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TECHNOLOGICAL CATCH-UP AND REVERSED HOME MARKET EFFECTS

Toru KIKUCHI

Graduate School of Economics, Kobe University, Kobe, Japan

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Abstract: This note develops a model of trade that highlights the effects of technological catch-up due to falling communication costs as a driving force behind trade in goods with positive transport costs. It is shown that, given transport costs are sufficiently low, the impact of catch-up may be magnified through firms' location decisions: due to the reversed home market effects, firms in the developed country begin to move to the developing country.

Key words: Technological Catch-up, Reversed Home Market Effects.

1. INTRODUCTION

One of the most important trends in the global economy in recent decades has been a gradual erosion of the technological superiority of advanced countries: the composition of developing countries' exports has changed, creating increased competition, especially in high-technology goods (e.g., fine chemicals, complex electrical and electronic machinery). To this narrowing of the technology gap may be attributed the increasing relative importance of *information-intensive* inputs in economic activities, and the secular decline in communication costs. It is increasingly recognized that the technological catch-up by developing countries is achieved through improved communications networks (e.g., the Internet, satellite communications networks) and a consequent increase in the flow of ideas across borders. The World Bank (1995), for example, documents the evolution of both transport costs and communication costs; shipping and airfreight costs have bottomed out from the 1980s onwards, while there has been an even more dramatic fall in communication costs. According to this, Harris (1998) argues that an increased information flow between countries tends to equalize skilled labor productivity, which

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works in favor of developing countries. The effects on trade of technological catch-up due to falling communication costs are at the heart of the debate over international economic policy.

In the existing literature on international trade, however, there has not been a model that captures the impact of technological catch-up due to falling communication costs, while positive transport costs remain. This study develops such a model. Krugman (1986) investigated the impact of technological catch-up in a model of North-South trade. However, his focus was on the case in which there are no transport costs for goods and no 'home market effects'.[1] The present note, in contrast, focuses on the role of technological catch-up (in the information-intensive activities) with positive transport costs.

For this purpose, the present note builds a two-country (North and South) model of monopolistic competition with two production factors (skilled and unskilled labor), and establishes a causal link between technological catch-up and its consequence in terms of home market effects. Initially, North is assumed to produce a more-than-proportional share of the technology goods, a result of the national income differential due to the higher efficiency of skilled labor in North. Due to a decrease in communication costs and a consequent increase in the flow of information, however, the national income gap will be reduced through factor market interactions. Furthermore, if the magnitude of catch-up is big enough and transport costs are sufficiently low, firms in North might begin to move to South due to the drastic expenditure shifting.

2. THE MODEL

Consider a world with two countries (North and South), each with two factors (skilled labor, H, and unskilled labor, L) and two types of goods (a homogeneous good and a large variety of differentiated products). I call the differentiated products *technology goods*. Countries are similar in regard to households' preferences, but differ in terms of factor endowments and the efficiency of skilled labor. I refer to South as an 'unskilled-labor abundant country'. Both countries have the same amount of skilled labor in physical units, while the efficiency of skilled labor in North is higher than that in South. Introducing the efficiency parameter γ ($\gamma \leq 1$) and allowing '$*$' to denote variables for South, one can summarize the endowment conditions as follows:

$$L < L^* , \quad L + L^* = \bar{L} , \tag{1}$$

$$H^* = \gamma H , \quad \gamma \leq 1 , \tag{2}$$

where H^* refers to South's endowment of skilled labor in terms of efficiency units. These settings emphasize that North has some advantages in skill-intensive activity while South has a larger endowment of unskilled labor and can potentially catch-up in

[1] Home market effects are defined as follows: if two countries differ only in size, the larger country will end up with a more-than-proportional share of the production of increasing-returns goods with positive transport costs. See Helpman and Krugman (1985).

the efficiency of its skilled labor, as represented by an increase in γ. The central assumption is that γ is decreasing in communication costs s: $\gamma'(s) < 0$. That is, productivity of Southern skilled labor is presumed to be decreasing in s—an increased information flow due to lower s makes it easier to tap various Northern sources of knowledge. Throughout this section, I assume that s is exogenously given and simply use γ instead of $\gamma(s)$.

