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Common Market and Equilibrium Growth

Cheng-te Lee
Department of International Trade, Chinese Culture University, Taiwan

Chen Fang
Department of International Trade, Takming University of Science and Technology, Taiwan

Kuo-hsing Kuo
Department of International Trade, Chinese Culture University, Taiwan

Abstract

We set up a two-sector equilibrium growth model with heterogeneous labor to analyze the impact of the creation of common market on the member countries' growth rate. We show that the economic integration will stimulate the backward country's economic growth. In addition, we prove that whether the economic integration can speed up the advanced country's economic growth or not depends on not only the average talent level of the backward country but also the size of the integrated-economy.

Correspondence: Cheng-Te Lee, Department of International Trade, Chinese Culture University, No. 55, Hwa-Kang Road, Yang-Ming-Shan, Taipei City 11114, Taiwan. E-mail: lzd4@faculty.pccu.edu.tw. We are grateful to the editor and the anonymous referees for useful comments on the earlier version of this paper. Any remaining errors are our responsibility.
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Contact: Cheng-te Lee - lzd4@faculty.pccu.edu.tw, Chen Fang - schwartz@takming.edu.tw, Kuo-hsing Kuo - kuo@staff.pccu.edu.tw.
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1. Introduction

The impact of the creation of a common market on economic growth has received considerable attention in recent years. According to the conventional view, an increase in the scale of market would lead to a rise in the growth rate of the member countries. Numerous empirical studies have examined the relationship between economic integration and economic growth. The empirical results reveal that the growth rates of the member countries may increase or decrease after integration. For example, Landau (1995), Henrekson *et al*. (1997), Gianetti (2002), Petrakos *et al*. (2003), Badinger (2005), Economidou *et al*. (2006), Kuştepeli (2006), McMorrow and Roger (2007), Cuaresma *et al*. (2008), and Becker *et al*. (2012) find that the growth rates of the member countries would increase after integration. In contrast, Haveman *et al*. (2001), Balcerowicz (2006), Badinger (2008), and Barrios and Strobl (2009) show that the growth rates of the member countries would decrease after integration. In other words, the effects of the creation of a common market on growth rates are inconclusive. A prominent example is that the creation of the European Union leads to a decrease in the growth rates of some advanced member-countries, for example, France, Germany, Sweden, and Italy. Therefore, the purpose of this paper is to construct a theoretical model that explains why the growth rates of some member countries can decline after integration.

Generally speaking, growth theory argues that human capital can accelerate economic growth. A great deal of theoretical and empirical literature analyzes the effects of the *level* of human capital on economic growth.[1] In contrast, papers exploring the relation between the *diversity* of human capital and economic growth are relatively few.[2] In his pioneering work, Das (2005) proves that the relation between growth rate and diversity may not be monotonically increasing by incorporating communication gaps among workers into the model. In addition, Lee and Huang (2014) postulate that, in addition to the conventional diversity effect, the degree of kurtosis of the human capital distribution also plays an important role in determining the growth rate of an economy. While Das (2005) stresses the importance of communication gaps among workers in a closed economy, this paper addresses that the creation of a common market would affect the relation between growth rate and the human capital distribution.

Intuitively, the creation of a common market will no doubt affect macroeconomic conditions in each of the members. That is, the human capital

[1] For the same notion, please see Lucas (1988), Rebelo (1991), Mankiw *et al*. (1992), Barro (1991), and Rivera-Batiz and Romer (1991).
[2] Bénabou (1996) and Takii and Tanaka (2009) demonstrate a positive link between the diversity of human capital and GDP.

distributions of the members may be altered due to the creation of a common market, which will influence the members' economic growth rate. Therefore, the main contribution of this paper is to develop a theoretical model where economic integration can lead to a reduction in growth through the mechanism of human capital. More specifically, the flow of labor between countries alters their talent distributions, which in turn alter growth.[3]

As a complement to the literature, we will extend Das (2005) to construct a two-sector equilibrium growth model with heterogeneous labor to analyze the impact of common market on members' economic growth. There are two sectors in each country, including the consumption-good sector and the R&D sector. As in Romer (1990), Das (2005) and Jones (2005), we consider the R&D sector producing new blueprints or ideas for these innovations and hence providing the engine of growth. We prove that, for the backward country, the creation of a common market will stimulate economic growth. In addition, for the advanced country, whether the creation of a common market can speed up economic growth or not depends on the size of the integrated-economy.[4]

The remainder of this paper is organized as follows. Section 2 presents an equilibrium growth model with heterogeneous labor and solves for the equilibrium growth rate. Section 3 discusses the impact of economic integration on growth. Section 4 concludes the paper.

