump-sum transfer, c is consumption and I is investment.

The law of motion for capital accumulation is

$$\dot{k}=I. \tag{6}$$

For simplicity, no depreciation in capital is assumed.

Given r, p, τ, T and $k(0)$, the representative agent's problem is to choose c, I, k to maximize the following discounted lifetime utility:

$$U=\int_0^\infty u(c)e^{-\rho t}dt, \tag{7}$$

subject to (5) and (6). Parameter $\rho>0$ is the rate of time preference. Following Ventura (1997), we assume the felicity is logarithmic form

$$u(c)=\ln c. \tag{8}$$

To solve the household's optimization problem, set up the current-value Hamiltonian,

$$H=\ln c+\lambda[rk+\pi+T-p(1+\tau)c],$$

where λ is the co-state variable of capital. Then, the necessary conditions for optimality are

$$\frac{1}{c} = \lambda p(1+\tau), \tag{9a}$$

$$\lambda r = \rho\lambda - \dot{\lambda}, \tag{9b}$$

with the transversality conditions $\lim_{t\to\infty} \lambda k e^{-\rho t} = 0$. While condition (9a) represents marginal benefit is equal to marginal cost for consumption condition, (9b) are Euler equations for capital.

2.3 Government

Suppose that the government in the Home country imposes an ad-valorem import tariff on the consumption goods with the amount of tariff revenue transferring to the households in a lump-sum fashion. Thus, the government budget constraint is

$$T = \tau p(c - y_1). \tag{10}$$

3. Two-country World Market Equilibrium

The world commodity market-clearing condition for the consumption goods is

$$c + c^* = y_1 + y_1^*. \tag{11}$$

Once (11) is satisfied, the world market for the investment goods is automatically cleared.

We are ready to analyze the equilibrium. The equilibrium is a path {y_1, y_2, y_1*, y_2*, c, c*, k, k*, k_1, k_2, k_1*, k_2*, I, I*, r, r*, p, λ, λ*, T} and is determined by (1)-(6), (9)-(11) and the Foreign's counterpart of (1)-(2), (5)-(6) and (9).

3.1. Transformation of the Economic System

In order to analyze the equilibrium, it is necessary to transform the equilibrium conditions with perpetual growth into a system with stationary variables. Denote $n=k^*/k$, $m=pc/k$, $m^*=pc^*/k^*$, $v=k_1/k$ and $v^*=k_1^*/k^*$. In what follows we briefly explain the transformation.

First, dividing (11) by k and utilizing (1),(2) and (3a)-(4b), the world market-clearing condition may be rewritten as

$$m + m^* n = a_2 \left(\frac{n}{1-v}\right)^{\alpha} v + a_2^* \left[\frac{1}{(1-v^*)n}\right]^{\eta} v^* n. \tag{12}$$

Next, (3a)-(3b) and (4a)-(4b) can be solved to yield the relationship between v and v^*.

$$\left(\frac{v}{1-v}\right)^{\alpha}=\frac{(1+\tau)a_1a_2^*}{a_1^*a_2}\left(\frac{v*}{1-v*}\right)^{\eta}. \tag{13}$$

This implies that the Home's fraction of capital allocated to the consumption sector and the Foreign's fraction are positive related with $\frac{\partial v*}{\partial v}=\frac{\alpha v*(1-v*)}{\eta v(1-v)}>0$. If $\alpha=\eta$, then $v>v*$ when Home has comparative advantage in the pure consumption good $[(1+\tau)a_1/a_2>a_1*/a_2*]$ and $v<v*$ when Home has comparative advantage in the pure investment good $[(1+\tau)a_1/a_2<a_1*/a_2*]$.