As in recent work in economic geography, international shipments of the technology goods incur the 'iceberg' effect of transport costs: for every t ($t > 1$) units shipped, only one unit arrives. Thus, the price of an imported variety to consumers in North will be tp^*, where p^* is the producer's price for South's product. I assume constant expenditure shares between the technology goods and the homogeneous goods, and that the subutility of the former takes the Dixit-Stiglitz form. The demand of consumers in North for a Northern variety and a Southern variety are

$$c = p^{-\sigma} P^{\sigma-1} \alpha I \,, \tag{3}$$

$$c' = (tp^*)^{-\sigma} P^{\sigma-1} \alpha I \,, \tag{4}$$

where α is the expenditure share for the technology goods, σ ($\sigma > 1$) is the elasticity of substitution, P is the price index for technology goods and I is the national income of North.

As for the supply side, the homogeneous good serves as the numeraire, and units are chosen so that one unit of unskilled labor produces one unit of output. Throughout the paper it is assumed that both countries produce the homogeneous good so that constant identical wages for unskilled labor hold.

To invent a new variety, skilled labor input is required; this means that the provision of highly differentiated technology goods requires skilled labor, which is referred to as an information-intensive factor. Skilled labor in the two countries has different efficiencies which are assumed to be dependent on the level of communication cost (s): 1 unit of Northern skilled labor is needed to develop a new variety, whereas $1/\gamma$ units of Southern skilled labor are required (see (2)). Each variety also has a unit cost of β in terms of unskilled labor: unskilled labor in both countries is equally efficient at producing technology goods. Skilled labor is brand-specific but does not need to be developed in the location where production actually takes place because there is free trade in designs. For example, if a variety developed in North is produced in South, the operating profits are repatriated to Northern skilled labor.[2]

Given a Dixit-Stiglitz specification with constant elasticity σ, each firm sets its price as $p/w_L = \beta\sigma/(\sigma - 1)$, where w_L is the reward to unskilled labor. By choice of units, one can set $\beta = (\sigma - 1)/\sigma$, to have[3]

$$p = w_L = p^* = w_L{}^* = 1 \,. \tag{5}$$

The reward to skilled labor, w_H ($w_H{}^*$), can be derived from the zero-profit condition:

[2] The possibility that one firm has option to produce technology goods in both countries is assumed away.

[3] Note that $w_L = w_L{}^* = 1$ holds because the numeraire is produced in both countries.

$$w_H = x/\sigma\,, \quad w_H{}^*/\gamma = x^*/\sigma\,, \tag{6}$$

where x (x^*) is output of products produced in North (South). Hence, the reward to skilled labor increases with output per brand.

Households are immobile so that their incomes are geographically fixed even though firms are not. When the design flows are unrestricted, the rewards for the skilled labor in efficiency units are equalized and $x = x^*$ holds in equilibrium (See (6)). National income of each country can be obtained as follows[4]

$$I = L + w_H H\,, \quad I^* = L^* + \gamma w_H H\,. \tag{7}$$

I assume that North is initially richer than South so that $I > I^*$.

The product market equilibrium requires that supply equal demand for each variety produced in North: $x = c + tc^{*\prime}$. By substituting (3), Southern counterpart to (4), and (7) into this condition yields the following equilibrium condition for Northern product and its Southern counterpart:

$$x = \frac{\alpha(L + w_H H)}{n + \tau n^*} + \frac{\tau\alpha(L^* + \gamma w_H H)}{\tau n + n^*}\,, \tag{8}$$

$$x^* = \frac{\tau\alpha(L + w_H H)}{n + \tau n^*} + \frac{\alpha(L^* + \gamma w_H H)}{\tau n + n^*}\,, \tag{9}$$

where $\tau \equiv t^{1-\sigma}$ ($\tau \leq 1$) measures the freeness of trade, and n (n^*) is the number of products available from North (South). Given both the level of communication costs (s) and the efficiency of skilled labor in South (γ), the total number of varieties, N, is fixed by the world endowment of skilled labor,

$$N \equiv n + n^* = H + H^* = (1 + \gamma)H\,. \tag{10}$$

Solving these conditions yields the equilibrium reward for skilled labor:

$$w_H(\gamma) = \frac{\alpha}{\sigma - \alpha}\frac{\bar{L}}{(1+\gamma)H}\,, \quad w_H' < 0\,. \tag{11}$$

Note that the level of transport costs does not affect the equilibrium reward.

