Trade, Knowledge Spillover and Economic Growth - A Theoretical Implication from the Knowledge-driven Economic Growth Model -

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ABSTRACT

This paper considers a broader concept of economic integration in order to analyze the impact of integration on economic growth within the context of the knowledge-driven endogenous economic growth model. The equilibrium growth rate derived from the model implies that while increasing the flow of ideas from integration speeds up the long-run rate of growth, impact of trade liberalization is complicated and not decisive. The overall impact of economic integration on economic growth depends on various aspects of the economy which are related to its R&D investment such as knowledge spillovers, and industrial and market structures. The results of this paper suggest that policy makers need to consider international economic policy, market structure and industrial policy all at once, with special emphasis on the effect of firms' R&D activities when making decisions on economic integration.

Keywords: *Economic Integration, Endogenous Growth, Knowledge-based Economy*

1. INTRODUCTION

Since the 1990s, two trends have dominated the evolution of the world economy: Globalization and the rise of the Knowledge-based economy. In particular, there has been a significant transformation from an industrial to a post industrial knowledge-based economy in the recent global economy. Hence, the rise of the knowledge-based economy and the importance of knowledge to economies have been paid considerable amount of attention and discussed in recent years. Many scholars have tried to link the increasing level and role of knowledge in technological innovation with economic growth (e.g., Romer (1990), Barro and Sala-i-Martin (1995 & 1997)). Specifically, in the knowledge-based economy, productivity and economic growth are mainly determined by the rate of technical innovation from the accumulation of knowledge through a firm's intentional R&D investment. The emergence of knowledge as a factor of production is a distinguishing feature of this so-called "knowledge-based

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economy" or "new economy". Another important feature of the knowledge-driven economy is globalization, along with technological innovations, and globalization speeding up knowledge spillovers across countries. In other words, two key trends of the recent world economy, globalization and knowledge-based economy, are inter-related.

Since Grossman and Helpman's (1990) work on trade and innovation, there has been an attempt to model economic integration (i.e., globalization) and technological changes in the context of the knowledge-based economy. However, there are some models in which trade restrictions can slow down the worldwide rate of growth (e.g., Grossman and Helpman (1990), Rivera-Batiz and Romer (1991)). There are others in which they can speed up the worldwide rate of growth (e.g., Grossman and Helpman (1996)). Interestingly, the previous works have focused largely on trade in goods in economic integration. However, the flow of knowledge has a more important implication in the knowledge-based economy because a key engine of growth in this model is the accumulation of knowledge. Also, economic integration refers to the flow of ideas, as well as trade in goods and services. Even though Rivera-Batiz and Romer (1991) in the knowledge-driven R&D model consider both flows of ideas and trade in goods, they analyze them separately.

In this paper, I consider a theoretically-broader notion of integration based on both flows of ideas and trade in goods simultaneously to examine the impact of economic integration in a broader notion on economic growth. To consider the knowledge-based economy along with economic integration, I adopt the knowledge-driven R&D model from Rivera-Batiz and Romer (1991) and generalize the model with allowing flows of ideas and at the same time trade of goods. By doing so, I generalize impact of economic integration on economic growth within the context of the knowledge-based economy.

A generalized form of the equilibrium growth rate derived from the model implies that while increasing flow of ideas speeds up the long-run rate of growth, impact of trade liberalization in goods on economic growth is more complicated. Through trade openness, increasing the varieties of intermediate inputs enhances economic growth through higher productivity in technology development. Also increasing competition induces productivity growth from domestic firms' increasing efficiency, but trade liberalization may slow down the rate of growth due to increasing competition in intermediate input markets and reducing incentive for the firm's R&D activity after integration. Increasing competition reduces monopoly power which motivates the firm's research, and as a result weakens incentive to invest in R&D activities, which serves as the engine of economic growth. Thus, whether or not economic integration yields a higher growth rate depends on whether or not the positive knowledge spillover effect dominates as a negative trade effect. Trade effect is also complicated by increasing varieties of intermediate inputs and decreasing incentive in R&D activity. Moreover, since flows of ideas cannot be separated from flows of goods, the overall impact of economic integration on economic growth is not decisive. This result could generalize to all possible cases from previous works in the effect of globalization on economic growth. The impact of economic integration on growth depends on various aspects of the economy such as knowledge spillovers,

international linkages, industrial and market structures. The results of this paper also suggest that when making decisions on economic integration, policy makers need to consider collectively, intellectual property, and international and industrial policies especially in firms' R&D activities, which is an engine of growth.