Differentiating (9a) and using (3b) and (9b) lead to the following growth rate of consumption.

$$\frac{\dot{c}}{c}=(1-\alpha)a_2\left(\frac{n}{1-v}\right)^{\alpha}-\rho-\frac{\dot{p}}{p}. \tag{14a}$$

Based on (5) and using (3a)-(3b) and (10), we get the growth rate of capital

$$\frac{\dot{k}}{k}=a_2\left(\frac{n}{1-v}\right)^{\alpha}\left[1-\frac{\tau v}{1+\tau}\right]-m \tag{14b}$$

Then, the growth rate of m can be derived by (14a) and (14b) as follows.

$$\frac{\dot{m}}{m}=\frac{\dot{p}}{p}+\frac{\dot{c}}{c}-\frac{\dot{k}}{k}=m-a_2\left(\frac{n}{1-v}\right)^{\alpha}\left[\alpha-\frac{\tau v}{1+\tau}\right]-\rho. \tag{15}$$

And the counterpart in the foreign country is

$$\frac{\dot{m}*}{m*}=\frac{\dot{p}}{p}+\frac{\dot{c}*}{c*}-\frac{\dot{k}*}{k*}=m*-\eta a_2^*\left[\frac{1}{(1-v*)n}\right]^{\eta}-\rho*. \tag{16}$$

Finally, with the help of (14b), the growth rate of n is

$$\frac{\dot{n}}{n}=\frac{\dot{k}*}{k*}-\frac{\dot{k}}{k}=a_2^*\left[\frac{1}{(1-v*)n}\right]^{\eta}-a_2\left(\frac{n}{1-v}\right)^{\alpha}\left[1-\frac{\tau v}{1+\tau}\right]+m-m*. \tag{17}$$

Therefore, the dynamics of the system can be described by (12)-(13) and (15)-(17) which determine the equilibrium paths of five variables, m, $m*$, n, v, and $v*$. Other variables are solved by other equations.

3.2. Balanced Growth Path

We now analyze the equilibrium in a steady state. A steady state is a perfect foresight equilibrium with a *balanced growth path* (*BGP*) under which m, $m*$, n, v, and $v*$ are constant, and thus $\dot{n}/n=\dot{m}/m=\dot{m}*/m*=0$. Denote $\tilde{n},\tilde{m},\tilde{m}*,\tilde{v},$ and $\tilde{v}*$ as the values in a BGP. Then, based on (15) and (16), we obtain

$$\tilde{m} = \alpha a_2 \left(\frac{\tilde{n}}{1-\tilde{v}} \right)^{\alpha} \left[\alpha - \frac{\tau v}{1+\tau} \right] + \rho, \tag{18a}$$

$$\tilde{m}^* = \eta a_2^* \left[\frac{1}{(1-\tilde{v}^*)\tilde{n}} \right]^{\eta} + \rho^*. \tag{18b}$$

Utilizing (18a) and (18b), Equation (17) implies that the rates of economic growth between these two countries are identical.

$$(1-\alpha) a_2 \left(\frac{\tilde{n}}{1-\tilde{v}} \right)^{\alpha} - \rho = (1-\eta) a_2^* \left[\frac{1}{(1-\tilde{v}^*)\tilde{n}} \right]^{\eta} - \rho^*, \tag{19a}$$

This equation is the main difference from the existing literature. Thanks to international technology spillover, $\tilde{n}$ appears in both Home's and Foreign's growth rate. After $\tilde{v}$ and $\tilde{v}^*$ are determined, the growth rates between countries may be different. But the two growth rates may converge to be identical by the adjustment of $\tilde{n}$. That is, (19a) can determine the value of $\tilde{n}$. In the past literature, they always assume no international difference in production technology and preference so that this equation is met automatically, such as Bond, Trask and Wang (2003) and Doi, Nishimura and Shimomura (2007).

Using (18a) and (18b), the world market-clearing condition can be rewritten by

$$\rho + \rho^* \tilde{n} = a_2 \left(\frac{\tilde{n}}{1-\tilde{v}} \right)^{\alpha} (\tilde{v} - \alpha) + a_2^* \left[\frac{1}{(1-\tilde{v}^*)\tilde{n}} \right]^{\eta} \tilde{n} (\tilde{v}^* - \eta). \tag{19b}$$

Since the left hand side is positive, we need to require $\tilde{v} > \alpha$ and $\tilde{v}^* > \eta$ for a positive left hand side. Thus, $\tilde{n}, \tilde{v},$ and $\tilde{v}^*$ can be solved by the system of (13), (19a) and (19b).