2. The model

Consider the economy comprising two small open countries, A and B, each with a fixed amount of workers (denoted by $L^j,\ \ j \in \{A, B\}$). Each worker is endowed with a fixed level of talent n which is assumed to be heterogeneous and perfectly observable to all workers. Thus, the talent n could be viewed as the worker's endowment and/or years of schooling. Assume that talent's distribution is uniform with probability density function $\phi^j(n)$ for country j as shown below:

$$\phi^j(n) = \begin{cases} \dfrac{1}{b^j}, & if \ \ n \in [n^j_{\min}, n^j_{\max}], \\ 0, & otherwise, \end{cases}$$

where

$$n^j_{\min} = \bar{n}^j - \frac{b^j}{2} > 0, \ \ n^j_{\max} = \bar{n}^j + \frac{b^j}{2}.$$

[3] This point was suggested by an anonymous referee, to whom we are grateful.
[4] Ethier (1979, 1982) argues that gains from trade depend on the size of the world market.

The variable b^j represents the diversity of talent. The larger value of b^j implies that the talent's distribution is more diverse. Clearly, $n^j_{\min}$ and $n^j_{\max}$ represent the minimum and maximum talent levels respectively and $\bar{n}^j$ is the average talent level. Without losing generality, we assume $n^j_{\min} > 0$ which implies that every worker's talent is positive.

Suppose that both countries are similar in their production technologies and that there are two sectors in each country, a consumption-good sector *C* with supermodular technology and an R&D sector *S* with submodular technology.[5] Two tasks, *x* and *v*, are indivisible and are involved in the production process of each sector. Furthermore, each task is performed by exactly one worker. For simplicity, we let the production function of sector *C* be $F_C(n_x, n_v) = \eta \min\{n_x, n_v\}$, where the first task (task *x*) is performed by a worker with talent n_x and the second (task *v*) by a worker with talent n_v, while η denotes the technology level for the economy generated by the R&D sector. More specifically, the R&D sector *S* produces the new blueprints $\dot{\eta}$ (the time derivative of η), which accelerates technology improvement for producing the consumption-good *C*. On the other hand, as in Romer (1990) and Das (2005), the level of existing technology or the stock of blueprints has a positive influence on the output of R&D sector. Mathematically, we let the production function of sector *S* be $F_S(n_x, n_v) = \eta \max\{n_x, n_v\}$.

By the properties of the supermodular and submodular technologies, as proved by Kremer (1993) and Grossman and Maggi (2000), in equilibrium sector *C* employs workers with identical talent, so-called "skill-clustering", and sector *S* attracts the most-talented and least-talented workers, i.e., "cross-matching". Therefore, we define that the variables $\hat{n}^j$ and $m^j(\hat{n}^j) = 2\bar{n}^j - \hat{n}^j$ are the talent levels of the least-talented and most-talented workers in the *C* sector respectively. Obviously, $n^j_{\min} < \hat{n}^j < \bar{n}^j$. Corresponding to a given level of $\hat{n}^j$, the level of output per capita of good *C* (denoted by y^j_C) can be computed as follows:

$$y^j_C = \frac{Y^j_C}{L^j} = \int_{\hat{n}^j}^{m^j(\hat{n}^j)} F_C(n,n)\phi^j(n)dn = \frac{\eta \bar{n}^j}{b^j}(\bar{n}^j - \hat{n}^j)\,. \quad (1)$$

Because $L^j \int_{n^j_{\min}}^{n^j} \phi^j(n)dn$ is the measure of workers in the country *j* with talent less than or equal to n^j, the variable Y^j_C represents the total output of good *C*, as in Grossman and Maggi (2000).