By substituting (11) into (8) and (9), the proportion of firms in North becomes:

$$\frac{n}{N} = \frac{L - \tau L^* + [\alpha/(\sigma - \alpha)][(1 - \tau\gamma)/(1+\gamma)]\bar{L}}{(1-\tau)[\sigma/(\sigma - \alpha)]\bar{L}}\,. \tag{12}$$

When the national income of North is greater than that of South, the above condition implies that $(n/N) > (1/2)$ holds, which means that the location with the highest national income (i.e., North) will get the majority of the firms. This result is the standard 'home market effects' analyzed by Helpman and Krugman (1985), which is a natural consequence of both scale economies and positive transport costs.

[4] By using (6), one can obtain $w_H{}^* = \gamma w_H$.

3. 'REVERSED' HOME MARKET EFFECTS

In this section I consider the following scenario: given that the initial equilibrium has been attained, there is technological catch-up due to falling communication costs. From (12), one can see the consequence of the catch-up, which is captured as an increase in $\gamma(s)$ (i.e., a decrease in communication costs s). Catch-up implies that, due to an increased information flow, the total endowment of the skilled labor increases in terms of efficiency units. As the number of varieties increases while unskilled labor endowments remain unchanged, the quantity of each variety supplied decreases and the reward for skilled labor also decreases (see (11)). These factor market effects work in opposite directions in the two countries: national income in North decreases while that in South increases. Thus technological catch-up leads to a decrease in income differentials between North and South (see (7).)

Before turning to firms' location decisions in detail, I must draw attention to the relationship between transport costs and the net export of designs. Since n is the number of varieties produced in North and H is the number of varieties developed in North, one can measure the extent of the net export of Northern designs as[5]

$$H - n = H - \frac{(L - \tau L^*)(1+\gamma) + [\alpha/(\sigma-\alpha)](1-\tau\gamma)\bar{L}}{(1-\tau)[\sigma/(\sigma-\alpha)]\bar{L}} H \,. \tag{13}$$

Consider the effect of an increase in γ on $H - n$ by the differentiation:

$$\frac{d(H-n)}{d\gamma} = \frac{-L + \tau L^* + [\alpha/(\sigma-\alpha)]\tau\bar{L}}{(1-\tau)[\sigma/(\sigma-\alpha)]\bar{L}} H \,. \tag{14}$$

If $\tau < (>) [L(\sigma-\alpha)/(\alpha L + \sigma L^*)]$, then the sign of the (14) becomes negative (positive). There are two opposite effects that explain why changes in the net export of designs are ambiguous. On one hand, an increase in the number of Southern designs due to catch-up tends to reduce the attractiveness of a design itself. Hence it works to reduce the net export of Northern designs. On the other hand, firms tend to locate where incomes become higher (i.e., South), which increases the export of Northern designs. However, when τ is small (i.e., transport costs are high), firms will prefer to be close to their own markets rather than to be concentrated.[6] Thus, when transport costs are sufficiently high, the former effect dominates the latter effect and the net export of Northern designs decreases due to technological catch-up. Since my main concern is the analysis of technological catch-up with sufficiently low transport costs,[7] I concentrate on the case of $\tau > [L(\sigma-\alpha)/(\alpha L + \sigma L^*)]$ (i.e., transport costs are sufficiently low) in what follows.[8]

Now turn to the scenario. There exists a cutoff level for catch-up in South which equalizes both countries' national incomes:

[5] This is obtained by using (10) and (12).

[6] See Helpman and Krugman (1985).

[7] See discussion in Section 1.