Now, we assess the existence of $\tilde{n}, \tilde{v},$ and $\tilde{v}^*$. Based on (13), we find that $\tilde{v}^* = \tilde{v}^*(\tilde{v})$.. Moreover, given $\tilde{v}$, (19a) can determine a unique $\tilde{n} = \tilde{n}(\tilde{v}) = [\frac{(1-\eta) a_2{}^*}{(1-\alpha) a_2} \frac{(1-v)^{\alpha}}{(1-v^*)^{\eta}}]^{\frac{1}{\alpha+\eta}}$ with $\frac{\partial \tilde{n}}{\partial \tilde{v}} = \frac{\alpha \tilde{n} (\tilde{v}^* - \tilde{v})}{(\alpha+\eta) \tilde{v} (1-\tilde{v})}$ under $\rho = \rho^*$. As a result, (19b) is a function of $\tilde{v}$ and may determine $\tilde{v}$. Rearrange (19b) as follows.

$$a_2 \left(\frac{\tilde{n}(\tilde{v})}{1-\tilde{v}} \right)^{\alpha} (\tilde{v} - \alpha) + a_2^* \left\{ \frac{1}{[1-\tilde{v}^*(\tilde{v})]\tilde{n}(\tilde{v})} \right\}^{\eta} \tilde{n}(\tilde{v}) [\tilde{v}^*(\tilde{v}) - \eta] - \rho^* \tilde{n}(\tilde{v}) = \rho. \tag{20}$$

We differentiate the left hand side (LHS) of (20) by $\tilde{v}$ under $\rho = \rho^*$ to get

$$\frac{dLHS}{d\tilde{v}} = \frac{y_2}{k_2}\frac{\{(\alpha+\eta)\tilde{v}[1-\tilde{v}+\alpha(\tilde{v}-\alpha)]-\alpha^2(\tilde{v}-\alpha)(\tilde{v}-\tilde{v}^*)\}}{\tilde{v}(1-\tilde{v})(\alpha+\eta)}$$
$$+\frac{y_2^*}{k_2^*}\frac{\alpha\tilde{n}\{(\alpha+\eta)\tilde{v}^*[1-\tilde{v}^*+\eta(\tilde{v}^*-\eta)]-\eta(1-\eta)(\tilde{v}^*-\eta)(\tilde{v}-\tilde{v}^*)\}}{\tilde{v}(1-\tilde{v})(\alpha+\eta)\eta}$$
$$+\frac{\alpha(\tilde{v}-\tilde{v}^*)}{\tilde{v}(1-\tilde{v})(\alpha+\eta)}\rho^*\tilde{n} > 0 \text{ if } \tilde{v} > \tilde{v}^*,$$
$$= \frac{y_2}{k_2}\frac{\{(\alpha+\eta)\tilde{v}[1-\tilde{v}+\alpha(\tilde{v}-\alpha)]-\alpha(1-\alpha)(\tilde{v}-\alpha)(\tilde{v}^*-\tilde{v})\}}{\tilde{v}(1-\tilde{v})(\alpha+\eta)}$$
$$+\frac{y_2^*}{k_2^*}\frac{\alpha\tilde{n}\{(\alpha+\eta)\tilde{v}^*[1-\tilde{v}^*+\eta(\tilde{v}^*-\eta)]-\eta^2(\tilde{v}^*-\eta)(\tilde{v}^*-\tilde{v})\}}{\tilde{v}(1-\tilde{v})(\alpha+\eta)\eta}$$
$$+\frac{\alpha(\tilde{v}^*-\tilde{v})}{\tilde{v}(1-\tilde{v})(\alpha+\eta)}\rho > 0 \text{ if } \tilde{v} < \tilde{v}^*.$$

We find that $\frac{dLHS}{d\tilde{v}} > 0$ if $\tilde{v} > \alpha$, $\tilde{v}^* > \eta$ and the difference between ρ and ρ^* is not too large. In addition, $LHS \to \infty$ as $\tilde{v} \to 1$ and $LHS \to -\rho^*\tilde{n}(\tilde{v}=0) < 0$ as $\tilde{v} \to 0$. Consequently, $\tilde{v}$ can be determined uniquely by (20) as depicted in Figure 1.