We assume that the level of output per capita of good *S* (denoted by y^j_S) must be equal to $\dot{\eta}$,[6] and then the y^j_S can be computed as follows:

[5] For the implications of the supermodular and submodular technologies, please see Milgrom and Roberts (1990), Kremer (1993), Grossman and Maggi (2000) and Das (2005).

[6] Young (1998) points out that the scale effects mean that larger economies should grow faster.

$$y_S^j = \frac{Y_S^j}{L^j} = \dot{\eta} = \int_{n_{\min}^j}^{\hat{n}^j} F_S[n, m^j(n)]\phi^j(n)dn = \frac{\eta}{2b^j}(\frac{b^j}{2} - \overline{n}^j + \hat{n}^j)(\frac{b^j}{2} + 3\overline{n}^j - \hat{n}^j). \quad (2)$$

The variable Y_S^j represents the total output of good *S*.

The production possibility frontier of country *j* is strictly concave and its marginal rate of transformation (MRT^j) can be calculated as follows:

$$MRT^j = -\frac{\partial y_C^j}{\partial y_S^j} = -\frac{\partial y_C^j / \partial \hat{n}^j}{\partial y_S^j / \partial \hat{n}^j} = \frac{\overline{n}^j}{2\overline{n}^j - \hat{n}^j}. \quad (3)$$

Let equation (3) be equal to the relative supply price of good *S*, say $1/p_{supply}^j$. That is,

$$\frac{1}{p_{supply}^j} = \frac{\overline{n}^j}{2\overline{n}^j - \hat{n}^j}, \quad (4)$$

where p_{supply}^j represents the relative supply price of good *C*.

It is assumed that the private sector holds no assets and thus no private savings. All of the net income of the households is spent on good *C*. There is a government which imposes an income tax to fund the new blueprints in a competitive market. At the same time, these new blueprints would be freely offered to the *C* sector. In other words, the knowledge-wealth is financed indirectly by the private sector via a government taxing the households. The simplest asset demand account can help to abstract from intertemporal decision making by households and thus to focus on the problem of talents allocation, as in Das (2005). Further, we can find that the tax proceeds are equal to $\tau^j[y_C^j + (1/p_{demand}^j)y_S^j]$. Thus, $\tau^j[y_C^j + (1/p_{demand}^j)y_S^j] = (1/p_{demand}^j)y_S^j$, which can be rewritten as follows:

$$\frac{1}{p_{demand}^j} = \Gamma^j \frac{y_C^j}{y_S^j}, \quad \Gamma^j \equiv \frac{\tau^j}{1-\tau^j}, \quad (5)$$

where τ^j is the income tax rate. The variable p_{demand}^j is the relative demand price of good *C* and hence $1/p_{demand}^j$ represents the relative demand price of good *S*.

In the free-trade equilibrium, the world relative price of good *C*, *p*, is given and $p = p_{supply}^j = p_{demand}^j$. Substituting $p_{supply}^j = p$ into equation (4) can get $\hat{n}^j = (2-p)\overline{n}^j$ (time-invariant) and then substituting $\hat{n}^j = (2-p)\overline{n}^j$ into equations (1) and (2) can solve the relative supply of good *S*. Again, by substituting $p_{demand}^j = p$ into equation (5), the relative demand of good *S* can also be obtained. As in the above analysis, $\hat{n}^j$ is independent of time in the free-trade equilibrium. By differentiating

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Therefore, the main purpose of the assumption is to eliminate the scale effects. For the same specification, please also see the Equation (3) of Das (2005).

equation (1) with respect to time, we can derive that the growth rate of consumption good is $g^j = \dot{\eta}/\eta$. Hence, combining equation (2) with $\hat{n}^j = (2-p)\bar{n}^j$ and eliminating $\hat{n}^j$, we can find the growth rate of country *j* as follows:

$$g^j = \frac{1}{2b^j}[\frac{b^j}{2} + (1-p)\bar{n}^j][\frac{b^j}{2} + (1+p)\bar{n}^j]. \tag{6}$$

There are no transitional dynamics. Finally, we substitute $\hat{n}^j = (2-p)\bar{n}^j$ into $n^j_{\min} < \hat{n}^j < \bar{n}^j$ to derive the range of *p* as follows:

$$1 < p < 1 + \frac{b^j}{2\bar{n}^j} < 2.$$ [7]

In summary, when the terms of trade (*p*) is given, the small open economy can find a critical point, $\hat{n}^j$, and then derive the growth rate.

