The Effect of Globalization in a Semi Endogenous Growth Model with Firm Heterogeneity, Endogenous International Spillover, and Trade

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Abstract

This paper shows that globalization increases (decreases) the growth rate if and only if the beachhead cost for the domestic market is strictly higher (lower) than that for the domestic market in a endogenous growth model with firm heterogeneity, international trade, and endogenous international spillover. The condition for gains from trade is also derived.

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1. Introduction

According to World Bank (1995), maritime transportation cost did not monotonically decreased, but decreased from 1920 to 1990, while air transportation cost monotonically decreased. Hummels (2007) shows that ad valorem air shipping and ocean shipping costs decreased except for mid 1980s and the initial period of 2000s between 1974 and 2004. Jacks, Meissner, and Novy (2008) shows that trade costs for U.S. fluctuated between 1950 and 1960 and declined between 1960 and 1980 and fluctuated but increased since then. Its costs declined except for around 1960, 1980s, and mid 1990.

How does trade liberalization affect economic growth? According to empirical analysis, trade liberalization affects growth positively or negatively. For example, Edwards (1998) found that greater trade openness leads to higher growth rates measured by for 93 countries between 1960 and 1990. Yanikkaya (2003) found that trade volume includes import and export positively affects growth, but trade restrictions like tariff and export tax leads to lower growth for 100 developed and developing countries between 1970 and 1997. Minier and Unel (2013) shows that trade restriction represented by tariff affects growth ambiguously for 86 countries between 1985 and 2007.

Recently, it is well known that firm heterogeneity plays an important role in international trade. For example, different firms have different productivities within an industry. Moreover, each firm exclusively chooses domestic or exporting firm who serve domestic as well as foreign markets according to the levels of productivities. Following trade liberalization, trade reallocates resources from the less productive to the more productive exporting or non-exporting firms by shutting down the less productive firms and increasing exports, industrial productivity rises see Bernard, Jensen, and Schott, 2006)[2].Based on these empirical papers, Melitz (2003) provide a monopolistically competitive model of trade with firm heterogeneity. Furthermore, some economists pay attention to the effects of firm heterogeneity on economic growth following trade liberalization based on Melitz (2003). Baldwin and Robert-Nicoud (2008) extended Melitz (2003) into a R&D based growth model of trade with firm heterogeneity. They showed that trade liberalization is detrimental to economic growth under exogenous international spillover. This is because it leads productive but domestic firms to start exporting and less productive domestic

[2] Melitz (2003) construct a monopolistic competition model with firm heterogeneity which is consistent with this empirical evidence.

firms exit due to fierce competition between domestic and foreign firms, which makes the ex-ante probability of a firm becoming production firm lower, which in turn increases R&D costs.

Coe and Helpman (1995) provide that imports convey international knowledge spillover among the trade partners in the R&D sector. Put differently, the amount of international spillover is endogenous, not exogenous. Based on Coe and Helpman (1995), they consider endogenous international spillover case as well. They assumed that the fraction of the value of imported goods of the values of goods produced in the trading country. More specifically, knowledge spillover from the trading country depends on the export cutoff relative to the zero profit cutoff.

Even in the case of endogenous international spillover, trade liberalization decreases economic growth. First, it leads productive but domestic firms to start exporting and less productive domestic firms exit due to fierce competition between domestic and foreign firms, which makes the ex-ante probability of a firm becoming production firm lower, which in turn increases R&D costs. Second, it leads to higher fraction of exporting firms among production firms, which in turn leads to higher international spillover. Third, the first negative channel unambiguously dominates the second one, and so growth rate decreases through trade liberalization.

This result seems to general result, but their analysis limited to one case of numerically estimated parameters.

Based on above analysis, we reinvestigate the relationship between trade openness and growth in a growth model.

Moreover, there is an ambiguous effect on welfare because there is a negative channel of decreases in the growth rate and higher R&D costs and there is a positive effect through increases in the weighted average of productivity among production firms, but they do not derive a parameter condition for gains from trade. Unel (2010) extends Romer (1990) into an R&D-based growth model with firm heterogeneity and endogenous international knowledge spillover[3]. They show that globalization increases or decreases economic growth and welfare, but his paper also does not derive a condition for gains from trade. Moreover, Gustafsson and Segerstrom (2010) show that due to diminishing returns to knowledge in the R&D sector globalization does not affect economic growth. Dinopoulos and Unel (2011) show that globalization affects economic growth ambiguously because there is a positive effect that the number of researchers

[3] Unel (2010) assumes that international knowledge spillover depends on the value of total trade relative to the value of intermediate goods produced domestically.

devoted increases due to an increase in the mark-up rate and a negative effect of higher R&D costs. They find that per capita expenditures and growth rates vary inversely, but they do not derive a condition for gains from trade.