[Insert Figure 1 here]

The one of the preconditions, $\tilde{v} > \alpha$, corresponds to $LHS(\tilde{v}=\alpha) < \rho$ and, together with the other precondition, $\tilde{v}^* > \eta$, we obtain the following condition for a unique $\alpha < \tilde{v} < 1$.

Condition S: $\eta < \frac{1}{1+\Omega} < \eta + \frac{\rho}{a_2^*}(1-\alpha)^{\frac{(1-\alpha)(1-\eta)}{\alpha+\eta}}(1-\eta)^{\frac{-(1-\eta)}{\alpha+\eta}}\left(\frac{\Omega}{1+\Omega}\right)^{\frac{\eta(1-\alpha)}{\alpha+\eta}}$,

where $\Omega \equiv (\frac{(1+\tau)a_1 a_2^*}{a_1^* a_2})^{\frac{1}{\eta}}(\frac{1-\alpha}{\alpha})^{\frac{\alpha}{\eta}}$. Given $\tilde{v}$, $\tilde{n} > 0$ and $\eta < \tilde{v}^* < 1$ can be solved by (19b) and (13), respectively.

In sum, we get the following proposition.

Proposition 1 *Under Condition S and not very large difference in the rate of time preference between Home and Foreign, the BGP is uniquely determined with incompletely specialization in each country.*

4. Import Tariff and Growth

In this section, we examine the long-run relationship between import tariffs and growth. Suppose $\rho = \rho^*$ and based on (13), (19a) and (19b), we total differentiate these three equations to obtain the effect of tariff on $\tilde{n}, \tilde{v},$ and $\tilde{v}^*$. (See appendix A for more detailed derivation.)

$$\frac{d\tilde{v}}{d\tau} = -\frac{1}{\Delta(1+\tau)}\left\{\frac{\eta}{1-\tilde{v}^*}\left[\frac{\alpha}{\tilde{n}} + \frac{(1-\alpha)(\tilde{v}^*-\eta)}{\Lambda} - \frac{1}{1+\tilde{n}}\right] + \frac{(\alpha+\eta)(1-\alpha)}{\Lambda}\right\} > 0, \tag{21a}$$

$$\frac{d\tilde{v}^*}{d\tau} = \frac{1}{\Delta(1+\tau)}\left\{\frac{\alpha+\eta}{n}\frac{1-\eta}{\Lambda} + \frac{\alpha}{1-\tilde{v}}\left[\frac{\eta}{\tilde{n}} + \frac{1}{1+\tilde{n}} - \frac{(1-\alpha)(\tilde{v}^*-\eta)}{\Lambda}\right]\right\} < 0, \tag{21b}$$

$$\frac{d\tilde{n}}{d\tau} = \frac{1}{\Delta(1+\tau)}\left\{\frac{\alpha}{1-\tilde{v}}\frac{(1-\alpha)\tilde{n}}{\Lambda} + \frac{\eta}{1-\tilde{v}^*}\left[\frac{\alpha}{1-\tilde{v}} + \frac{1-\eta}{\Lambda}\right]\right\} < 0, \tag{21c}$$

where $\Lambda \equiv (\tilde{v}-\alpha)(1-\eta) + (1-\alpha)\tilde{n}(\tilde{v}^*-\eta) > 0$ and