3. The creation of a common market and growth

A common market is one of several different types of economic integration which means that some countries join together to create a larger economic entity allowing free trade and free labor movement between member-countries. In this paper, assume that countries *A* and *B* join together to create a common market, and hence workers can be mobile freely between countries *A* and *B*. With that, we will analyze the impact of the creation of a common market on economic growth.

After creating a common market, the free movement of workers between countries *A* and *B* would lead to the changes of the labor forces and the talent's distributions. We make use of the superscript "*I*" to denote the variables after creating a common market. Therefore, L^I is the measure of labor forces ($L^I = L^A + L^B$) and $\phi^I(n)$ represents the probability density function of talent. We assume that $n^I_{\min} = \bar{n}^I - (b^I/2)$ and $n^I_{\max} = \bar{n}^I + (b^I/2)$ are the minimum and maximum talent levels respectively, where the variable $\bar{n}^I$ is the average talent level and the variable b^I denotes the diversity of talent after creating a common market.

For simplicity and without losing generality, suppose that the diversities of talent and the measures of labor forces in countries *A* and *B* are identical, i.e., $b^A=b^B=b$ and $L^A=L^B=L$. Therefore, the $\phi^I(n)$ will depend on the average talent levels of countries *A* and *B*. For simplicity, we assume that the $\phi^I(n)$ is also the uniform distribution. Thus, there are two cases considered in Sections 3.1 and 3.2.

Because the $\phi^I(n)$ is also a uniform distribution, making use of the analytical method of Section 2 can derive the g^I representing the growth rate after creating a common market as shown below:

[7] The assumption of $n^j_{\min} > 0$ implies that the relationship of $(b^j/2\bar{n}^j) < 1$ holds.

$$g^I = \frac{1}{2b^I}[\frac{b^I}{2} + (1-p)\overline{n}^I][\frac{b^I}{2} + (1+p)\overline{n}^I]. \quad (7)$$

As mentioned earlier, the average talent levels in countries *A* and *B* will play an important role in determining the $\phi^I(n)$. Therefore, Sections 3.1 and 3.2 will analyze the impact of the creation of a common market on economic growth under identical and different average talent levels respectively.

3.1 The creation of a common market with identical countries

Suppose that countries *A* and *B* are identical before economic integration. In other words, the average talent levels in countries *A* and *B* are identical, i.e., $\overline{n}^A = \overline{n}^B = \overline{n}$. After economic integration, the probability density function $\phi^I(n)$ would be:

$$\phi^I(n) = \begin{cases} \frac{1}{b}, & \textit{if} \;\; n \in [n^I_{\min}, n^I_{\max}], \\ 0, & \textit{otherwise}, \end{cases}$$

where

$$n^I_{\min} = \overline{n} - \frac{b}{2}, \;\; n^I_{\max} = \overline{n} + \frac{b}{2}.$$

Note that the probability density functions of talent are identical before and after economic integration when countries *A* and *B* are identical, i.e., $\phi^I(n) = \phi^A(n) = \phi^B(n) = 1/b$. Therefore, by substituting the relationships of $b^A=b^B=b^I=b$ and $\overline{n}^A = \overline{n}^B = \overline{n}^I = \overline{n}$ into equations (6) and (7), we can derive the differences of growth rates before and after the integration for countries *A* and *B* respectively as following:

$$g^I - g^A = g^I - g^B = 0. \quad (8)$$

Obviously, from equation (8), we can infer that, if countries *A* and *B* are identical, the growth rates of countries *A* and *B* remain unchanged after creating a common market and hereby yield the Lemma 1 as follows:

