Boomerang Effects or Wells Effects?

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As a home firm licenses technology abroad, foreign companies begin competing against home products. An attempt to enhance revenues by selling knowhow abroad might "boomerang" back to reduce profits. Foreign entry into the final goods industry, however, may stimulate home exports of intermediate goods to the foreign country ("wells effects"). This upstream expansion may partially of more than offset the profit loss in the home downstream industry. Net gains from technology licensing could go in either direction a priori. (*JEL* Classifications: F12, L13)

I. Introduction

The phenomenon of "boomerang effects" originally referred to the "imports in reverse" into Japan that would follow the overseas expansion of Japanese enterprises and the subsequent need to make adjustments in the domestic industry. The term further broadened to the case of exports of technology that would intensify the competition not only in the domestic market but also in third-country markets. Some cases often cited by Japanese press and businessmen are illustrative.

In the early 1970s, South Korea planned to build a large integrated steelmill whose construction was first offered to a consortium of Western steelmakers. That arrangement went unsettled due to an unwillingness to provide sufficient credit. Then Japanese steel firms stepped in and began supplying plant and equipment on good credit terms. Now the deal has come back to haunt them: POSCO is one of the most efficient steel firms in the world and finally in a position to

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Table 1
COMPARISON OF 1988 STEEL PRICES BY COUNTRY

Country	Steel Products ($ per ton)		
	Hot Coil	Plate	Cold Rolled Coil
Korea	320	326	451
Taiwan	385	385	473
United States	638	688	765
Japan	435	491	621

Source: Steers et al. (1989)

meet most of Korea's domestic demands, while Japanese steel exports are being cut back correspondingly. Japanese firms also face growing competition in third markets, especially in the United States and Southeast Asia. Japan has begun to import Korean steel. POSCO now produces high-quality steel and sells it on the world market, as can be seen in Table 1 at very competitive prices.

To take another example, a similar progression took place with Samsung Electronics Company, the largest electronics firm in Korea. Much of the firm's original equipment was supplied by Japanese companies; the result was the rise of the Korean electronics industry which was slowly threatening Japan's earlier supremacy. Korean producers in some industries have nearly driven their Japanese counterparts out of the market for simple items like radios, cassette recorders and black-and-white televisions and are challenging the market for color televisions and memory chips.

The above examples vividly illustrate the "boomerang effect"[1] in the 1980s. A firm ships plants and equipment abroad, which in time produce goods to replace its own exports. Then, as capacity expands and sophistication rises, these companies begin competing against home products in third-country markets and even in the home market. The short-term advantages of technology transfer, then are coming back and haunting the technology licensor.

This has been one of the hot issues between Japan and Asian NICs, especially in Korea in the 1980s. When firms in Korea want advanced technology transfers, Japanese businessmen and government bureaucrats have often been reluctant to provide their blueprints worrying about the possible boomerang effects against them. They argue that if a

[1]The "boomerang effect" is a term coined by Prof. Miyohei Shinohara of Japan in 1976. A good reference book on "Boomerang effect" is Shinohara (1982).

TABLE 2
IMPORT PENETRATION TO JAPAN BY ASIAN NICS FOR TOTAL MANUFACTURING

	Import Penetration Ratio			
	1970	1974	1979	1985
Asian NICs	0.24	0.69	0.82	0.75
Korea	0.08	0.31	0.33	0.30

Source: OECD (1988)

Table 3
TRADE BALANCE AMONG U.S., JAPAN AND KOREA

	A's exports to *B*/ *A*'s imports from *B*		
A *B*	1982	1985	1988
U.S.-Japan	24,185/36,546	26,009/66,684	42,267/90,245
Japan-Korea	4,869/3,270	7,159/4,144	15,442/11,827
U.S.-Korea	5,529/6,011	5,956/10,713	11,290/21,209

Source: Compiled from IMF (1989)

domestic firm licenses their knowhow to a foreign firm, the foreign licensee will expand its production, eventually exporting to the Japanese market and increasing competition with the original licensor. It is true that the expansion of Korean exports has decreased Japan's market share in the iron and steel, radio and textile industries. We cannot, however, predict adverse effects in other Japanese industries in general. As Table 2 shows, the import penetration of Asian NICs, especially Korea, to Japan has remained steady since the mid-1970s.