The remainder of this paper is organized as follows: section II describes key features of the knowledge-driven R&D growth model. In section III, I extend the model with consideration of economic integration, and derive the equilibrium growth rate to examine the impact of integration. The conclusion is presented in section IV.

II. KNOWLEDGE-DRIVEN R&D GROWTH MODEL

Under consideration is a model with knowledge-driven R&D based on Rivera-Batiz and Romer (1991). The model describes well the characteristics of the knowledge-based economy and its economic integration, because in this model a key engine of economic growth is technology progress from knowledge accumulation from firm's intentional R&D investment. The fundamental assumptions in this model are that many types of intermediate inputs are used in production, that these are not perfect substitutes, that intermediate inputs production occurs under imperfect competition, and that technological progress arises from the invention of a new variety of these goods through R&D activity.

Consider two countries, home and foreign. In the home country, output of final goods, Y , in a perfectly competitive industry is produced according to the familiar specification of Dixit and Stiglitz,

$$Y = AL^{1-\alpha} \left[\int_0^N \chi(i)^\alpha di + \int_0^{N^*} \chi^*(i^*)^\alpha di^* \right], \quad 0 < \alpha < 1,$$

where $A > 0$ is a constant productivity parameter, α is constant elasticity of substitution, L is labor employed, $\chi(i)$ and $\chi^*(i^*)$ are domestic and foreign intermediate inputs of variety i & i^* available. At a given point in time, there is a range $N(N^*)$ of domestic (foreign) distinct inputs varieties available. As in Romer (1990), these ranges are an index of the level of technology in each country; they are increased through R&D investment spending.

The maximization problem of producer of final goods can be represented as;

$$\max_{x, x^*} Y\{L, x(\cdot), x^*(\cdot)\} - wL - \int_0^N P_x(i)x(i)di - \int_0^{N^*} P_x^*x^*(i^*)di^*,$$

where w is wage, P_x refers to the price of domestic intermediates and P_x^* is the price of foreign intermediates.

Derived from first order necessary conditions for the above maximization problem, the implied derived demands for domestic and foreign inputs are:

$$X(i) = L \{A\alpha / P_x(i)\}^{1/(1-\alpha)}$$

$$X^*(i) = L \{A\alpha / P_x(I^*)\}^{1/(1-\alpha)} \quad (1.1)$$

Intermediate inputs production occurs under conditions of imperfect competition¹. For simplicity, we suppose that once invented, intermediate inputs of type j cost one unit of Y to produce. We are, in other words, using the assumption of the one-sector production model for the use of output as intermediate goods. Optimal pricing of the monopolists of the intermediate inputs sector sets the price P_j at each date to maximize the present value of the returns from discovering the j^{th} intermediate good as:

$$V(t) = \int_t^{\infty} (P_j - 1) \cdot X_j \cdot e^{-\bar{r}(v,t) \cdot (v-t)} dv,$$

where X_j is the total quantity produced at each date, and

$$\bar{r}(v,t) \equiv [1/(v-t)] \cdot \int_t^v r(w) dw$$

is the average interest rate between times t and v .

Therefore, the monopolist sets the price P_j at each date to maximize $(P_j - 1) \cdot X_j$, where $X_j = L \{A\alpha / P_j\}^{1/(1-\alpha)}$ from (1.1).

The solution for the monopoly price $P_j = P = 1/\alpha$.

An analogous procedure yields the pricing equation for the foreign intermediate input $P_j^* = P^*$.

