한국경제학보 제16권 제1호
The Korean Journal of Economics Vol. 16, No. 1(Spring 2009)

# North-South Trade and the Effects of Government Policy on Imitation and Innovation

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Abstracts

Grossman and Helpman (1991b)'s product cycle model focuses on the analysis of only the steady states (wide gap and narrow gap equilibrium) mainly due to analytical intractability of the model, and thus cannot explain the dynamic change in the wage gap between the North and the South. We develop a two-period version of Grossman and Helpman (1991b) and show that wage convergence between the North and the South takes place in our model, which is consistent with stylized facts. Our model also carries the following policy implications: 1) the subsidy on imitation in the South is effective in promoting imitation in the wide gap case while the effect is ambiguous in the narrow gap case; 2) the production subsidy is not an effective policy tool to enhance the level of imitation.

KRF Classification : B030800
Keywords : North-South trade, Wide gap, Narrow gap, Subsidy

## Ⅰ. Introduction

Since Vernon has introduced the concept of 'product cycle' in

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his celebrated 1966 paper, many trade economists have endeavored to make subsequent progress in this special topic. At the forefront of theoretical literature on product cycle, Krugman (1979) put forth a formal model which conveys the Vernon's original idea. Envisaging the world with two regions: advanced North and lagging South, he assumes that the North engages in innovations while the South only imitates what the North has invented. His main finding is that while an increase in the rate of both innovation and imitation increases the level of the world output (i.e., the sum of the Northern and the Southern output), the world distribution of income also alters. Thus, he concludes that 'imitation' is beneficial only from the perspective of 'global' efficiency. However, one important drawback of this model is that the rates of innovation and imitation are exogenous.

Later, to address the drawback of Krugman's model, Grossman and Helpman (1991b) endogenize the process of innovation and imitation, and show that even when the South can only imitate the Northern inventions, the North can grow faster when it trades with the South than when it remains economically isolated. In their model, however, they analyze only two steady states (i.e., the wide gap equilibrium and the narrow gap equilibrium, which are named after the wage gap between the North and the South) without explicating transitional dynamics.

Grossman and Helpman (1991b)'s model focuses only on the steady states mainly because the original model contains a system of non-linear differential equations that is analytically intractable. In this paper, we develop a two-period version of the North-South trade model à la Grossman and Helpman (1991b), and study the determination of innovation and imitation, wage convergence among the North and the South, and finally the impact of government policy on innovation and imitation. While our

theoretical findings are mostly consistent with Grossman and Helpman (1991b), our model makes an important point of departure from their model in that our model contains the simple transition that generates 'wage convergence' among the North and the South. We argue that such transition where wage convergence takes place reconciles well with empirical stylized facts in the real economy.[1)]

This paper is organized as follows. Section 2 introduces a two-period version of Grossman and Helpman (1991b)'s original model. We, then, discuss on the determination of innovation and imitation in Section 3. In section 4, we analyze the effects of various government policies on innovation and imitation. Conclusion is found in the last section.

## Ⅱ. A Two-period North-South Trade Model

Consider the world economy that consists of the North and the South. First, we assume that representative consumers in both the North and the South share the following Dixit-Stiglitz type utility function:

$$U^i = \log D_1^i + \beta \log D_2^i \qquad i = N, S \tag{2.1}$$

$$D_t^i \left[ \int_0^{n_t} x_t(j)^\alpha \right]^{\frac{1}{\alpha}} \qquad t = 1, 2 \quad 0 < \alpha < 1 \tag{2.2}$$

where $\beta$ denotes discount factor, $x_t(j)$ represents final good $j$ consumed in both the North and the South (produced in either

1) See Dollar and Wolff (1993) for empirical evidences for the wage convergence between the North and the South.

the North or the South but not in both due to specialization) at time $t$. The elasticity of substitution between any two final goods is $\epsilon = \frac{1}{1-\alpha}$. We can rewrite consumption index, $D_t^i$ as:

$$D_t^i = \frac{E_t^i}{P_{Dt}} \qquad i = N, S \tag{2.3}$$

where $E_t^i$ is aggregate spending of region $i$ at time $t$, $P_{Dt}$ denotes the price index of all existing final goods at time $t$. For simplicity, we normalize prices such that $E_t^N + E_t^S = 1$.