This paper derives the necessary and sufficient conditions under which globalization increases (decreases) economic growth when the sunk beachhead cost for the domestic market is higher (lower) than that for the foreign market in a model with firm heterogeneity and endogenous international spillover[4]. This result is more relevant to the empirical evidence cited above. This paper shows that endogenous international spillover plays an important role in economic growth because Baldwin and Robert-Nicoud (2008) and Unel (2010) show that further exposure to international trade necessarily decreases economic growth in the exogenous international spillover model and may increase economic growth in all other endogenous international spillover models. The rest of the paper is organized as follows: In section 2, we describe and explain the model. In section 3, we offer our concluding remarks.

2. The Model

2.1 Basic model structure

There are two symmetric countries. Each consumer supplies inelastically one unit of labor in each period. Labor is the only production factor, grows at the rate of population growth and serves as the numeraire. There are monopolistically competitive goods and perfectly competitive R&D sectors. In the former sector, the firms are heterogeneous with regard to marginal cost, which is drawn from a Pareto distribution. To enter each a market, each firm has to incur a sunk cost for drawing a marginal cost, and then chooses entering by incurring the sunk cost for each market. Exporters face iceberg costs as well. Thus, each firm is classified as a production firms (exporting and domestic firms) or a shutdown firms. In the R&D sector, there are diminishing returns to knowledge and the growth rate in a steady state is pinned down by parameters, as in Jones (1995 a). We follow Baldwin and Robert-Nicoud (2008) and Unel (2010) who assume endogenous international spillovers consistent with Coe and Helpman (1995) and who assume an exogenous

[4] We assume the sunk cost for the foreign market relative to that for the domestic market is higher than a measure of free trade, $\tau^{1-\sigma}$, where τ is the iceberg cost and $\sigma > 1$ is the elasticity of substitution between varieties.

domestic knowledge spillover in autarky and there are endogenous international knowledge spillovers as well in the open economy.

2.2. Consumer

The consumer is a representative agent. Each consumer supplies inelastically one unit of labor in each time period. The total amount of labor supplied equals the size of the population denoted by L_t. The consumer earns incomes from his or her assets and labor, and chooses the path of consumption expenditure and assets so as to maximize the sum of his or her discounted value of utility. The inter-temporal utility function is given by

$$u(c_t) = \int_0^{\infty} \log c_t e^{-\rho t} \mathrm{d}t, \tag{1}$$

where c_t is a consumption index which depends on the consumption of a continuum of varieties, given by

$$c_t = \left(\int_{\Omega_t} (x_{Lt}(i))^{\frac{\sigma-1}{\sigma}} \mathrm{d}i + \int_{\Omega_t} (x_{Et}(i))^{\frac{\sigma-1}{\sigma}} \mathrm{d}i \right)^{\frac{\sigma}{\sigma-1}}, \sigma > 1, \tag{2}$$

where Ω_t is the set of varieties that can be consumed, $x_{Lt}(i)$ ($x_{Et}(i)$) the demand for the i-th variety produced domestically (produced abroad and exported), and ρ the individual's subjective discount rate. The inter-temporal budget constraint is

$$\dot{s}_t = r_t s_t + w_t - e_t, \tag{3}$$

where s_t is the per capita assets, r_t the rate of return on assets, w_t the wage, and e_t expenditure. Solving the dynamic optimization problem implies that

$$\frac{\dot{e}_t}{e_t} = r_t - \rho \tag{4}$$

Static optimization means maximizes (2) given budget constraint:

$$c_t = \int_{\Omega_t} p_{Lt}(i) x_{Lt}(i) \mathrm{d}i + \int_{\Omega_t} p_{Et}(i) x_{Et}(i) \mathrm{d}i, \tag{5}$$