III. ECONOMIC INTEGRATION AND GROWTH

Next, I introduce the feature of an imperfect global integration in trade of goods. Due to an imperfectly integrated goods market, I introduce a general index for the degree of integration " D " in trade of goods, following from a similar index in the approach of Samuelson (1954); delivering x units of a foreign intermediate to the home country requires sending xe^D units ($D > 0$; D depends on many factors such as the existence of trade barriers and non-trade barriers, transaction costs, transportation costs, etc.; $D = 0$ in perfectly integrated economy). Then, one can show that optimal pricing of the foreign monopolists implies $P_j^* = P^* = e^D/\alpha$. Interestingly, this implies that integration in the goods market affects the monopolistic price through the integration parameter " D ". In other words, openness in trade of goods influences market structure of intermediate inputs. This has a very important economic implication in the knowledge-driven endogenous growth model. In the model, a key engine of growth is that technology progresses from accumulation of knowledge, which a firm conducts through intentional R&D investment when monopolistic profit provides the incentive for invention of new technology (see footnote 1 for further discussion). More openness in the goods market increases competition in producing

¹ In order to motivate research, successful innovators have to be compensated in some manner. So, this model assumes that the inventor of the good j retains a perpetual monopoly right over the production and sale of good X_j , that uses his or her design. The flow of monopoly rentals will then provide the incentive for invention. For further discussion, see the analysis of behavior of the monopolist in inventing a new variety of products in Barro and Sala-i-martin (1995, Ch. 6).

intermediate goods and consequently weakens a firms incentive to invest in new technology development due to lower monopolistic profit, leading to a decrease in the growth rate. This is one negative impact of trade effects in economic integration on economic growth.

Substituting P and P^* into (1.1) for the expressions of $X(i)$ & $X^*(i^*)$, we can determine the equilibrium quantities of $X(i)$ & $X^*(i^*)$ as:

$$X(i) = L \cdot A^{1/(1-\sigma)} \cdot \alpha^{2/(1-\sigma)},$$

$$X^*(i^*) = L \cdot A^{1/(1-\sigma)} \cdot \alpha^{2/(1-\sigma)} \cdot e^{-D/(1-\sigma)}.$$

Then, the equilibrium level of output is determined as:

$$\begin{aligned} Y &= A \cdot L^{1-\sigma} [N \{L \cdot A^{1/(1-\sigma)} \cdot \alpha^{2/(1-\sigma)}\}^\sigma + N^* \{L \cdot A^{1/(1-\sigma)} \cdot \alpha^{2/(1-\sigma)} \cdot e^{-D/(1-\sigma)}\}^\sigma] \\ &= A^{1/(1-\sigma)} \cdot \alpha^{2\sigma/(1-\sigma)} L \cdot \{N + N^* \cdot e^{-\sigma D/(1-\sigma)}\} \\ &= A^{1/(1-\sigma)} \cdot \alpha^{2\sigma/(1-\sigma)} L \cdot \{N + f(D) \cdot N^*\}, \end{aligned} \quad (1.2)$$

where $f(D) = e^{-\sigma D/(1-\sigma)}$, $f(0)=1$, and $f'(D) < 0$. The above equation predicts that output is falling, all else equal, if less open to the domestic economy. If total factor

productivity is defined as Solow residual, $F = \frac{Y}{K^{1-\sigma} L^\sigma}$, then equation (1.2) leads to

$$F = \tilde{A} [N + f(D) N^*], \quad (1.3)$$

where $\tilde{A} = A^{1/(1-\sigma)} \cdot \alpha^{2\sigma/(1-\sigma)}$ is a country specific heterogeneous production parameter.

The above equation (1.3) in this model implies that domestic productivity (F) is directly related to the number of varieties of domestically-employed differentiated inputs from abroad which are conditioned on the degree of integration ($f(D)N^*$), because a new variety of foreign imports is directly employed in the domestic production. This is the other positive impact of trade effects directly on the economy's growth through technology diffusion. Foreign technology changes that arise from foreign R&D investment diffuses into domestic productivity directly through employing new varieties of import goods in domestic production.