$$\Delta \equiv -\{\tfrac{\eta}{\tilde{v}^*(1-\tilde{v}^*)}[\tfrac{\alpha}{1-\tilde{v}}(\tfrac{1}{1+\tilde{n}} + \tfrac{\eta}{\tilde{n}} - \tfrac{(1-\alpha)(\tilde{v}^*-\eta)}{\Lambda}) + \tfrac{\alpha+\eta}{\tilde{n}}\tfrac{1-\eta}{\Lambda}] + \tfrac{\alpha}{\tilde{v}(1-\tilde{v})}[\tfrac{\eta}{1-\tilde{v}^*}(\tfrac{\alpha}{\tilde{n}} + \tfrac{(1-\alpha)(\tilde{v}^*-\eta)}{\Lambda} - \tfrac{1}{1+\tilde{n}}) + \tfrac{(1-\alpha)(\alpha+\eta)}{\Lambda}]\} < 0.$$

According to (19a), Home's growth rate, denoted as g, is

$$g = (1-\alpha)a_2\left(\frac{\tilde{n}}{1-\tilde{v}}\right)^{\alpha} - \rho. \tag{22}$$

Then, utilizing (21a) and (21c), the effect of tariff on growth rate is

$$\frac{dg}{d\tau} = \frac{(g+\rho)\alpha\eta(1-\alpha)}{\Delta(1+\tau)\tilde{n}(1+\tilde{n})(1-\tilde{v}^*)\Lambda}\left\{1-\left(\frac{a_2^*}{a_2}\right)^{\frac{1}{\alpha}}\right\} \gtrless 0 \text{ if } a_2^* \gtrless a_2. \tag{23}$$

Under $\alpha=\eta$ and $\rho=\rho^*$, the only possibility for Home to import the pure consumption good is that Home has comparative advantage in the pure investment good i.e $(1+\tau)a_1/a_2<a_1^*/a_2^*$.[3] Based on (23), a higher tariff can raise growth rate if Foreign has absolute advantage in the pure investment good, i.e. $a_2^*>a_2$. It also implies $a_1^*>(1+\tau)a_1a_2^*/a_2>a_1$ which means that Foreign has absolute advantage in the pure consumption good.

The intuition may be explained as follows. A higher tariff makes domestic price of the pure consumption good higher and thereby the resources reallocate to the consumption sector from the investment sector, i.e. $\tilde{v}$ increases. This effect causes a rise in the supply of the pure consumption good in the world market and then a lower international price of the pure consumption good. Thus, Foreign reallocates resources to the investment sector from the consumption sector, i.e $\tilde{v}^*$ decreases. With diminishing marginal product of capital, the increase in $\tilde{v}$ induces a higher domestic marginal product of capital in the pure investment sector and the decrease in $\tilde{v}^*$ induces a lower foreign marginal product of capital. It follows that Home's growth rate is greater that Foreign's. It also implies that Home's growth rate of capital (Home's investment) is greater than

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[3] Please see appendix B to show this condition.

Foreign's. By international technology spillover, Foreign's firms absorb more knowledge than Home's so that Home's growth rate decreases and Foreign's growth rate increase. That is, $\tilde{n}$ will reduce to narrow down the difference between two-country growth rates. Eventually, the growth rates between the two countries will converge to be identical. Under $a_2^*>a_2$, the Foreign's speed of convergence is greater than Home's and then the new long-run two-country growth rate exceeds the original one. As a result, the growth rate rises as a higher tariff. On the contrary, under $a_2^*<a_2$, the reverse will be true.

To sum up, we get the following proposition.

Propositon 2. *Suppose that Home and Foreign differ only in the relative productivity, the import tariff on the pure consumption good raises (reduces) the rate of economic growth if Foreign (Home) has absolute advantage in the pure investment good.*

5. Import Tariff and welfare

Now we turn to examining the relationship between import tariff and welfare in the long run. As is clear from below, a higher tariff may raise the level of welfare under some parameter spaces.