where $p_L(i)$ the price of varieties produced domestically, and $p_E(i)$ the price of the varieties produced abroad and exported. It yields the demand for each variety, given by

$$x_t(i) = \frac{p_j(i)^{-\sigma}}{(P_t)^{1-\sigma}} e_t, \ j = L, E, \tag{6}$$

where

$$P_t = \left(\int_{i\in\Omega}[p_L(i)]^{1-\sigma}\,\mathrm{d}i + \int_{i\in\Omega}[p_E(i)]^{1-\sigma}\,\mathrm{d}i\right)^{\frac{1}{1-\sigma}} \tag{7}$$

is the price index,

2.3 Innovation

We next explain firm behavior. For firms to enter the market, they have to pay the sunk start-up cost $b_{It}F_I$, where $b_{It} \equiv \frac{1}{(1+T^k)m_t}$ represents the unit labor requirement for knowledge creation, $T^k m_t$ the international knowledge spillover which is defined explicitly later, m_t the number of varieties produced and the inter-temporal knowledge spillover[5]. These assumptions follow Baldwin and Robert-Nicoud (2008). As more variety created, R&D researchers learn to generate knowledge more efficiently, and the unit labor requirement for knowledge creation will be lower. Then they find the unit labor requirement for manufacturing from a Pareto distribution, given by

$$G(B) = (\tfrac{B}{\bar{B}})^k, \text{ where } 1 + k - \sigma > 0. \tag{8}$$

To enter the market, each firm has to pay the domestic and exporting sunk costs, given by $b_{It}F_L$ and $b_{It}F_E$, respectively. For one unit of good entering the domestic and exporting markets, 1 and τ units of goods, respectively, must be transported. Following Baldwin and Robert-Nicoud (2008), lower τ corresponds to trade liberalization. Firms with unit labor requirement $B > B_L$ exit the market immediately. Firms with unit labor requirement $B_E < B < B_L$ enter only domestic market. Firms with unit labor requirement $B < B_E$ enter the both markets. Hereafter, we call firms whose productivities are higher than B_L as a production firm.

2.4 Product Market

If a firm with unit labor requirement B enters the market, the firm earns profits

$$\pi_{Lt}(B) = p_{Lt}(B)x_{Lt}(B) - Bx_{Lt}(B).$$

The profit-maximizing price is given by

$$p_{Lt}(B) = \frac{\sigma B}{\sigma - 1}. \tag{9}$$

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Thus, the profit function can be given by

$$\pi_{Lt}(B) = \frac{\sigma^{-\sigma}(\sigma-1)^{\sigma-1}B^{1-\sigma}e_t}{(P_t)^{1-\sigma}}. \tag{10}$$

Given consumer expenditure and the price index, the profit function monotonically decreases according to the level of the unit labor requirement for manufacturing. For a firm to export one unit of a good, the firm must produce $\tau > 1$ units.

If a firm with unit labor requirement B enters the market, the firm earns profits

$$\pi_{Et}(B) = p_{Et}(B)x_{Et}(B) - \tau B x_{Et}(B).$$

and the profit-maximizing price would be

$$p_{Et}(B) = \frac{\tau\sigma B}{\sigma-1}. \tag{11}$$

Thus, the profit function for exporting is given by

$$\pi_{Et}(B) = \frac{\tau^{1-\sigma}\sigma^{-\sigma}(\sigma-1)^{\sigma-1}B^{1-\sigma}e_t}{(P_t)^{1-\sigma}}. \tag{12}$$

A consumer has two methods to accumulate assets: firm shares and riskless bonds. The rate of return on the former type of assets depends on dividends and capital loss (gain). The latter type comes from the interest. In equilibrium, the two rates of return are equalized. Thus, the following no-arbitrage condition holds:

$$\frac{\pi_{jt}(B)}{V_{jt}(B)} + \frac{\dot{V}_{jt}(B)}{V_{jt}(B)} = r_t,\ j = L, E \Longrightarrow V_{it}(B) = \frac{\sigma^{-\sigma}(\sigma-1)^{\sigma-1}(B)^{1-\sigma}e_t}{(P_t)^{1-\sigma}\left(r_t - \frac{\dot{V}_{it}(B)}{V_{it}(B)}\right)}. \tag{13}$$