Korean economists often countered in the 1980s that Korea's trade deficit with Japan was actually worsening year by year, while her trade surplus with the US. was continuously widening. If we take (export-import)/(export + import) which is assumed to be k as an indicator of trade imbalance between two countries, as shown by Table 3, Korea's trade deficit with Japan worsened (from k =-0.917 in 1982 to k =-0.267 in 1985), whereas Korea's trade surplus with the U.S. soared sharply (from k = 0.042 in 1982 to k = 0.306 in 1988). This being the case, it may be that Japan was in effect indirectly exporting to the U.S. by exporting intermediate goods to Korea. From the perspective of an entire industrial structure, production expansion in the Korean down-stream market could stimulate exports of Japanese intermediate and capital goods to the technology importer.[2] For instance, as they began to make VCRs, Korean electronics firms further imported many expensive but indispensable parts like the VCR heads. This upstream expansion partially or overly offset the profit loss in the final goods industry. So it can be said that Korea might suffer from counter-boomerang effects if her exports to Japan and third country markets were less than her imports of intermediate and capital goods from Japan, that is, net gains in the technology-exporting country could go in either direction a priori.

II. A Model

The story of the paper was inspired by the Japan-Korea technology transfer debates. However, the results are not country specific and similar progress had been made between the U.S. and Japan or any developed and developing countries. For convenience of modeling, we approach this problem from the Japanese point of view by assuming that Japan is the home country and Korea the foreign. We also assume that there are only two countries, home and foreign in the world.

For convenience of exposition, we assume a process whereby a computer is assembled from RAM chips with labor; RAM chips are supplied by a home monopolist and labor is supplied in each country's competitive market. Production technology is that of a fixed proportion of chips and labor. The world computer market is integrated and firms in the downstream oligopoly have identical costs. The semiconductor firm in the home country chooses the price of RAM chips to maximize profit, and computer firms are price takers in the factor market. We assume that there are at least more than two downstream firms at home in order to avoid bilateral monopoly bargaining problems. Cournot competition is assumed in the final goods market in which firms compete in quantities. There are no production facilities to supply either intermediate or final goods in the foreign market before a new foreign firm enters the final goods market via a transfer of technology from the home country.

Our analysis proceeds by examining how a foreign entrant in the downstream influences the profits of downstream firms and upstream monopoly in the home country. The welfare effects of a foreign firm's downstream entry in the international context are considered consequently.

[2]This was aptly named as "Wells Effects" by Prof. Youngho Kim at Kyungbook University, Korea.

The integrated world demand for a computer is given by

$$p = D\,(Q), \quad Q = nq, \tag{1}$$

where $D'(Q) < 0$, Q = the industry output, n = the number of the downstream firms, and q = an individual firm's output.

A downstream firm maximizes its profit:

$$\pi^d = pq - c\,(w,\, r)\, q, \tag{2}$$

where r is the price of the RAM chips produced by the monopolist and the wage rate is given at w in each country's competitive labor market. $c\,(w,\, r)$ is the marginal cost of producing a computer.

The first order condition for a downstream firm yields

$$\frac{\partial \pi^d}{\partial q} = 0, \quad D(Q) + \frac{Q}{n} D'(Q) = c(w, r), \tag{3}$$

where $2D' + qD'' < 0$ is the second order condition required.

$Q = Q\,(n,\, r,\, w)$ is defined by the implicit function theorem, and the total cost of production is $Q{\cdot}c\,(w,\, r)$. By Shephard's Lemma, the total conditional factor demand is

$$X = \partial Q \cdot \frac{c(w, r)}{\partial r} = Q \cdot c_r(w, r). \tag{4}$$

An upstream semiconductor firm's profit is

$$\pi^u = \underset{r}{\text{Max}}\; Q\,(n, r)\; c_r\,(w,\, r)\,(r - r_0), \tag{5}$$

where r_0 is the marginal cost of producing intermediate goods (RAM chips).

The first order condition for the maximization of (5) yields

$$\frac{d\pi^u}{dr} = Q(n, r)c_r(w, r) + Q(n, r)c_{rr}(w, r)(r - r_0) + Q_r(n, r)c_r(w, r)(r - r_0) = 0. \tag{6}$$

From (6), r is implicitly defined: $r = \hat{r}\,(r_0,\, n,\, w)$.