In a BGP, the representative agent's lifetime utility in the Home country is

$$U = \int_0^\infty u(c) e^{-\rho t} dt = \frac{1}{\rho}\left(\ln c_0 + \frac{g}{\rho}\right), \tag{24}$$

where $c_0 = \frac{\tilde{m}k_0}{\tilde{p}} = \frac{k_0 a_1^*}{a_2^*}(\frac{1-\tilde{v}^*}{1-\tilde{v}})^\eta \{\alpha a_2 (\frac{\tilde{n}}{1-\tilde{v}})^\alpha (\alpha - \frac{\tau\tilde{v}}{1+\tau}) + \rho\}$, which is the initial value of consumption which represents the present consumption, and g is the growth rate in the long-run which represents the future consumption. And it indicates that the welfare is increasing in c_0 and g.

Since it is difficult to conduct a welfare analysis of government policy in the same way as in the previous section, we will instead use a numerical approach to investigate the welfare effect of tariff below. For simplicity and in accordance with Home importing the pure consumption good, we assume two countries identical in every aspect except for the relative productivity, i.e. $\alpha=\eta$, $\rho=\rho^*$ and $(1+\tau)a_1/a_2<a_1^*/a_2^*$.

In the following simulation, the benchmark parameter values are summarized in Table 1. First, the time preference rate is chosen at $\rho=0.025$ in accordance with Benhabib and Perli (1994). Second, we set a relative small value of the degree of externality at $\alpha=\eta=0.05$. Third, without loss of generality, we normalize the parameter values of the productivity coefficient in Sector y_1 by

a_1=1. Parameters a_2 and a_2* are chosen at the range of [0, 2]. Fourth, in accordance with $(1+\tau)a_1/a_2<a_1^*/a_2^*$, we set $a_1^*=(1+\tau)a_1a_2^*/a_2+0.02$. Finally, we assume that government raises the rate of tariff from 0.01 to 0.02.

[Insert Table 1 here]

Under the benchmark parameter spaces, we find that tariff reduces the initial consumption, c_0. This relationship can also be assessed by (9a) in the sense that a higher tariff leads to a higher domestic price of the pure consumption good, $p(1+\tau)$, and then a lower demand for the pure consumption good. It appears that the only way to raise welfare is that growth rate should be lifted by a higher tariff and this effect should be greater than that of the drop in initial consumption.

[Insert Figure 2 here]

We find it possible to get a better welfare under tariff policy. In Figure 2, we simulate the region in the (a_2, a_2*) plane separating a better-off and worse-off area, with the shaded area exhibiting a better welfare. Two observations are in order. First, a_2* should be greater than a_2 which implies a higher growth rate under tariff policy. Second, the difference between a_2 and a_2* is limited to Condition S for the existence of steady state and hence the gap between a_2 and a_2* should be not too large. That is why these two parameters are positive correlated.

6. Concluding Remarks

We have presented a basic two-country endogenous growth model, which is regarded as an integration of two-courntry economy and endogenous growth. First, we show that there exists a unique long-run equilibrium with both countries being incompletely specialized. Second, unlike the past literature, we don’t need to make an assumption such that the growth rates between countries are identical in a BGP. Third, a higher import tariff may boost (reduce) the rate of economic growth when the foreign (domestic) country has absolute advantage in the investment good. Finally, a higher import tariff may also raise welfare under some parameter spaces.

Since the model is a basic one, there are many directions to extend this model to discuss trade and growth issues. One direction is to extend this model to include two factors, such as physical capital and labor or physical capital and human capital. This may reexamine the hypothesis of Heckscher-Ohlin model. Moreover, the international knowledge is a public good in this model but in the real world most of this is a private good. If the firms absorbing international knowledge should pay the cost, we can extend this model to a R&D structure such as Romer (1990).