Lemma 1. *The creation of a common market involving two identical countries does not impact on the economic growth of these countries*.[8]

3.2 The creation of a common market with advanced and backward countries

[8] In the Grossman and Maggi (2000) paper, trade occurs because of cross-country differences in the distributions of talent. No trade occurs if countries are identical. How does having factor mobility change the results in Grossman and Maggi? Because having factor mobility in Grossman and Maggis' model does not affect the talent distributions of two identical countries, the results in Grossman and Maggi would remain unchanged. In addition, if having factor mobility leads to an increase in the talent's diversity of a country, then the country has comparative advantage in the R&D sector *S*, which is the same as the results in Grossman and Maggi. This point was suggested by an anonymous referee, to whom we are grateful.

It is now assumed that country *A* is an advanced country with a larger average talent level than country *B*, a backward country with a lower average talent level such that $n^A_{\min} = n^B_{\max}$, $\bar{n}^A = \bar{n} + b$ and $\bar{n}^B = \bar{n}$. This implies that the talent distributions of the two countries are stacked back to back while having the same range. Hence, we have Assumption 1 as follows:

Assumption 1. The talent distributions of member countries are stacked back to back.[9]

Therefore, after creating a common market, the probability density function $\phi^I(n)$ would be:

$$\phi^I(n) = \begin{cases} \dfrac{1}{2b}, & if\ \ n \in [n^I_{\min}, n^I_{\max}], \\ 0, & otherwise, \end{cases}$$

where

$$n^I_{\min} = n^B_{\min} = \bar{n} - \frac{b}{2},\ \ n^I_{\max} = n^A_{\max} = \bar{n} + \frac{3b}{2}.$$

Note that the integration of advanced and backward countries would lead to the changes of the probability density functions of talent and the average talent levels, i.e., $\phi^I(n) = 1/2b$ and $\bar{n}^I = \bar{n} + b/2$. Again, by substituting the relationships of b^A=b^B=b, $\bar{n}^A = \bar{n} + b$ and $\bar{n}^B = \bar{n}$ into equation (6), we can obtain the growth rates of countries *A* and *B* before the integration as follows:

$$g^A = \frac{1}{2b}[\frac{b}{2} + (1-p)(\bar{n}+b)][\frac{b}{2} + (1+p)(\bar{n}+b)], \tag{9a}$$

$$g^B = \frac{1}{2b}[\frac{b}{2} + (1-p)\bar{n}][\frac{b}{2} + (1+p)\bar{n}]. \tag{9b}$$

By substituting the relationships of b^I=2b and $\bar{n}^I = \bar{n} + b/2$ into equation (7), we can find the growth rate after creating a common market as follows:

$$g^I = \frac{1}{4b}[b + (1-p)(\bar{n} + \frac{b}{2})][b + (1+p)(\bar{n} + \frac{b}{2})]. \tag{9c}$$

It will not be difficult to calculate the differences of growth rates before and after the integration for countries *A* and *B*, respectively. First, we consider the effect of the integration on country *B*'s growth rate. From equations (9b) and (9c), we can derive the difference of growth rates for country *B* before and after the integration as follows:

[9] The existing theoretical results show that an increase in diversity would lead to a rise in growth rate. Assumption 1 implies that the integrated economy owns the largest diversity. Therefore, the growth rate of the integrated economy with Assumption 1 would be larger than that with overlapping talent distribution. This point was suggested by an anonymous referee, to whom we are grateful.

$$g^I - g^B = \frac{1}{4b}[(\overline{n} - \frac{b}{2})^2 (p^2 - 1) + \frac{b^2}{2}(4 - p^2)] > 0 . \tag{10}$$

Equation (10) claims that the impact of the creation of a common market on the growth rate for backward country is positive. The economic intuition is that rises in the diversity of talent and the average talent level after integration, from the backward country's point of view, will lead to more output of good *S* and hence stimulate growth.