The representative consumer in each region maximizes his utility with two stages. At the first stage, he decides on the time profile of aggregate spending, and at the second stage, he chooses the composition of final goods given the level of aggregate spending in each period. Using (2.3), we can rewrite utility function as:

$$U^i = (\log D_1^i - \log P_{D1}) + \beta(\log D_2^i - \log P_{D2}). \quad i = N, S \tag{2.4}$$

We assume that representative consumer of region $i$ supplies one unit of labor in each period, and receives $w_t^i$ as wage, and that the wealth of representative agent in period 1 is $W_1$. Then, the life-time budget constraint of the representative consumer is:[2)]

$$E_1^i + \frac{E_2^i}{1+r} = w_1^i + \frac{w_2^i}{1+r} + W_1. \qquad i = N, S \tag{2.5}$$

First-order condition will generate the following Euler equation:

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2) For simplicity, we assume that the interest rates in the North and the South are the same as $r$.

$$E_1^i = \beta(1+r)E_2^i, \qquad i = N, S \tag{2.6}$$

Euler equation suggests that if $\beta$ is less than $\frac{1}{1+r}$, the time profile of aggregate spending is upward-sloping, and vice versa. However, since we normalized world spending as one, and the utility function is a logged form, each region's aggregate spending turns out to be a constant fraction of world spending in each period. Therefore, we have $\beta = \frac{1}{1+r}$ in equilibrium.

We now consider the production side of the economy. In this model, we assume that only the North develops new products (innovation) and the South merely copies some of the products developed in North (imitation). Once a Northern product is copied by the South, it is produced only by the Southern manufacturer who can take advantage of lower unit cost in the South.

We assume that each region has a history of innovation/imitation at the beginning of the period 1. Specifically, the number of products produced in each region prior to the period 1 is given by $(n_0^N, n_0^S, n_0)$ where the third element represents the total number of products (i.e., the sum of the first and the second elements) produced in the world prior to period 1.[3] We further assume that $n_0^N$ is greater than $n_0^S$. In period 1, we have only innovation activities in the North: the Northern firms invent $n^N$ new products that are produced from the same period. In period 2, we have only imitation activities in the South: the Southern firms copy $n^S$ products out of all the products existing in the North in period 1, and produce them in the same period. With these assumptions on timing, the number of products produced in each region and in each period is given by:

3) We will use this notation as convention in this paper.

$$(n_1^N, n_1^S, n_1) = (n_0^N + n^N, n_0^S, n_0 + n^N). \tag{2.7}$$

$$(n_2^N, n_2^S, n_2) = (n_0^N + n^N - n^S, n_0^S + n^S, n_0 + n^N). \tag{2.8}$$

While it costs $a$ units of labor for the Northern manufacturer to invent one new product, we assume that there exist knowledge spillovers in innovation activities, such that the cost of innovation is given by $\frac{a}{n_0}$ where $n_0$ is the total number of invented products. Similarly, there exist knowledge spillovers in imitation activity such that the cost of imitation is $\frac{a_m}{n_1^S}$ where $a_m$ denotes the unit labor requirement for the Southern firm to imitate one Northern product in the absence of knowledge spillovers. Then, free entry condition in both regions will dictate following arbitrage conditions:

$$v^N = \frac{w_1^N a}{n_0}. \tag{2.9}$$

$$v^S = \frac{w_1^S a_m}{n_1^S(1+r)}. \tag{2.10}$$

where $v^i$ is the value of firm (that is defined as the present value of expected profits) in region $i$. Since the Northern firms that invented new products in period 1 will not make any profits in period 2 with probability $\frac{n^S}{n_1^S}$, $v^N$ and $v^S$ can be rewritten as:

$$v^N = \pi_1^N + \frac{\pi_2^N}{(1+r)}(1 - \frac{n^S}{n_1^N}). \tag{2.11}$$

$$v^S = \frac{\pi_2^S}{(1+r)}. \tag{2.12}$$

Each product can be produced with one unit of labor in both the North and the South, and in every period LN and LS amount of labor are endowed in the North and the South respectively. Then, labor market equilibrium condition in each period and of each region will be:

**North:**

$$n_1^N x_1^N + \frac{an^N}{n_0} = L^N, \tag{2.13}$$

$$n_2^N x_2^N = L^N. \tag{2.14}$$

**South:**

$$n_1^S x_1^S = L^S, \tag{2.15}$$

$$n_1^S x_1^S + \frac{a_m n^S}{n_1^S} = L^S. \tag{2.16}$$

We now turn to the pricing behavior of Northern and Southern firms. We follow Grossman and Helpman (1991b) that considers the wide gap case and the narrow gap case. A Northern firm charges monopoly price for its product $\frac{w_t^N}{\alpha}$, unless the product is copied by Southern firms. However, if the Northern product is copied by a Southern firm, there will be a competition between the Southern firm and the Northern firm which developed the imitated product. If we assume that the Southern wage is lower than the Northern one, the Southern firm has price competitiveness. More specifically, the Southern firm can charge monopoly price, $\frac{w_t^S}{\alpha}$, when the wage gap between two regions are sufficiently 'wide,' that is, $\frac{w_t^S}{w_t^N} < \alpha$. On the contrary, the Southern firm will undercut the minimum price which can be charged by the Northern competitor, $w_t^N$, when the wage gap

