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Multinationals, tax holidays, and technology transfer

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Abstract

Host country governments often grant investment incentives to foreign firms locating in their territories. We show that such preferential treatment of foreign firms can facilitate transfer of foreign technology, induce entry by the local firm, and increase host country welfare. However, this pro-competitive result occurs when preferential treatment is granted for a limited time; i.e., it takes the form of tax holidays, and is absent under permanent tax concessions.

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1. Introduction

Governments often grant investment incentives to foreign firms locating in their territories. A typical incentive package includes preferential tax treatment, lower duties on imported raw materials and components, subsidized labor training costs and financial loans. Such investment incentives may be needed to attract limited supplies of foreign capital. However, there is the concern that preferential treatment of foreign multinationals puts local firms at an unfair disadvantage and is therefore anticompetitive. The objective of this paper is to show that preferential treatment of multinationals can be pro-competitive and welfare-improving for the host country. However, to induce this pro-competitive and welfare-improving effect, investment incentives must be granted only for limited periods; i.e., they must take the form of "tax holidays."

We demonstrate such a pro-competitive and welfare effect by extending the classical model of entry deterrence (Dixit 1979, 1980) to an infinite-horizon setting. The game begins when the foreign firm opens a subsidiary in the home country and takes measures aimed at preventing unintended transfer of the technology it brings. Such preventive measures may include keeping key production steps privy only to the firms' top management. Firms are also known to resort to what is called "masquing," that is, altering products and production methods so as to make reverse engineering more difficult or even imbedding physical security systems hidden in the product so as to facilitate conviction of technology thieves, should thievery occur (Taylor 1993). Firms may eve invest in legal procedures, working with the host country governments, to prosecute imitators and infringers of firms' intellectual property rights. The immediate consequence of such anti-theft investment is to make it harder for the entrant to gain access to the foreign technology needed for entry.

Once the foreign firm commences production, the home firm tries to imitate the foreign firm's technology (or product) and enter. This sequence of moves is natural in the real world, where foreign technology is often indispensable for entry by local entrepreneurs; see, e.g., Maskus (2000). Once the home firm enters, the two firms compete in prices or quantities over time. Without entry, the foreign firm remains a monopoly.

The analysis of this paper centers on the foreign firm's decision whether to deter or accommodate entry by the home firm. The foreign firm naturally dislikes competition. But, since entry deterrence is costly, the foreign firm would be willing to accommodate small-scale or inoffensive entry rather than pursue the costly entry-deterring strategy. The home firm would also prefer to delay entry rather than have entry denied. This is in the spirit of judo economics as explicated in Gelman and Salop (1983). The problem is, unlike the entrant featured in the Gelman-Salop analysis, the home firm here cannot commit to delayed entry.

It is in such circumstances that tax holiday programs work as a commitment device for the home firm. The intuition is simple. Preferential tax treatment makes the foreign firm a "tougher" competitor temporarily, making immediate entry less profitable, and prompting the home firm to postpone entry until the foreign firm loses its tax advantage. Thus, tax holiday programs serve as a puppy-dog ploy (Fudenberg and Tirole, 1984), and facilitate entry by the home firm into the new market that would otherwise be monopolized by the foreign firm.

Now, it is immediate that this entry-promoting effect is absent under permanent tax concessions. Under permanent tax concessions, the foreign firm's competitiveness remains constant over time, so there is no incentive for the home firm to delay entry. But, if entry is not delayed, the foreign firm has every incentive to ensure that entry does not occur. Furthermore, because subsidies benefit the foreign firm more when it is a monopolist than when it is a duopolist, the foreign firm has more of an incentive to defend its monopoly status. For these two reasons, permanent tax concessions prove indeed to be anti-competitive as is generally believed.

Today, most of foreign investment incentives are dispensed to foreign firms locating in free-trade zones (FTZs), and indeed take the form of tax holidays. For example, Costa Rica offers 100-percent tax exemption for 8 years and 50% exemption for another 4 years. Israel provides foreign multinationals with the choice between 10-year tax exemption and upfront cash subsidy. In Morocco, the incentives packages come with 5 to 10 year tax concessions, depending on which region of the country foreign firms invest. Ghana and Malaysia, too, provide tax exemption and duty-free status on manufacturing machinery during the first 10 years of firm's operations. China grants 5-year tax breaks followed by another 5 years with 50% tax liability.