The upstream firm's profit increases with one more firm enters the final good industry: $d\pi^u/dn > 0$, because $d\pi^u/dn = Q_n c_r (r - r_0)$ by the envelope theorem and

$$Q_n = \frac{\dfrac{Q}{n}}{n + 1 + Q\dfrac{D''(Q)}{D'(Q)}} > 0.$$

The denominator is positive from the stability condition in Seade (1982). Next, we check the entry entry effect on the price of the intermediate good: $dr/dn = -\pi^u_{nr}/\pi^u_{rr}$. The sign of π^u_{nr} determines that of dr/dn because $\pi^u_{rr} < 0$ from the second order condition of profit maximization (π^u). The intermediate goods' price is increasing with the new entry of a firm if the condition of $QQ_m > Q_rQ_n$ is satisfied[3].

The profit function in the downstream industry is derived:

$$\pi^d = \frac{-q^2D'\left(n+1+\dfrac{QD''}{D'}\right)}{n+1+\dfrac{QD''}{D'}},$$

where $-QD''/D'$ is the elasticity of the slope of demand.

In the downstream industry, a firm's profit falls with new entry of firms. The change in profit of a downstream firm as an additional foreign firm enters the market is given by:

$$\frac{\partial\pi^d}{\partial n} = \frac{D\partial q}{\partial n} + qD'\left(q + \frac{n\partial q}{\partial n}\right) - \frac{c\partial q}{\partial n}$$

$$= q^2D'\frac{2+\dfrac{qD''}{D'}}{n+1+\dfrac{nqD''}{D'}} < 0, \tag{7}$$

because $D' < 0$ and $2 + qD''/D' > 0$ from the second order condition of $\partial\pi^d/\partial q = 0$ and $n + 1\ nqD''/D' > 0$ from the stability condition.

Now we consider the possibility of technology licensing. The licensing of knowhow between firms in principle requires: (i) the existence of joint gains from sharing; and (ii) the resolution of a bilateral bargaining problem.[4] It is not the purpose of this paper to determine how licensing fees or royalties are established among home and foreign firms. We are only interested in how the new entry of foreign firms in the downstream industry influences the profits of firms in their multiple stages of pro-

[3]Taking the logs of (6) and (8) and differentiation them yields

$$\frac{\pi_r}{\pi} = \frac{Q_r}{Q} + \frac{c_{rr}}{c_r} + \frac{1}{r-r_0},\quad \frac{\pi_m}{\pi_n} = \frac{Q_m}{Q_n} + \frac{c_{rr}}{c_r} + \frac{1}{r-r_0}.$$

It follows from the above and $\pi_r = 0$ that $\pi_m/\pi_n = Q_m/Q_n - Q_r/Q$.
If $QQ_m > Q_rQ_n$, $\pi_m > 0$; $dr/dn > 0$.

[4]This point is mentioned in Chin and Grossman (1990).

duction as well as the welfare of the home country and the world. Therefore, we adopt the simplest assumption that an exporter of know-how gets a part of a licensee's profit: royalties = $\lambda \times$ profit, λ is a royalty rate.

Now we check whether the upstream profit gains at home can cover the profit loss of all the downstream firms in the home country which is equivalent to the boomerang effects minus royalty revenues. The upstream profit change and the negative externalities to the downstream firms sum to

$$\frac{\partial \pi^u}{\partial n} + \frac{n \partial \pi^d}{\partial n} = q \frac{c_r(r - r_0) - n(p - c)\left(2 + \dfrac{qD''}{D'}\right)}{n + 1 + \dfrac{nqD''}{D'}}. \tag{8}$$

It may be argued that the net profit increases depending on the condition that $c_r\,(r - r_0) - n\,(p - c)\,(2 + qD''/D') > 0$; the numerator of (8) is more likely to be positive[5] (negative) if the demand curve of the downstream industry is more convex (concave), i.e. $D'' > 0$ $(D'' < 0)$.

Net profits are indeterminate a priori although we suspect that total profits could go down since the value of $c_r\,(r - r_0)$ may not dominate that of $n\,(p - c)\,(2 + qD''/D')$. We calculate the profit effects in the following section adopting specific functional forms of the demand.