between two regions are sufficiently 'narrow,' that is, $\frac{w_t^S}{w_t^N} > \alpha$. The former is referred to as the *wide* gap case, and the latter the *narrow* gap case.[4] According to these assumptions, the profit of Northern firm in each period is:

$$\pi_t^N = (1-\alpha)p_t^N x_t^N. \tag{2.17}$$

The profit of Southern firm will be:

**Wide gap:**

$$\pi_t^S = (1-\alpha)p_t^S x_t^S. \tag{2.18}$$

**Narrow gap:**

$$\pi_t^S = (1-\frac{w_t^S}{w_t^N})p_t^S x_t^S \tag{2.19}$$

where $x_t^i$ denotes per brand sales for firms located in each region, which can be calculated as:

$$x_t^i = \frac{(p_t^i)^{-\epsilon}}{n_t^i(p_t^i)^{1-\epsilon} + n_t^j(p_t^j)^{1-\epsilon}}. \qquad i = N, S \tag{2.20}$$

## Ⅲ. The Determination of Innovation and Imitation

In this section, we analyze the determination of innovation and imitation, $n^N$ and $n^S$. We start with the 'wide' gap case. From (2.9), (2.11), (2.13), (2.14), and (2.17), we find the equation for the

4) For details on the pricing behaviors, refer to Grossman and Helpman (1991 pp.284-285).

number of innovation, $n^N$:

$$n^N = \frac{(1-\alpha)n_0 L^N}{a}\left(1+\beta\frac{w_2^N}{w_1^N}\right)-\alpha n_0^N. \qquad (3.1)$$

Equation (3.1) suggests that the number of innovation, $n^N$ is higher as the degree of monopoly power is higher (i.e., lower $\alpha$). A higher discount factor $\beta$ and a higher inter-temporal wage in the North, $\frac{w_2^N}{w_1^N}$ will also induce a higher level of innovation. The lower cost of R&D (lower $a$) and the larger size of labor force will also be resulted in the higher level of innovation. The effect of the higher $n_0^N$ is ambiguous since the higher $n_0^N$ will lower the cost of innovation due to knowledge spillovers while the higher $n_0^N$ will deter innovation due to the resource competition effect in the North.

It is worthwhile to mention that no linkage between innovation and imitation is found in our model.[5] This is true since an increase in the number of imitations creates a following trade-off for the Northern firms. First, since the probability of being copied in period 2 increases with more imitations, the expected profits of a Northern firm will be lower accordingly. However, as more Northern products are copied by the Southern firms, the survived Northern firms will enjoy higher profits since they can take advantage of lower cost of production due to less severe resource competition. In our model, these two conflicting effects are exactly canceled off.

And, from (2.10), (2.12), (2.16), and (2.18), we find the equation

5) This point will become clearer when we consider the determination of imitation.

for the number of imitation, $n^S$:

$$n^S = (1-\alpha)\frac{n_0^S L^S}{a_m} - \alpha n_0^S. \tag{3.2}$$

We can interpret (3.2) in the similar manner as we do (3.1). The higher degree of monopoly power (lower $\alpha$), the larger size of labor force, and the lower cost of imitation (lower $a_m$) will foster imitation in the South. The effect of the number of pre-existing products, $n_0^S$ is ambiguous. When it is high, it will reduce the cost of imitation due to the knowledge spillover effect. However, a higher number of $n_0^S$ will result in a lower number of imitations due to the resource competition effect. From (3.2), we can confirm that imitation is determined independently of innovation and wages.

We can solve for the wages, $(w_1^N, w_1^S; w_2^N, w_2^S)$ using (2.13), (2.14), (2.15), (2.16), (2.20), and (3.1). The calculation to solve for the absolute wages is complicated. However, since we can focus on only the relative wages, $\frac{w_1^N}{w_1^S}$ and $\frac{w_2^N}{w_2^S}$ to draw qualitative conclusions from our model, we find the relative wages instead of the absolute ones. Using (2.13), (2.15), and (2.20), we can find the relative wage in period 1 that is determined in the following equation:

$$\left(\frac{w_1^N}{w_1^S}\right)^{\epsilon} = \left(\frac{L^S}{L^N - \frac{an^N}{n_0}}\right)\frac{n_0^N + n^N}{n_0^S}. \tag{3.3}$$