Next, we will explore the effects of the integration on country *A*'s growth rate. From equations (9a) and (9c), the difference of growth rates for country *A* before and after the integration is as follows:

$$g^I - g^A = \frac{b}{8[\Omega^2(b,\overline{n}) - 1]}[p + \Omega(b,\overline{n})][p - \Omega(b,\overline{n})] , \tag{11a}$$

where

$$\Omega(b,\overline{n}) = (1 + \frac{2b^2}{4\overline{n}^2 + 12b\overline{n} + 7b^2})^{0.5}, \ 1 < \Omega(b,\overline{n}) < 2 . \tag{11b}$$

Therefore, we get

$$g^I - g^A \begin{Bmatrix} > \\ = \\ < \end{Bmatrix} 0 \text{ , if } \begin{cases} \Omega(b,\overline{n}) < p < 2 \\ p = \Omega(b,\overline{n}) \\ 1 < p < \Omega(b,\overline{n}) \end{cases} . \tag{11c}$$

Equation (11c) indicates that whether the growth rate for country *A* after integration rises or not depends on the world price *p*, which in turn can be described in Figure 1. As we can see from equation (11b), the factors affecting the critical point $\Omega(b,\overline{n})$ include the diversity of talent (*b*) and the average talent level ($\overline{n}$). However, under certain situation as has been considered in this subsection, the only difference of countries *A* and *B* is the average talent level. Therefore, we will analyze the impact of the average talent level on the critical point. From equation (11b), we can find that the higher value of $\overline{n}$ would lead to a lower critical value of $\Omega(b,\overline{n})$.[10] As we can observe from Figure 1, when the average talent level $\overline{n}$ rises, the critical point $\Omega(b,\overline{n})$ will shift left. That is to say, the higher the average talent level for backward country is, the more possible an increase in the growth rate for advanced country after integration will be. As in the above analysis, these features are summarized as Proposition 1:

Proposition 1. *The creation of a common market has a positive effect on the growth rate of the backward country, but has an ambiguous effect on the growth rate of the advanced country*.

[10] $\partial\Omega(b,\overline{n}) / \partial\overline{n} = -\{(3b + 2\overline{n})[\Omega^2(b,\overline{n}) - 1]^2\} / [b^2\Omega(b,\overline{n})] < 0$.

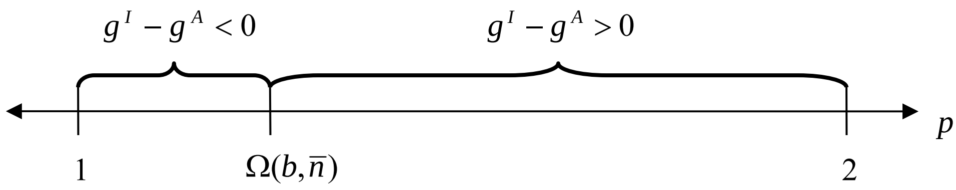

Figure 1. Terms of trade and growth rate for advanced country

Finally, suppose that the integration of countries *A* and *B* creates an economic unit that is large enough to alter the world price. Appendix proves that the integration will make the relative output of good *S* rise, i.e., $y_S^I / y_C^I > y_S^B / y_C^B > y_S^A / y_C^A$. As a result, for the integrated-economy, the world relative price of good *C* (*p*) will increase. Thus, as we can observe from Figure 1, the probability of the terms of trade, *p*, locating between ($\Omega(b,\bar{n})$, 2) is large. That is to say, the larger the integrated-economy is, the more possible a rise in the growth rate for advanced country after integration will be. Therefore, this result is summarized in the following corollary.

Corollary 1. *The larger the integrated-economy*, *the more likely it is that the creating a common market will speed up economic growth for advanced country*.

4. Conclusion

By using a two-sector equilibrium growth model with heterogeneous labor, we have analyzed the growth effects of economic integration referring to common market. We demonstrate that the creation of a common market will stimulate the backward country's economic growth. In addition, we prove that the larger the integrated-economy is, the more likely it is that the creation of a common market can speed up the advanced country's economic growth. However, our results have sharp contrasts to the one by Walz (1998) who shows that the deepening integration might lead to a reduction in growth due to migration for unskilled labor or emigration for skilled labor. While Das (2005) considers the growth effects of a closed economy, we analyze the growth effects of economic integration. Finally, our results are the same as Lee (2009) and Lee *et al*. (2013).