FTZs made their first appearances during the first decade of the 20th century but their impressive growth began during the 1970s and 1980s. According to World Bank reports, there are about 3,000 FTZs in 120 countries, as of 2007. While countries creating FTZs expressed hopes that the presence of foreign firms in their territories would increase employment opportunities and boost the economy's productivity through technology transfer, the formal analysis of FTZs has primarily focused on the welfare impact of tax exemption in the static general competitive equilibrium framework; see e.g., Hamada (1974), Miyagiwa (1986), Young (1987), and Facchini and Willmann (1999).[1] This paper, to the best of our knowledge, is the first to extend the literature to the case of imperfect competition and to examine the effect of tax exemption on technology transfer in a dynamic setting.

There also exists work explaining tax holidays in terms of the host country governments' inability to commit to long-term tax policies; Bond and Samuelson (1986) and Doyle and van Wijnbergen (1994). However, most of FTZs are operated by the non-government enterprises sanctioned by the host country governments, with the consequence that FTZ authorities and firms are legally bound to honor the terms of contracts, including tax rates, they have signed at the time of the opening of subsidiaries. Thus, there seems little concern of time inconsistency featured in those studies.

The remainder of the paper is organized in 6 sections. The next section sets up the model. Section 3 solves the model under the assumption that the foreign firm receives subsidies at a constant rate over time. Section 4 applies the model to show that, if it deters entry at zero subsidies, the foreign firm has a greater incentive to deter entry under a permanent subsidy program. Section 5 presents our main result, that is, the pro-competitive effect of temporary subsidy programs. Section 6 discusses the welfare impact of temporary subsidy programs. Section 7 extends the model to the case of eventual entry, that is, when entry cannot be deterred forever, and shows that our main result generally carries over to the case of eventual entry. Section 8 summarizes our findings and makes suggestions for future research.

2. The model setup

[1] Young and Miyagiwa (1987), Miyagiwa (1991), Chaudhiri and Adhikari (1993), and Gupta (2000) study the effect of FTZs on unemployment.

The model involves two firms, one foreign and one home, which interact over time. The foreign firm is incumbent while the home firm is a potential entrant, needing the foreign firm's technology to enter. Time runs continuously from zero to infinity and is indexed by t. It is useful to think of the game in three stages. The first stage occurs at $t = 0$, at which only the foreign firm moves. It builds a factory in the home country, and chooses a level of investment, K, aimed at preventing unintended transfer of its technology to the home firm, as described earlier. The one-time cost of this investment is denoted by C(K), which we assume is convex and differentiable, with $C'(K) > 0$ and $C''(K) > 0$ (primes denote differentiation).

The second stage has the home firm deciding whether to imitate the foreign firm's technology at a one-time cost of f(K). Assume $f'(K) > 0$; that is, the more the foreign firm invested, the higher the cost of imitation. As for the timing of entry, there is no loss of generality in assuming that imitation is immediate so assume that the home firm can enter at any time $t \in (0, \infty)$.

The third stage begins only if the home firm enters. Then, the two firms compete in quantities or prices. If there is no entry, the foreign firm remains a monopoly. The environment is stationary; the market demands and factor prices do not change over time.

3. Equilibrium

We first solve the above model under the assumption that subsidies are given at a constant rate s per unit of output over time. Seeking a subgame-perfect equilibrium, we beign with the subgame that starts when the home firm enters. We then move back to the home firm's entry decision problem, and finally we determine the foreign firm's optimal investment strategy.

In solving the post-entry game, we seek Markov-perfect equilibrium as a solution concept. Since flow profits do not depend explicitly on time due to the stationary environment, the Markov-perfect equilibrium profits are just the Nash equilibrium duopoly profits of a one-shot game. Write these flow profits as $\Pi(s)$ and $\pi(s)$ for the foreign and the home firm, respectively. Denote the foreign firm's flow monopoly profit by $M(s)$. These profit functions are assumed to be continuously differentiable and satisfy the following properties.

Assumption 1: $M'(s) > \Pi'(s) > 0 > \pi'(s)$.

The first inequality states that the benefit of a subsidy is greater when the foreign firm is a monopolist than when it is a duopolist. This assumption is rationalized by the intuition that a monopolist produces a greater quantity of output than a duopolist and hence must benefit more from a per-unit-of-output subsidy, and is satisfied in the standard Cournot and (differentiated-goods) Bertrand models. It is also the standard assumption in the literature investigating similar issues; e.g., Besley and Suzumura (1992), McAfee and Schwartz (1994) and Miyagiwa and Ohno (1995). The last inequality follows because a lower marginal cost for the foreign firm harms the competitiveness of the home firm.