For behavior of consumers, we assume standard Ramsey-type preferences over an infinite horizon:

$$U = \int_0^\infty \frac{C^{1-\sigma}}{1-\sigma} e^{-\rho t} dt,$$

where the parameter σ represents the elasticity of the marginal utility of consumption while its inverse equals the intertemporal elasticity of substitution. ρ represents the subjective rate of time preference.

Individuals maximize the infinite horizon utility function subject to budget

constraints. Consumer's dynamic optimization with usual Hamiltonian and transversality conditions produces First-order condition and then Euler equation (i.e., Ramsey rule)², and the consumer allocates consumption according to the rule:

$$r = \rho + \sigma \left(\frac{\dot{C}}{C} \right).$$

The only way in which these preferences enter the computation of the balanced growth equilibrium is through the relationship that they imply between the rate of growth of consumption and the market interest rate.

The process determining N and N^* in the research sector completes the description of the model for the computation of balanced growth. For simplicity, we assume that only labor is used in research. Output of a new variety is a function of labor employed and the stock of ideas that someone who does research has access to.³ As trade in goods, we assume that integration in the sense of flows of ideas is possible but partial due to the restriction in imperfect integration. Then, the output of designs for new varieties in the home country can be written as:

$$\dot{N} = \delta L_N N^{world} = \delta L_N [N + i(D)N^*],$$

where D is the degree of integration as described above, $i(D)$ refers to the effect of the degree of integration on flow of ideas; $0 \leq i(D) \leq 1$, $i(0) = 1$, and $i'(D) < 0$.

Free entry into the intermediate sector ensures that the discounted value of profit equals design costs P_N :

$$P_N(t) = \int_t^{\infty} \pi(s) e^{-\int_t^s r(s) ds} ds.$$

With assumption of constant r , we seek a solution characterized by a constant value for P_N , in which case the arbitrage equation reduces to:

$$P_N = (1/r) \pi(t) = (1/r) \{ (P-1) (X + X^*) \}.$$

Substituting $P = 1/\alpha$ into the above equation,

$$P_N = (1/r) \pi(t) = (1/r) [\{ (1-\alpha)/\alpha \} (X + X^*)].$$

Equating the marginal product of labor in research, $\delta P_N N^{world}$, to that in final goods, dY/dL_Y , and applying the relation of $X^* = X e^{-D/(1-\alpha)}$, yields:

$$\delta \left(\frac{1}{r} \right) \left(\frac{1-\alpha}{\alpha} \right) (1 + e^{-\frac{D}{1-\alpha}}) X \cdot N^{world} = (1-\alpha) L^{-\alpha} [N + N^* (e^{-\frac{\alpha D}{1-\alpha}})] X^{\alpha}$$

² Refer to the Appendix of Barro and Sala-i-Martin (1995) for more about consumer's dynamic optimization and Maximum Principle.

³ For different functional forms of research technology, see Rivera-Batiz and Romer (1990, Ch.2.B).

To solve L_Y , for the simplicity of computation, we assume free flows of ideas ($N^{world} = N + N^*$); no restriction on flows of ideas and only restriction on trade in goods, and impose the symmetry condition ($N/N^{world} = N^*/N^{world} = 1/2$). This yields a formula for L_Y in terms of r .

$$L_Y = \frac{\{1+f(D)\}r}{2\delta\alpha A\{1+f(D)\}^{1/\alpha}} \quad (1.4)$$

Under balanced growth, the growth rate g is determined by the rate of growth of the total number of inputs:

$$g = \delta L_N + \delta L_N^*$$

Again, with symmetry condition,

$$g = 2\delta L_N.$$

Inserting this into the expression for r from the preference condition gives:

$$r = \rho + 2\sigma\delta L_N.$$

To solve for L_N , combining this preference condition with the technological condition in (1.4), we obtain:

$$L_N = L - L_Y = L - \frac{\{1+f(D)\}}{2\delta\alpha A\{1+f(D)\}^{1/\alpha}} (\rho + 2\sigma\delta L_N)$$

$$L_N = \frac{2\delta\alpha A L - \rho h(D)}{2\delta\alpha A\{1+(\sigma/\alpha A)h(D)\}}, \text{ where } h(D) = \frac{1+f(D)}{1+f(D)^{1/\alpha}}.$$