Some policy implications can be drawn from our results. From the viewpoint of the backward country, joining in a common market is the best policy. However, in order to raise the growth rate, the advanced country must try to enlarge the scale of the integrated-economy.

It should be worth noting here that the assumption of uniform talent distribution is to simplify the analysis by using the simplest symmetrical distribution to highlight the growth effects of the creation of a common market. Releasing the assumption (e.g. the cases of the mean-preserving spread and the overlapping distribution) will complicate the analysis severely. Further extension study on these directions should be worthwhile.[11]

Appendix Derivations of the relative outputs before and after economic integration under advanced and backward countries

In this Appendix, we will derive the relative outputs before and after economic integration under advanced and backward countries. First, we describe the relative supply of good *S* before integration. In the free-trade equilibrium, the world relative price of good *C*, *p*, is given. Therefore, substituting $p^j_{supply} = p$ into equation (4) can get $\hat{n}^j = (2-p)\overline{n}^j$ and then by substituting $\hat{n}^j = (2-p)\overline{n}^j$ into equations (1) and (2), we can obtain the relative supply of good *S* (denoted by y^j_S / y^j_C) for country *j* before integration as follows:

$$\frac{y^j_S}{y^j_C} = \frac{[(1+\frac{b^j}{2\overline{n}^j})]^2 - p^2}{2(p-1)}. \tag{A.1}$$

Second, after the integration, under certain situation as will be considered in this paper, the $\phi^I(n)$ will also be an uniform distribution. Therefore, by using the analytical method earlier, we can find the relative supply of good *S* (denoted by y^I_S / y^I_C) after the integration as shown below:

$$\frac{y^I_S}{y^I_C} = \frac{[(1+\frac{b^I}{2\overline{n}^I})]^2 - p^2}{2(p-1)}. \tag{A.2}$$

Finally, assume that countries *A* and *B* represent advanced and backward countries respectively and that they are different only in their average talent levels i.e., $\overline{n}^A = \overline{n} + b$ and $\overline{n}^B = \overline{n}$. By substituting the relationships of $b^A = b$ and $\overline{n}^A = \overline{n} + b$ into equation (*A*.1), we can obtain the relative supply for country *A* before integration as shown below:

$$\frac{y^A_S}{y^A_C} = \frac{[1+\frac{b}{2(\overline{n}+b)}]^2 - p^2}{2(p-1)}. \tag{A.3}$$

Similarly, by substituting the relationships of $b^B = b$ and $\overline{n}^B = \overline{n}$ into equation

[11] This point was suggested by an anonymous referee, to whom we are grateful.

(A.1), the relative supply for country B before integration can be derived as follows:

$$\frac{y_S^B}{y_C^B} = \frac{(1+\frac{b}{2\overline{n}})^2 - p^2}{2(p-1)} . \tag{A.4}$$

After the integration, the relationships of $\overline{n}^I = \overline{n} + b/2$, b^I=2b and $\phi^I(n) = 1/2b$ hold. With that, from equations (A.2), we also can find the relative supply after economic integration as shown below:

$$\frac{y_S^I}{y_C^I} = \frac{(1+\frac{b}{\overline{n}+b/2})^2 - p^2}{2(p-1)} . \tag{A.5}$$

Without losing generality, we assume that every worker's talent is positive, i.e., $n_{\min}^I = \overline{n}^I - b^I/2 = \overline{n} - b/2 > 0$. By making use of $\overline{n} > b/2$, we obtain:

$$\overline{n} + \frac{b}{2} < 2\overline{n} < 2(\overline{n} + b) . \tag{A.6}$$

By using equations (A.3), (A.4), (A.5), and (A.6), we can find:

$$\frac{y_S^I}{y_C^I} > \frac{y_S^B}{y_C^B} > \frac{y_S^A}{y_C^A} . \tag{A.7}$$

Obviously, equation (A.7) indicates the order of the relative outputs before and after economic integration at any given world price.

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