Since the foreign firm's profit is newly added and the other home firms' profits go down, we evaluate how the final goods industry's total profits in the two countries change as an additional firm abroad enters the market. The profit of the world downstream industry is decreasing[6] by checking that,

$$\frac{\partial n \pi^d}{\partial n} = \frac{(n - 1)q^2 D'}{n + 1 + \dfrac{QD''}{D'}} < 0.$$

Defining welfare as the sum of consumers' surplus and producers' profits, the total world welfare is

$$W = CS + \Pi^u + \Pi^d, \tag{9}$$

where CS stands for Consumer's Surplus and Π^d (Π^u) the total profits in the world downstream (upstream) industry. Equal weights are given

[5]This means that $c_r\,(r - r_0) > n\,(p - c)\,(2 + qD''/D')$ which is not probable.
[6]This is generally true in Cournot competition. See Seade (1980).

to both consumers' and producers' surplus.

As one more foreign firm enters the downstream industry, the changes in welfare of the world, home and foreign country are defined respectively:

$$\frac{\partial w}{\partial n} = \frac{\partial cs}{\partial n} + \frac{\partial \pi^u}{\partial n} + \pi^d + n\frac{\partial \pi^d}{\partial n},$$
$$\frac{\partial W_h}{\partial n} = \theta\frac{\partial cs}{\partial n} + \frac{\partial \pi^u}{\partial n} + n\frac{\partial \pi^d}{\partial n} + \lambda\pi^d, \tag{10}$$
$$\frac{\partial W_f}{\partial n} = (1-\theta)\frac{\partial cs}{\partial n} + (1-\lambda)\pi^d,$$

assuming the home consumers enjoy a fraction θ of the total world consumers' surplus. Welfare effects are explicitly calculated in the next section.

III. Examples

A. A Constant Elasticity Demand Function

Let the demand function for a computer be given by

$$P = AQ^{-\alpha} \text{ where } Q = nq. \tag{11}$$

Fixed proportion of production inputs gives

$$c = w + br, \tag{12}$$

where w and r is defined in (2); one unit of labor and b units of RAM chips are required to assemble a computer.

Now we ask if the upstream profit increase of the technology-exporting country is sufficient to cover the profit loss of all the downstream firms in the home country.

The answer is no. In other words, $\partial\pi^u/\partial n + n\,\partial\pi^d/\partial n < 0$ because

$$c_r(r - r_0) - (p - c)\left(2n + \frac{QD''}{D'}\right)$$
$$= -\frac{\alpha(w + br_0)(n-1)}{(1-\alpha)(n-\alpha)} < 0.$$

since $0 < \alpha < 1$ and $-QD''/D'$ is $(1+\alpha)$, given the demand function: $p = AQ^{-\alpha}$.

Since the sum of upstream and downstream profits in the home and foreign country is positive,[7] the entry of a foreign entrant makes the producers' surplus increase; if the home country gets the substantial part of the foreign firm's profit, there is room for potential gains to the both parties from technology transfer. Also, we check whether the upstream profit increase can cover the profit loss of one downstream firm at home; this turns out to be true.[8] Finally, we calculate the welfare effects with consumer's surplus considered:

$$CS = A^{\frac{1}{\alpha}} \frac{\alpha}{(1-\alpha)} \left\{ \frac{w + br_0}{(1-\alpha)(1-\frac{\alpha}{n})} \right\}^{1-\frac{1}{\alpha}} \tag{13}$$

The change in the home country's welfare is

$$\frac{\partial W_h}{\partial n} = \theta \frac{\partial cs}{\partial n} + \frac{\partial \pi^u}{\partial n} + n \frac{\partial \pi^d}{\partial n} + \lambda \pi^d$$
$$= \frac{\alpha A^{\frac{1}{\alpha}}}{n^2} \left\{ \frac{w + br_0}{(1-\alpha)(1-\frac{\alpha}{n})} \right\}^{1-\frac{1}{\alpha}} \left(\frac{n\theta - n + 1}{n - \alpha} + \lambda \right), \tag{14}$$

where θ is a fraction of the world consumers' surplus enjoyed by the domestic consumers and λ is a royalty rate. From (14), we have the next proposition:

$$\frac{\partial W_h}{\partial n} > 0 \quad \text{if} \quad \frac{n\theta - n + 1}{n - \alpha} + \lambda > 0.$$

The iso-welfare line is defined by

$$\theta = -\lambda\left(1 - \frac{\alpha}{n}\right) + 1 - \frac{1}{n}, \tag{15}$$

where the slope of the linear function is $-(1 - \alpha/n) > -1$;
If $\theta = 0$, $\lambda \geq (n-1)/(n-\alpha)$ for the home country to be better off.