Hence,

$$g = \frac{2\delta L - \Lambda \rho h(D)}{1 + \Lambda \sigma h(D)}, \text{ where } \Lambda = 1/\alpha A.$$

This reproduces the formula from River-Batiz and Romer (1991) for the growth rate with the presence of tariffs: $h(D)=f(\tau)$ if there exist only a tariff barrier on the trade of intermediate goods. Also, because $h(0)=1$, this becomes equal to the formula from Romer (1990) for the growth rate with a perfect integration economy.

Finally, relaxing the assumption of perfect flows of ideas, that is, the balanced rate of growth for an open economy under imperfect integration both in trade of goods and in flows of ideas is, from the above formula of growth rate:

$$g = \frac{\delta\{L+i(D)L^*\} - \Lambda \rho h(D)}{1 + \Lambda \sigma h(D)},$$

where $\Lambda = 1/\alpha A$, $h(D) = \frac{1+f(D)}{1+f(D)^{1/\alpha}}$, and D is the degree of integration as described

above, $i(D)$ refers to the effect of the degree of integration on flow of ideas; $0 \leq i(D) \leq 1$, $i(0)=1$, and $i'(D) < 0$.

This is a generalized form of the growth rate in the global economy. The generalized form implies that the economic growth rate in the global economy is non-linear in the degree of integration. More specifically, whether or not further economic integration yields higher growth depends on both the knowledge spillover effect (through $i(D)$) and trade-in-goods effect (through $f(D)$ and α). It implies that while increasing flow of ideas through knowledge spillover speeds up the long-run rate of growth, impact of trade liberalization in goods on economic growth is much more complicated. The integration effect of trade in goods interacts with the integration effect ($f(D)$) and market structure (α). Intuitively, trade liberalization enhances the varieties of intermediate inputs and as a result increases directly the productivity in the economy. On the other hand, more trade in intermediate inputs reduces monopolistic profit due to increasing competition in the industry and then weakens incentive to invest in R&D activities, which is the engine of endogenous growth, leading to a decrease in the growth rate. Furthermore, since flows of ideas cannot be separated from flows of goods, overall impact of economic integration on economic growth is not decisive, depending on relative importance of the positive effect and negative effect of integration on the economy. This analysis shows that it depends on various aspects of knowledge-spillover effect, trade-in-goods effect, and market competition effect.

IV. CONCLUSION

This paper analyzed the question of whether or not economic integration leads to higher economic growth in the context of the knowledge-driven endogenous economic growth model, focusing on a broader-theoretical treatment of economic integration. This theoretical implication is determined through various aspects of the economy including the degree of international linkages, knowledge spillovers, and industrial and market structures.

The finding of this analysis suggests that more economic integration is not always advantageous for economic growth. While knowledge spillover in flows of ideas facilitates economic growth, trading more in goods has a more complicated effect. In the knowledge-driven R&D model, an engine of growth is the firms incentive to invest in R&D activity, which crucially depends on monopolistic profit from market power. Thus, in examining the overall impact of economic integration on growth, we should not only consider increased market size and more varieties of goods, but also knowledge spillovers and changes in industrial and market structures after integration. Moreover, since flows of ideas cannot be easily separated from flows of goods, the overall impact of economic integration on economic growth is not decisive. This result could generalize all possible cases from previous work on impact of integration on economic growth. Impact of economic integration on growth depends on various aspects of the economy such as knowledge spillovers, and industrial and market

structures. The results of this paper also suggest that when making decisions on economic integration, policy makers need to consider intellectual property, as well as trade and industrial policies collectively, especially in firms R&D activities.

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