Having described the post-entry subgame equilibrium, we turn to the second stage: the home firm's entry decision problem. If the home firm enters at time $t \geq 0$, its discounted total profit is:

$$e^{-rt}[\pi(s)/r - f(K)],$$

where r is the (common) instantaneous rate of interest, and f(K) is given in the first stage of the game. If the term in brackets, $\pi(s) - rf(K)$, is positive, the home firm enters at $t = 0$. If it is non-positive the home firm never enters.[2] We assume that there is $\bar{K}(s)$ at which the home firm is indifferent between the two options.

Assumption 2: For given s, there is $\bar{K}(s)$ such that $\pi(s) = rf(\bar{K}(s))$.

By Assumption 1, an increase in s decreases the minimum level of K needed to prevent entry, i.e., $d\bar{K}(s)/ds < 0$. Thus, the home firm's optimal strategies can be restated as follows:

(i) Enter at $t = 0$, if $\pi(s) - rf(K) > 0$ or $K < \bar{K}(s)$;

(ii) Never enter, if $\pi(s) - rf(K) \leq 0$ or $K \geq \bar{K}(s)$.

Finally, we turn to the foreign firm's investment strategy. If the foreign firm remains a monopoly, its net total profit is:

$$\int_0^{\infty} e^{-rz} M(s)dz - C(K) = M(s)/r - C(K).$$

Since this profit is decreasing in K, the foreign firm, if unthreatened, would optimally set $K = 0$. In this analysis, however, assume f(0) is sufficiently low so that the home firm enters when the

[2] We adopt the convention that there is no entry unless there is strictly positive profit, no matter small.

foreign firm chooses K = 0, i.e., $\pi(s) - rf(0) > 0$ for relevant values of s. Thus, entry deterrence requires investing at least $\bar{K}(s) > 0$. Since an increase in K reduces the net profit, however, the foreign firm never invests more than $\bar{K}(s)$. Thus, the maximum profit from deterring entry equals

$$M(s)/r - C[\bar{K}(s)].$$

On the other hand, any investment less than $\bar{K}(s)$ induces entry at t = 0, yielding the net profit:

$$\int_0^\infty e^{-rz}\Pi(s)dz - C(K) = \Pi(s)/r - C(K).$$

When entry is inevitable, however, the foreign firm optimally sets K = 0, which results in the total maximum profit $\Pi(s)/r$.

Let $\Omega(s)$ be the difference in profit to the foreign firm between deterring and accommodating entry:

$$\Omega(s) \equiv M(s)/r - C(\bar{K}(s)) - \Pi(s)/r \tag{1}$$

The foreign firm chooses to deter entry if and only if $\Omega(s) \geq 0$. This completes the description of the basic model.

Evaluating the above model at s = 0 yields the equilibrium outcome without subsidies. We assume that without subsidies the foreign firm prefers to deter entry.

Assumption 3: Without subsidies the foreign firm deters entry; i.e.,

$$\Omega(0) = M(0)/r - C(\bar{K}(0)) - \Pi(0)/r > 0.$$

4. Permanent subsidies

We now apply the above model to analyze the effect of a permanent subsidy program. We want to find out the sign of $\Omega(s)$, given that $\Omega(0) > 0$ (Assumption 3). Differentiate (1) yields:

$$\Omega'(s) = [M'(s) - \Pi'(s)]/r - \bar{K}'(s)C'(\bar{K}(s)). \tag{2}$$

The first term on the right-hand side is positive by Assumption 1. The second term is negative since $\bar{K}'(s) < 0$ and $C'(K) > 0$. Therefore, $\Omega'(s) > 0$. It follows that $\Omega(s) > \Omega(0) > 0$ for $s > 0$.

Proposition 1: A permanent subsidy program increases the foreign firm's incentives to deter entry, thereby preventing technology transfer.

The intuition is straightforward. A permanent subsidy program decreases the post-entry profit to the home firm, making it easier for the foreign firm to deter entry, as indicated by the second term in (2). In addition, the foreign firm benefits more from subsidies as a monopoly than a duopolist, as indicated by the first term of (2). Thus, a permanent subsidy gives the foreign firm more of an incentive to deter entry. Even if the foreign firm is willing to accommodate entry without subsidies, a permanent program with sufficiently high subsidies may induce the foreign firm to switch to entry deterrence. It is obvious that such a policy is deleterious to the home country.