This equation determines the value of a firm serving the market as a function of the level of its unit labor requirement. The cost associated with serving the domestic market is $b_{It}F_i, i = L, E$. Thus, the local cutoff levels $B_i, i = L, E$, is determined as follows:

$$V_{it}(B_i) = \frac{\sigma^{-\sigma}(\sigma-1)^{\sigma-1}(B_i)^{1-\sigma}e_t}{(P_t)^{1-\sigma}\left(r_t - \frac{\dot{V}_{it}(B_i)}{V_{it}(B_i)}\right)} = b_{It}F_i, i = L, E. \tag{14}$$

Using

The cost associated with serving the domestic market is $b_{It}F_L$. Thus, the local cutoff B_L is determined as follows:

$$V_{Lt}(B_L) = \frac{\sigma^{-\sigma}(\sigma-1)^{\sigma-1}(B_L)^{1-\sigma}e_t}{(P_t)^{1-\sigma}\left(r_t - \frac{\dot{b_{It}}}{b_{It}}\right)} = b_{It}F_L, \tag{15}$$

where $\frac{\dot{V_{it}}(B_i)}{V_{it}(B_i)} = \frac{\dot{b_{It}}(B_i)}{b_{It}(B_i)}, i = L, E$ is used from (14). Similarly, there exists a foreign cutoff B_E satisfying

$$V_{Et}(B_E) = \frac{\sigma^{-\sigma}(\sigma-1)^{\sigma-1}(B_E)^{1-\sigma}e_t}{(P_t)^{1-\sigma}\left(r_t + \frac{\dot{b_{It}}}{b_{It}}\right)} = b_{It}F_E. \tag{16}$$

Using the two cut off conditions (15) and (16), we obtain the cutoff ratio as a function of the iceberg costs and the ratio of the second stage sunk costs

$$\frac{B_E}{B_L} = \left(\frac{\tau^{1-\sigma}F_L}{F_E}\right)^{\frac{1}{\sigma-1}} < 1.. \tag{17}$$

Empirical evidence by >>>>> shows that exporter is more productive than domestic firms. Following Melitz (2003), we assume a necessary and sufficient condition for the partition of exporting status is

$$\left(\frac{\tau^{1-\sigma}F_L}{F_E}\right)^{\frac{1}{\sigma-1}} < 1. \tag{18}$$

On the other hand, Baldwin and Robert-Nicoud (2008) assume that a sufficient condition for the partition of exporting status, and its condition is the sunk cost for exporting is strictly greater than that for domestic market:

$$F_L < F_E. \tag{19}$$

2.5 Innovation Incentives

A firm does not know its own productivity before the sunk start-up cost and decides whether to enter or not by weighing its ex-ante value and the ex-ante expected R&D sunk cost. Due to free entry and exit in R&D sector, the free-entry condition is

$$\int_0^{B_L}[V_{Lt}(B_L)-b_{It}F_L]g(B)\mathrm{dB}+\int_0^{B_E}[V_{Et}(B_L)-b_{It}F_E]g(B)\mathrm{dB}=b_{It}F_I \qquad (20)$$

Substituting $b_{It}F_L$ and $b_{It}F_E$ into the right hand side and dividing both sides by $G(B_L)$, we get

$$\int_0^{B_L}V_{Lt}(B_L)\frac{g(B)\mathrm{dB}}{G(B_L)}+\int_0^{B_E}V_{Et}(B_L)\frac{g(B)\mathrm{dB}}{G(B_L)}=b_{It}\bar{F} \qquad (21)$$

where

$$\bar{F}\equiv\frac{F_I}{G(B_L)}+\int_0^{B_L}F_L\frac{g(B)\mathrm{dB}}{G(B_L)}+\int_0^{B_E}F_E\frac{g(B)\mathrm{dB}}{G(B_L)} \qquad (22)$$

is the ex-ante expected cost of production firms.