Appendix A

This section total differentiate the three equations, (13), (19a) and (19b), to yield (21a), (21b) and (21c). The result after total differentiate is

$$\begin{pmatrix} \frac{\alpha}{\tilde{v}(1-\tilde{v})} & \frac{-\eta}{\tilde{v}^*(1-\tilde{v}^*)} & 0 \\ \frac{\alpha}{1-\tilde{v}} & \frac{-\eta}{1-\tilde{v}^*} & \frac{\alpha+\eta}{\tilde{n}} \\ \frac{\alpha}{1-\tilde{v}}+\frac{1-\eta}{\Lambda} & \frac{(1-\alpha)\tilde{n}}{\Lambda} & \frac{\alpha}{\tilde{n}}+\frac{(1-\alpha)(\tilde{v}^*-\eta)}{\Lambda}-\frac{1}{1+\tilde{n}} \end{pmatrix} \begin{pmatrix} d\tilde{v} \\ d\tilde{v}^* \\ d\tilde{n} \end{pmatrix} = \begin{pmatrix} \frac{1}{1+\tau}d\tau \\ 0 \\ 0 \end{pmatrix}, \qquad \text{(A1)}$$

where Λ is defined in (21c). Then, (21a)-(21c) are derived by Cramer's rule. Finally, based on (22), utilizing (21a) and (21c), the effect of tariff on growth rate is

$$\begin{aligned} \frac{dg}{d\tau} &= (g+\rho)\alpha\left(\frac{1}{\tilde{n}}\frac{d\tilde{n}}{d\tau}+\frac{1}{1-\tilde{v}}\frac{d\tilde{v}}{d\tau}\right) \\ &= \frac{(g+\rho)\alpha\eta}{\Delta(1+\tau)\tilde{n}(1+\tilde{n})(1-\tilde{v})(1-\tilde{v}^*)\Lambda}\left\{\tilde{n}(1-\eta)(\tilde{v}-\alpha)-\tilde{n}(1-\alpha)(\tilde{v}^*-\eta)\right. \\ &\qquad \left.+(1-\eta)(1-\tilde{v})(1+\tilde{n})-(1-\alpha)\tilde{n}(1+\tilde{n})(1-\tilde{v}^*)\right\} \qquad \text{(A2)} \\ &= \frac{(g+\rho)\alpha\eta(1-\alpha)}{\Delta(1+\tau)\tilde{n}(1+\tilde{n})(1-\tilde{v})(1-\tilde{v}^*)\Lambda}\left\{1-\tilde{v}-\tilde{n}^2(1-\tilde{v}^*)\right\} \text{ if } \alpha=\eta \\ &= \frac{(g+\rho)\alpha\eta(1-\alpha)}{\Delta(1+\tau)\tilde{n}(1+\tilde{n})(1-\tilde{v}^*)\Lambda}\left\{1-\left(\frac{a_2^*}{a_2}\right)^{\frac{1}{\alpha}}\right\} \gtrless 0 \text{ if } a_2^* \gtrless a_2, \end{aligned}$$

where Δ is defined in (21c).

Appendix B

This section show that Home imports the pure consumption good and exports the pure investment good when Home has comparative advantage in the pure investment good i.e $(1+\tau)a_1/a_2<a_1^*/a_2^*$. The each country's excess demand for the pure consumption good in a BGP are respectively

$$ED = \tilde{c}-\tilde{y}_1 = \frac{\tilde{k}}{\tilde{p}}\left[\tilde{m}-a_2 b^{\alpha}\left(\frac{\tilde{n}}{1-\tilde{v}}\right)^{\alpha}\tilde{v}\right], \qquad \text{(B1)}$$

$$ED^* = \tilde{c}^*-\tilde{y}_1^* = \frac{\tilde{k}}{\tilde{p}}\tilde{n}\left[\tilde{m}^*-a_2^* b^{*\eta}\left[\frac{1}{(1-\tilde{v}^*)\tilde{n}}\right]^{\eta}\tilde{v}^*\right]. \qquad \text{(B2)}$$

In the autarkic economy, $ED=0=ED^*$ and in the free-trade economy, $ED+ED^*=0$.