[8] Of course, it is important to fully analyze the interaction of transport costs and technical catch-up. I would like to thank the referee for pointing this out.

$$\bar{\gamma} = [2\alpha L^* - \sigma(L^* - L)]/[(\sigma - \alpha)(L^* - L) + \alpha\bar{L}]. \qquad (15)$$

If there is a discrete jump in γ (i.e., from $\gamma(s_1) < \bar{\gamma}$ to $\gamma(s_2) > \bar{\gamma}$, $s_1 > s_2$), which reflects a technological improvement in Southern information intensive activities, the income differential will be reversed and firms' locations will be drastically changed: some of the varieties developed in North will be produced in South, which now has the highest expenditure level due to its relatively large amount of unskilled labor. This implies that North exports both designs and the homogeneous good while South becomes a net exporter of the technology goods. These effects, which I call *reversed home market effects*, are attributable to a combination of asymmetries in factor endowments and the presence of transport costs. The intuition is quite simple: if the technological lead of North matters less, the relative importance of the larger (unskilled) labor base of South will be highlightened.

Figure 1 illustrates this relationship. The line ll shows the share of Northern products (n/N). Point 1 shows the initial situation while point 2 is the situation after technological catch-up in South has taken place. From this figure, it is clear that the level of transport costs, as represented by t, determines the magnitude of the production shift. Line $l'l'$ depicts the case with relatively free trade (i.e., smaller t): when transport costs become lower, the sensitivity of the location decision to market size differentials increases because it is easier for firms to locate in the largest country and then export to the other country.[9] By using this figure, we can compare the impact of a decline

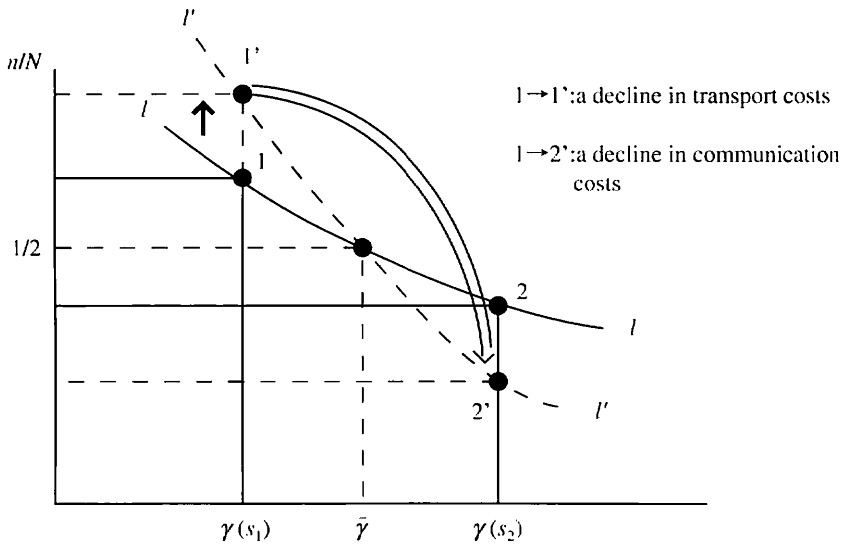

Figure 1.

[9] See Helpman and Krugman (1985).

in communication costs (s) to that of transport costs (t): two notable features emerge from this figure. First, if there is a decrease in transport costs while technology-gap remains unchanged, *industrial concentration* in North (e.g., from point 1 to point 1′) occurs. Second, if there is a technological catch-up due to falling communication costs, in contrast, a more substantial production shift (from point 1′ to point 2′) or *industrial diversion* occurs.

This note highlights the effects of technological catch-up due to falling communication costs as a driving force behind trade in goods with positive transport costs. It is shown that, given transports costs are sufficiently small, the impact of catch-up may be magnified through the firms' location decisions: due to the reversed home market effects, firms in North begin to move to South. These results have some importance for economic policy. If the magnitudes of cost reduction in transport costs and communication costs are different, then one of the first effects of technological catch-up by developing countries will be a drastic change in the firms' location choices and trade patterns.

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