Similarly, using (2.14), (2.16), and (2.20), we can show that the relative wage in period 2 is determined in the following equation:

$$\left(\frac{w_2^N}{w_2^S}\right)' = \left(\frac{L^S - \frac{a_m n^S}{n_0^S}}{L^N}\right)\frac{n_0^N + n^N - n^S}{n_0^S + n^S}. \tag{3.4}$$

The interpretation of the determination of the relative wage is straightforward. For example, the relative wage in period 2 depends on the resource endowments, the number of products produced in each region, and the demand for resources from imitation activities. Since $\epsilon > 1$, the condition for the convergence of the relative wage (i.e., smaller relative wage in period 2) is given by:

$$\left(\frac{L^S}{L^N - \frac{an^N}{n_0}}\right)\frac{n_0^N + n^N}{n_0^S} > \left(\frac{L^S - \frac{a_m n^S}{n_0^S}}{L^N}\right)\frac{n_0^N + n^N - n^S}{n_0^S + n^S}. \tag{3.5}$$

Note that the condition (3.5) is always satisfied, which confirms wage convergence among the North and the South. More importantly, this further implies that we can have a transition from the wide gap case to the narrow gap case in our model.

We now turn to the 'narrow' gap case.[6] We do not have any change in the equation for innovation since the Northern firm makes zero profit as the product it produces is copied. The only change we have in the narrow gap case is the pricing behavior of the Southern firms. Remind that the Southern firm will undercut the Northern wage in the narrow gap case. Thus, we have change only in the equation for imitation. Using (2.10), (2.12), (2.16), and (2.19), we find the equation for imitation in the narrow gap case:

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6) We have two possible scenarios wherein the narrow gap case occurs: 1) the narrow gap case occurs in both periods; and 2) the wide gap case occurs in period 1 and the narrow gap case in period 2.

$$n^S = (1 - \frac{w_2^S}{w_2^N})\frac{n_0^S L^S}{a_m} - \frac{w_2^S}{w_2^N} n_0^S. \qquad (3.6)$$

Equation (3.6) is similar as equation (3.2) we find in the wide gap case. However, in equation (3.6), $\frac{w_2^S}{w_2^N}$ plays the role of $\alpha$ in equation (3.2), and therefore we can see that imitation is not independently determined from the relative wage. Furthermore, as the relative wage is smaller, the number of imitations is higher, which is intuitive since $\frac{w_2^S}{w_2^N}$ represents the cost advantage of the South over the North.

## Ⅳ. The Effects of Government Policy on Innovation and Imitation

In this section, we consider two different government policies: 1) subsidy on innovation and imitation and 2) production subsidy, which are intended to increase innovation and imitation indirectly, and study their impacts on innovation and imitation. First, we study the effects of subsidizing the cost of R&D activity in the North and the cost of imitation in the South. Specifically, we consider a case where the Northern government subsidizes the cost of R&D by the amount of $\phi^N a$, and assume that the economy is in the wide gap case. Then, the subsidy will transform equation (3.1) into:

$$n^N = \frac{(1-\alpha)n_0 L^N}{a(1-\phi^N)}\left(1 + \beta\frac{w_2^N}{w_1^N}\right) - \alpha n_0^N \qquad (4.1)$$

While it seems that the R&D subsidy increases the number of

innovations in a straightforward way, we have to take into account the fact that the subsidy has an impact on the wages before we jump to the conclusion. In fact, when the cost of investing in R&D becomes lower due to the government subsidy, the demand for labor increases in period 1, and thus the inter-temporal wage, $\frac{w_2^S}{w_1^N}$ falls. Thus, the overall effect of the subsidy is 'ambiguous.'

Now, we consider the government subsidy imposed by the Southern government. We assume that the Southern government subsidizes the cost of imitation by the amount of $\phi^S a_m$, and also that the economy is in the wide gap case. The new equation for imitation with the government subsidy is found as:

$$n^S = (1-\alpha)\frac{n_0^S L^S}{a_m(1-\phi^S)} - \alpha n_0^S \qquad (4.2)$$

Equation (4.2) suggests that the government subsidy on the cost of imitation *always* increases the number of imitations in the wide gap case. However, in the narrow gap case, we have different findings. Specifically, in narrow gap case, the equation for imitation will be given by:

$$n^S = (1-\frac{w_2^S}{w_2^N})\frac{n_0^S L^S}{a_m(1-\phi^S)} - \frac{w_2^S}{w_2^N} n_0^S \qquad (4.3)$$