Under $\alpha=\eta$ and $\rho=\rho^*$, the system of BGP becomes

$$\frac{\tilde{v}}{1-\tilde{v}}=\left(\frac{(1+\tau)a_1a_2^*}{a_1^*a_2}\right)^{\frac{1}{\alpha}}\frac{\tilde{v}*}{1-\tilde{v}*}, \tag{B3}$$

$$a_2\left(\frac{\tilde{n}}{1-\tilde{v}}\right)^{\alpha}=a_2^*\left[\frac{1}{(1-\tilde{v}*)\tilde{n}}\right]^{\alpha}, \tag{B4}$$

$$\rho(1+\tilde{n})=a_2\left(\frac{\tilde{n}}{1-\tilde{v}}\right)^{\alpha}(\tilde{v}-\alpha)+a_2^*\left[\frac{1}{(1-\tilde{v}*)\tilde{n}}\right]^{\alpha}\tilde{n}(\tilde{v}*-\alpha). \tag{B5}$$

With the help of (18a)-(18b) and (B4), the excess demands for the pure consumption good are

$$ED=\frac{\tilde{k}}{\tilde{p}}\left[\rho-a_2\left(\frac{\tilde{n}}{1-\tilde{v}}\right)^{\alpha}(\tilde{v}-\alpha)\right], \tag{B6}$$

$$ED*=\frac{\tilde{k}}{\tilde{p}}\tilde{n}\left[\rho-a_2\left(\frac{\tilde{n}}{1-\tilde{v}}\right)^{\alpha}(\tilde{v}*-\alpha)\right]. \tag{B7}$$

With $(1+\tau)a_1/a_2<a_1^*/a_2^*$, (B3) implies that $\tilde{v}*>\tilde{v}$ and then the value of the square bracket in (B6) is greater than that in (B7). Thus, $ED>0>ED*$ which means that Home imports the pure consumption good and exports the pure investment good.

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Figure 1: Existence of BGP

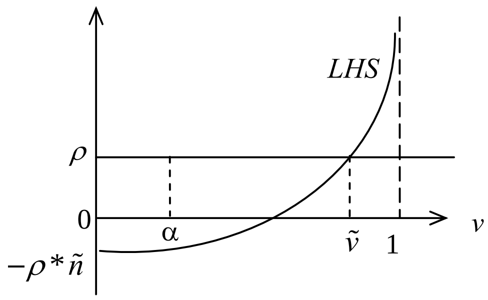
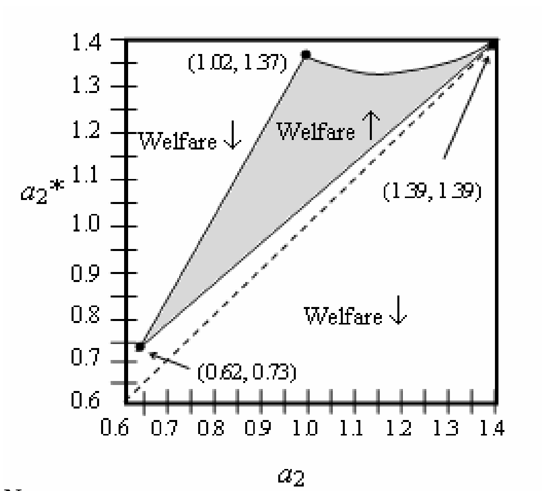


Table 1: Benchmark parameter values

ρ	ρ^*	α	η	a_1	a_2	a_2^*	a_1^*	Variation of τ
0.025	0.025	0.05	0.05	1	[0, 2]	[0, 2]	$[(1+\tau)a_1 a_2^*/a_2]+0.02$.	0.01 to 0.02

Figure 2: Welfare analysis



Note:
1.$\rho=\rho^*=0.025$, $\alpha=\eta=0.05$, $a_1=1$, $\tau=0.01$ to 0.02 and $a_1^*=[(1+\tau)a_1a_2^*/a_2]+0.02$.
2. The shaded area presents the region for a better-off welfare