[7] $\partial\pi^u/\partial n + \pi^d + n \cdot \partial\pi^d/\partial n > 0$ because $c_r(r - r_o) - (p - c)(n - 1)$

$$\geq \frac{\alpha(w + br_0)(1-\alpha)}{(1-\alpha)(n-\alpha)} < 0, \quad 0 < \alpha < 1$$

[8] $\partial\pi^u/\partial n + \partial\pi^d/\partial n > 0$ if and only if $c_r(r - r_0) - (p - c)(2 + QD''/nD')$

$$= \frac{\alpha(w + br_0)(n-1)(n-1-\alpha)}{n(1-\alpha)(n-\alpha)} > 0 \quad \text{if} \quad n \geq 2.$$

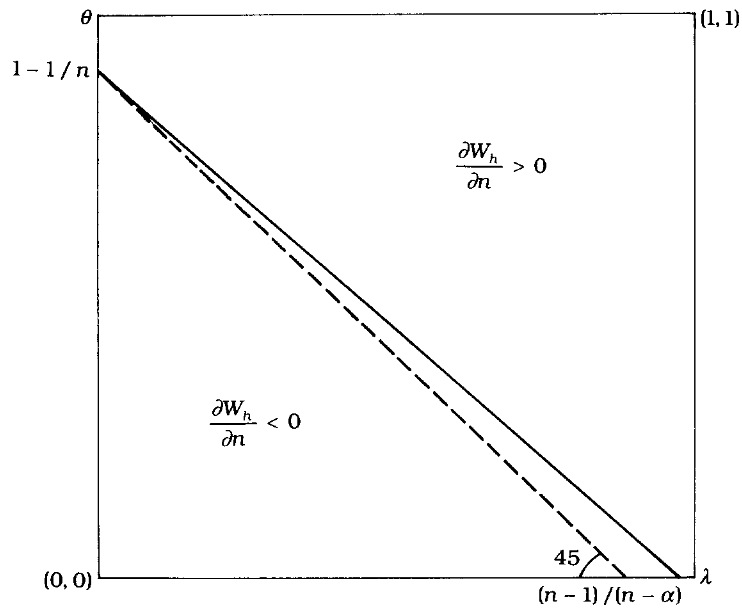

FIGURE 1
THE HOME COUNTRY'S WELFARE INCREASES WITH A FOREIGN FIRM'S ENTRY INTO THE DOWNSTREAM IF THE CONSTANT ELASTICITY DEMAND FUNCTION IS ASSUMED: $P = AQ^{-\alpha}$

If $\lambda = 0$, $\theta \geq 1 - 1/n$ for the home country to be better off.

We assumed that there are at least more than two firms in the final goods market so that home country's share of consumers' surplus must be larger than that of the foreign country for the home welfare gains if we disregard royalty revenues. For example, if the home country has five firms in the downstream industry, the home country's share of consumers' surplus, θ, must be over 80% of the world's.

In Figure 1, values of λ and θ above the iso-welfare line make the home country better off but those of λ and θ below the line make the home worse off. As the value of "n" increases or the value of "α" goes to 1, the intercept of the θ axis, $1 - 1/n$, and that of λ axis, $(n - 1)/(n - \alpha)$, respectively approaches to 1 so that there shrinks the area of the home welfare gains ($\partial W_h/\partial n > 0$). In other words, as the downstream industry ar home prior to technology transfer tends to become more competitive, the entry of a foreign firm is more likely to make the home country worse off.