Using, (8), (10), (12)-(13), and $\frac{\dot{V}_{it}(B_i)}{V_{it}(B_i)}=\frac{\dot{b}_{It}(B_i)}{b_{It}(B_i)}=-\frac{\dot{m}_t}{m_t}$ in the left-hand side of (21), (21) becomes

$$E[V]\equiv\frac{\sigma^{-\sigma}(\sigma-1)^{\sigma-1}\Delta e_t}{(P_t)^{1-\sigma}\left(r_t+\frac{\dot{m}_t}{m_t}\right)}=b_{It}\bar{F}. \qquad (23)$$

where

$$\Delta\equiv\int_0^{B_L}B^{1-\sigma}\frac{g(B)\mathrm{dB}}{G(B_L)}+\tau^{1-\sigma}\int_0^{B_E}B^{1-\sigma}\frac{g(B)\mathrm{dB}}{G(B_L)} \qquad (24)$$

is the weighted average of productivities among production firms and the left-hand side of (23) is the ex-ante expected value of a production firm.

We turn to R&D activity which produces knowledge which in turn a new variety. The production factor is the labor. The production function for a new variety is given by

$$\dot{m}_t=\frac{L_R}{b_{It}\bar{F}}=\frac{(1+T^k)m_tL_R}{\bar{F}}, \qquad (25)$$

where we used $b_{It}=\frac{1}{(1+T^k)m_t}$ to derive the second equality

Following Baldwin and Robert-Nicoud (2008), we consider the Coe and Helpman case. Coe and Helpman (1995) found that the knowledge spillover from trade partner depends on the share of domestic imports in GDP. In other words, knowledge spillover from trade partner is larger in more open economies. Baldwin and Robert-Nicoud (2008) assumes that the international knowledge spillover depends on the fraction of foreign varieties that are imported, and it takes the form:

$$T^k=\left(\frac{B_E}{B_L}\right)^k. \qquad (26)$$

As we will show, the reason why Baldwin and Robert-Nicoud (2008) assumed the function form of international spillover takes (25) is that the fraction of foreign varieties imported are $\frac{\int_0^{B_E} m_t p_E(B) x_E(B) \frac{g(B)}{G(B_L)}}{\int_0^{B_L} m_t p_L(B) x_L(B) \frac{g(B)}{G(B_L)}} = \frac{(B_E)^{1+k-\sigma}}{(B_L)^{1+k-\sigma}}$. From (25) and (26), growth rate becomes

$$g = \frac{(1 + \left(\frac{B_E}{B_L}\right)^k) L_R}{\bar{F}}. \tag{27}$$

We turn to derive the labor market condition. The labor market is perfectly competitive, and it is used for R&D or manufacturing and the full employment condition is

$$L_t = L_R + L_x, \tag{28}$$

where

$$L_x = \int_0^{B_L} B x_L(B)\, m_t \frac{g(B)\mathrm{dB}}{G(B_L)} + \tau \int_0^{B_E} B x_E(B) m_t \frac{g(B)\mathrm{dB}}{G(B_L)} \tag{29}$$

is the labor used for manufacturing. The price index is given by

$$(P_t)^{1-\sigma} = m_t \left(\sum_{j=L,E} \int_0^{B_j} P_{jt}(B)^{1-\sigma} \frac{g(B)\mathrm{dB}}{G(B_L)} \right) = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} m_t \Delta, \;\; j = L, E. \tag{30}$$

where L_R represents the R&D researchers. We finished the explanation of the model.

2.7 Solving the Steady State

Following Baldwin and Robert-Nicoud (2008), we our restrict analysis to the steady state. We first derive the local market cutoff level. For its object, we rewrite the ex-ante expected costs of creating a new variety using (8), calculating integrate, and using (17) yields

$$\bar{F} = F_I \left(\frac{\bar{B}}{B_L}\right)^k + F_L \left[1 + \tau^{-k} \left(\frac{F_L}{F_E}\right)^{\frac{1+k-\sigma}{\sigma-1}}\right] \tag{31}$$

Substituting the ex-ante expected costs of creating a new variety (31), the free-entry condition (23), the ex-ante expected costs of creating a new variety (), the weighted average of the unit labor requirement of production firms, and the Pareto distribution into the local cut-off condition yields the unique solution of the local market cutoff level, determined by

$$\frac{1+k-\sigma}{k\left[1+\tau^{-k}\left(\frac{F_L}{F_E}\right)^{\frac{1+k-\sigma}{\sigma-1}}\right]} = \frac{F_L}{F_I\left(\frac{\bar{B}}{B_L}\right)^k + F_L\left[1+\tau^{-k}\left(\frac{F_L}{F_E}\right)^{\frac{1+k-\sigma}{\sigma-1}}\right]}. \tag{32}$$