As we can see from equation (4.3), the effects of government subsidy depend on the relative wage between the North and the South in period 2, $\frac{w_2^S}{w_2^N}$. Therefore, in order to find out the effects of the subsidy on imitation, we have to consider the effects of the subsidy on the relative wages in period 2 as well. Intuitively, the

government subsidy will increase the level of imitation, and thereby will increase the labor demand in the South in period 2. This suggests that the relative wage in period 2, $\frac{w_2^S}{w_2^N}$ will rise. Furthermore, since $\frac{w_2^S}{w_2^N}$ is greater than $\alpha$ in the narrow gap case, we conclude that the effects of subsidy on imitation will be 'smaller' in the narrow gap case than in the wide gap case.[7]

To summarize, the subsidy on imitation in the South is more effective in the wide gap case. Thus, our model carries important policy implications for the South. In the preceding analysis, we have already shown that we have wage convergence among the North and the South in our model. If the economy is in the wage gap case in period 1 and this situation continues until period 2 regardless of the wage convergence, the government subsidy on imitation in the South will be effective. This is true when the labor demand in the South is much lower than that in the North. However, if the wage convergence leads to the narrow gap case at least in period 2, the government subsidy will be less effective. Therefore, the government subsidy in the South is more effective as the economic gap between the North and the South is wider.[8]

Next, we consider the subsidy to manufacturers of differentiated products. Let $\phi_x$ denote the ad *valorem* rate of subsidy to price of differentiated products. Note that with the introduction of the

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7) Note that the effects can even be 'negative' depending on the parameters in the narrow gap. If so, our findings are consistent with those from the model of Grossman and Helpman (1991), where they show that the government subsidy on imitation is effective only in the wide gap case.

8) Another important point is that the level of imitation will be even negative if $\frac{w_2^S}{w_2^N}$ is close to one (high level of wage convergence) as we can see from equation (4.3). This suggests that imitation is not an 'ultimate' answer for the South. Imitation is effective only when the South can enjoy the cost advantage over the North.

production subsidy, manufacturers will face a higher level of wage, $(1+\phi_x)w_t^i$. We first consider the North. From equation (3.1), it is clear that permanent production subsidy (which is implemented in both periods) will be 'ineffective' since there would no change in the inter-temporal wage in the North. This is because the government subsidy increases not only the price but also the wage. An increase in the wage in period 1, which makes the cost of innovation higher, completely nullifies the effect of production subsidy. However, if the production subsidy is provided only in period 2, the number of innovations will increase.

We now consider the production subsidy in the South. We only focus on the narrow gap case since the production subsidy has no effects on imitation in the wide gap case (see equation (3.2)). In the narrow gap case, the subsidy to price will increase the Southern wage in period 2, and thereby the level of imitation will decrease since the wage gap becomes even smaller. Thus, we conclude that the production subsidy is not an effective policy tool to enhance the level of imitation.

## V. Conclusion

An important message from our model is that when South does not have significant cost advantage over the North (i.e., the wage gap is sufficiently narrow), the effort of the Southern government to increase the growth rate may fail. Recently, economies of NIEs (newly industrialized economies) in East Asia are struggling with the low growth rates. Many scholars point out the steady growth in wages in NIEs as the main culprit, and, in fact, many manufacturing industries are migrating into the South East Asian

countries or China that can harness their cost advantages. In such situation, our model prescribes that the government policy such as subsidy on production or imitation activities will not be any help, and rather, NIEs has better transform their economies from the imitation-oriented economy to the innovation-oriented economy to achieve a sustainable growth.

*Received: November 27, 2008. Revised: May 20, 2009. Accepted: May 25, 2009.*

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# 남북무역과 정부정책이 혁신과 모방에 미치는 효과

정 재 호*

## 논문초록

Grossman and Helpman (1991b)의 상품주기모형은 모형의 복잡성 때문에 steady state (큰 임금격차의 steady state와 작은 임금격차의 steady state)의 분석에만 초점을 맞추어서 남북간 임금격차의 동태적인 변화를 설명하지 못하고 있다. 본 논문은 Grossman and Helpman (1991b) 모형을 2기 버전으로 단순화하여 남북간의 임금이 시간이 지남에 따라 수렴함을 보인다. 단순화된 2기 모형의 주요한 정책적 함의는: 1) 개도국 정부의 모방에 대한 보조금은 남북간 임금격차가 큰 경우에는 모방을 증가시키는데 효과적이며 남북간 임금격차가 작은 경우에는 그 효과가 불확실하다. 2) 개도국 정부의 생산보조금은 모방을 증가시키는데 아무런 효과가 없다.

주제분류 : B030800
핵심 주제어 : 남북무역, 큰 임금격차, 작은 임금격차, 보조금

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