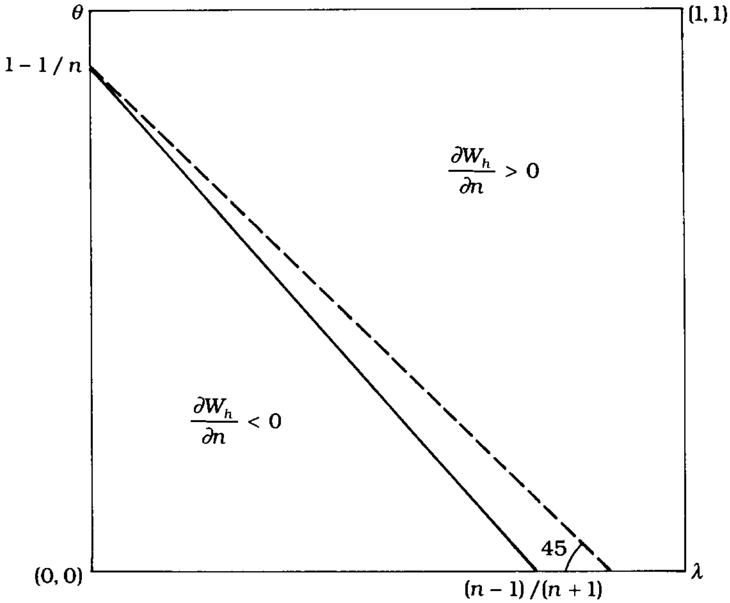

FIGURE 2

THE HOME COUTRY'S WELFARE INCREASES WITH A FOREIGN FIRM'S ENTRY INTO THE DOWNSTREAM IF THE LINEAR DEMAND FUNCTION IS ASSUMED: $P = A - Q$

We give some intuition for this result. When there are a large number of downstream firms in the home country, the home consumers are already enjoying sufficiently large consumers' surplus. Then, the home firms' total profit loss from the entry of a foreign firm can outweigh the small gains in the home consumers' surplus because each domestic downstream firm's loss is multiplied by the large number of firms.

B. A Linear Demand Case

A linear demand function for a computer is assumed:

$$p = a - Q,\ Q = nq. \tag{16}$$

Avoiding redundant derivations, we only present two important results. Is the upstream profit increase of the technology-exporting country sufficient to cover the profit loss of all the downstream firms in the home country? We show that it is not, in other words, $\partial\pi^u\partial n + n \cdot \partial\pi^d/\partial n < 0$ since $c_r\,(\hat{r} - r_0) - 2n\,(p - c) = -(n - 1)\,(a - w - br_0)/2\,(n + 1) < 0$.

It is easily shown that the home country is better off when a foreign firm enters the downstream, in other words, $\partial W_h/\partial n \geq 0$ if $\theta \geq (1 - 1/n) - \lambda\,(1 + 1/n)$.

The iso-welfare line in Figure 2 is given by

$$\theta = -\lambda\left(1 + \frac{1}{n}\right) + \left(1 - \frac{1}{n}\right), \tag{17}$$

where the slope, $d\theta/d\lambda$, is - $(1 + 1/n)$. The intercepts are given as $\lambda = (n - 1)/(n + 1)$ if $\theta = 0$ and $\theta = 1 - 1/n$ if $\lambda = 0$. Combinations of (λ, θ) above the iso-welfare line provide the positive marginal home welfare but those of (λ, θ) below the line, negative. As n increases, λ and θ approaches to 1; the area of the home country's welfare gains shrinks. The boomerang effects tend to dominate the royalty and upstream profit gains. We conclude that the adoption of a linear demand function produces the similar qualitative results of the subsection *A*.

IV. Summary

We have set up a simple model to analyze the welfare gains or losses of an international technology transfer considering its subsequent effects effects on the upstream industry and the consumers' surplus. We found that (i) The profit loss of the technology exporting country's downstream industry is larger than the profit increase of its upstream industry. (ii) Unless most of the new entrant's profit is taken by the licensor, this entry into the downstream reduces producers' surplus in the technology exporting country. However, the sum of the upstream and downstream profits in the world is increasing. (iii) The more competitive is the downstream industry in the licensor's country, the more likely a new entrant is to make the technology exporting country worse off because the boomerang effect dominates the welfare gains of its consumers' surplus. So technology transfers become less desirable if licensor's downstream industry tends to be more competitive. (iv) The World welfare is always increasing regardless of the consumption share distribution and the market structure in the final goods industry.

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