The closed-form solution of the local cut-off level is given by

$$B_L = \left(\frac{(1+k-\sigma)F_I}{(\sigma-1)F_L}\right)^{\frac{1}{k}} \left[1+\tau^{-k}\left(\frac{F_L}{F_E}\right)^{\frac{1+k-\sigma}{\sigma-1}}\right]^{\frac{-1}{k}} \bar{B}. \tag{33}$$

The domestic market cutoff level is the same as with the exogenous international spillover economy type given by Baldwin and Robert-Nicoud (2008) and Gustafsson and Segerstrom (2010). We follow the explanation given by Furusawa and Konishi (2012). A decrease in the iceberg cost leads to more competition due to imports from abroad, and leads to a lower demand for each variety and higher demand for labor due to numeraire. Thus, a variety with lower productivity cannot serve the domestic market.

We now turn to derive the closed-form solutions for expenditure and economic growth. We obtain the first relationship between expenditure and economic growth from full employment. Using (6), (8), (29)-(30), and summing over productivities yields the demand for manufacturing labor as follows: $\frac{\sigma-1}{\sigma}E$. Moreover, we in turn obtain the demand for R&D labor. From (31) and (33), the ex-ante expected costs of creating a new variety is

$$\bar{F} = \frac{kF_L}{1+k-\sigma}\left[1+\tau^{-k}\left(\frac{F_L}{F_E}\right)^{\frac{1+k-\sigma}{\sigma-1}}\right]. \tag{34}$$

By (17), (25), and (34), the deman

d for R&D labor is $\frac{kF_L\left[1+\tau^{-k}\left(\frac{F_L}{F_E}\right)^{\frac{1+k-\sigma}{\sigma-1}}\right]g}{(1+k-\sigma)\left[1+\tau^{-k}\left(\frac{F_L}{F_E}\right)^{\frac{k}{\sigma-1}}\right]}$. Thus, the full employment condition is

$$L = \frac{\sigma-1}{\sigma}e + \frac{kF_L\left[1+\tau^{-k}\left(\frac{F_L}{F_E}\right)^{\frac{1+k-\sigma}{\sigma-1}}\right]g}{(1+k-\sigma)\left[1+\tau^{-k}\left(\frac{F_L}{F_E}\right)^{\frac{k}{\sigma-1}}\right]}. \tag{35}$$

The full employment condition is represented by line a with negative slope line with positive E-intercept in (e, g) plane, because an increase in e implies a larger number of manufacturing firms and a lower value of g a smaller number of researchers to maintain the equality. We obtain the second relationship between per capita expenditure and R&D difficulty from the free-entry condition using the definition of b_{It}, (23), (26), and (30)-(31) yields the free entry condition as follows:

$$\frac{e}{\sigma(\rho+g)} = \frac{kF_L\left[1+\tau^{-k}\left(\frac{F_L}{F_E}\right)^{\frac{1+k-\sigma}{\sigma-1}}\right]}{(1+k-\sigma)\left[1+\tau^{-k}\left(\frac{F_L}{F_E}\right)^{\frac{k}{\sigma-1}}\right]}. \tag{36}$$

The free-entry condition is an upward sloping curve that starts at the origin of the (e, g) plane, because an increase in e implies a larger benefit from creating a new variety and associated costs. Using these conditions, the closed-form solutions of per capita expenditure and economic growth, respectively, are given by

$$e = \frac{\sigma(\rho+\phi g)}{g+(\sigma-1)(\rho+\phi g)} \text{ and } g = \frac{1}{\sigma}\left[\frac{L(1+k-\sigma)\left[1+\tau^{-k}\left(\frac{F_L}{F_E}\right)^{\frac{k}{\sigma-1}}\right]}{kF_L\left[1+\tau^{-k}\left(\frac{F_L}{F_E}\right)^{\frac{1+k-\sigma}{\sigma-1}}\right]} - (\sigma-1)\rho\right], \tag{37}$$

respectively. We next analyze the effects of trade liberalization on the growth rate. We obtain higher R&D knowledge spillover from a foreign country and an increase in R&D cost by increasing the value of firms, which in turn increases the cost of creating a new variety through decreasing the domestic cutoff level and increasing the exporting cutoff level to satisfy the cutoff conditions.

2.8 Comparative Statistics

We next analyze the effects of trade liberalization on the growth rate. We obtain higher R&D knowledge spillover from a foreign country and an increase in R&D cost by increasing the value of firms, which in turn increases the cost of creating a new variety through decreasing the domestic cutoff level and increasing the exporting cutoff level to satisfy the cutoff conditions. The condition for an increase in the growth rate resulting from further exposure to trade is

$$\text{sign}\left(-\frac{\partial g}{\partial \tau} > 0\right)$$
$$= \left[1 + \tau^{-k}\left(\frac{F_L}{F_E}\right)^{\frac{k}{\sigma-1}}\left(\frac{F_E}{F_L}\right)\right] \tag{38}$$
$$-\left(\frac{F_E}{F_L}\right)\left[1 + \tau^{-k}\left(\frac{F_L}{F_E}\right)^{\frac{k}{\sigma-1}}\right] < 0$$

The growth rate increases (decreases) from further exposure to international trade when the sunk beachhead cost for the domestic market is strictly larger than the sunk cost for entering the foreign market. This is because there is a positive effect through endogenous international spillover, which depends on the sunk cost for entering the domestic market relative to that for the foreign market and a negative effect of an increase in R&D cost through changes in cutoff points, which depends negatively on the sunk cost for entering the foreign market relative to that for the domestic market. This result seems to be relevant to empirical evidence between globalization and economic growth. According to Davis and Harrigan (2011), both parameter cases of Baldwin and Robert-Nicoud (2008) and this paper are consistent with real world.

We turn to deriving a sufficient condition for gains from trade. Welfare is derived as $\rho U = \log E(t) - \log P(t) + \frac{g}{(\sigma-1)\rho}$. The effect of further exposure to trade is given by

$$-\frac{d}{dt}\rho U$$
$$= \underbrace{\frac{-L(1+k-\sigma)\frac{\partial \chi}{\partial \tau} - \rho k F_L \frac{\partial \Phi}{\partial \tau}}{L(1+k-\sigma)\chi + \rho k F_L \Phi} + \frac{\frac{\partial}{\partial \tau}\chi}{\chi}}_{-\frac{\partial \log E}{\partial \tau}} \underbrace{- \frac{1}{\sigma-1}\frac{\frac{\partial}{\partial \tau}\Phi}{\Phi}}_{+\frac{\partial \log P}{\partial \tau}}$$
$$+ \underbrace{\frac{1}{(\sigma-1)\rho}\frac{(1+k-\sigma)L\left[\chi\frac{\partial}{\partial \tau}\Phi - \Phi\frac{\partial}{\partial \tau}\chi\right]}{k\sigma F_L(\Phi)^2}}_{-\frac{\partial \frac{g}{(\sigma-1)\rho}}{\partial \tau}},$$

where $\chi \equiv 1 + \tau^{-k}\left(\frac{F_E}{F_L}\right)^{\frac{k}{\sigma-1}}$ and $\Phi \equiv \left[1 + \tau^{-k}\left(\frac{F_L}{F_E}\right)^{\frac{1+k-\sigma}{\sigma-1}}\right]$.

The first term is the effect of changes in aggregate expenditure and is ambiguous. The second term represents the effect of changes in the price index and is unambiguously positive. The final term is the effect of changes in the growth rates and is also ambiguous. When the elasticity of substitution between varieties is sufficiently small and the sunk cost for the foreign market strictly exceeds that for the domestic market, welfare increases because the former condition means the positive effect of decreases in the price index through increases in the weighted average of active firms dominates the negative effect of decreases in aggregate expenditure through the international knowledge spillover which further reduces the cost of R&D. The latter condition means that the growth rate rises.

3. Conclusions

This paper shows the necessary and sufficient conditions under which further exposure to international trade raises the growth rate and a sufficient condition for gains from trade in an endogenous growth model with firm heterogeneity, endogenous international spillovers, and international trade. When the sunk cost for the domestic market is strictly higher (lower) than that for the foreign market, the growth rate increases (decreases). When the elasticity of substitution between varieties is sufficiently small and the sunk cost for the foreign market is strictly larger than that for the domestic market, welfare increases. We can extend this model into a scale invariant endogenous growth model by introducing population growth and diminishing returns to knowledge in the R&D sector as in Jones (1995).

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