5. Temporary subsidies

We now examine the effect of a temporary subsidy or a tax holiday program. Consider a program with the constant subsidy rate $s > 0$ that begins at time zero and ends at T. Note that under this subsidy program the environment is stationary after $t = T$ so, if the home firm does not want to enter at $t = T$, it never wants to do so at $t > T$. This allows us to focus on the possibility of entry during the interval [0, T]. Entering at $t \le T$, the home firm receives the flow profit $\pi(s)$ between t and T and $\pi(0)$ afterwards, which totals:

$$(e^{-rt} - e^{-rT})\pi(s)/r + e^{-rT}\pi(0)/r - e^{-rt}f(K) \qquad (t \le T).$$

Since $\pi(0) > \pi(s)$, the following describes the optimal strategies for the home firm:

(a) if $\pi(s) - rf(K) > 0$, enter at $t = 0$,

(b) if $\pi(0) - rf(K) \ge 0 > \pi(s) - rf(K)$, enter at $t = T > 0$,

(c) if $0 \ge \pi(0) - rf(K)$, do not enter.

Given $\bar{K}(0) > \bar{K}(s)$, the above entry rule is restated as

Lemma 1: (the best responses for the home firm)

(A) If $K < \bar{K}(s)$, enter at $t = 0$.

(B) If $\bar{K}(0) > K \ge \bar{K}(s)$, enter at $t = T > 0$.

(C) If $K \ge \bar{K}(0)$, do not enter.

We next characterize the foreign firm's optimal strategy under a temporary subsidy program. Lemma 1 presents three options. Firstly, investing $K < \bar{K}(s)$ induces entry at $t = 0$, in which case the foreign firm optimally sets $K = 0$, earning the maximum profit

$$A_1 \equiv (1 - e^{-rT})\Pi(s)/r + e^{-rT}\Pi(0)/r.$$

Secondly, investing $K \in [\bar{K}(s), \bar{K}(0))$ entails entry at T, yielding the profit

$$(1 - e^{-rT})M(s)/r + e^{-rT}\Pi(0)/r - C(K).$$

In this case, investing the minimal level of investment, $\bar{K}(s)$, yields the maximum profit:

$$A_2 \equiv (1 - e^{-rT})M(s)/r + e^{-rT}\Pi(0)/r - C(\bar{K}(s)).$$

Lastly, investing $K \geq \bar{K}(0)$ deters entry. Again, investing the minimum, $\bar{K}(0)$, yields the maximum profit:

$$D = (1 - e^{-rT})M(s)/r + e^{-rT}M(0)/r - C(\bar{K}(0)).$$

Now we present our main result.

Proposition 2: Let the subsidy rate s be given. Then, there is a unique time, $\tilde{T}$, such that for any temporary subsidy program lasting from t = zero to $T > \tilde{T}$ the foreign firm accommodates entry at T.

To prove this we must show that $D < \mathrm{Max}\{A_1, A_2\}$. To that end, we begin by comparing A_1 and A_2. Taking the difference yields

(3) $$A_2 - A_1 = (1 - e^{-rT})[M(s) - \Pi(s)]/r - C(\bar{K}(s))$$

At T = 0 the right-hand side of (3) is negative because the first term vanishes. But as T increases sufficiently, the right-had side of (3) approaches $\Omega(s)$, which by Proposition 1 is positive. Then, due to continuity, there exists $\hat{T}$ satisfying $A_2 - A_1 = 0$, such that $A_2 \leq A_1$ for T $\leq \hat{T}$ and $A_2 > A_1$ for $T > \hat{T}$.

Consider $T \leq \hat{T}$. Then, since $A_1 \geq A_2$, we compare A_1 and D. The difference is

$$D - A_1 = (1 - e^{-rT})[M(s) - \Pi(s)]/r + e^{-rT}[M(0) - \Pi(0)]/r - C(\bar{K}(0)).$$

Differentiating we have

$$d(D - A_1)/dT = [M(s) - \Pi(s)] - [M(0) - \Pi(0)]e^{-rT}$$

$$= \int_0^s [M'(v) - \Pi'(v)]e^{-rT}dv > 0$$

by Assumption 1. Thus, as T is increased, D is increased relative to A_1. Further, at T = 0

$$D - A_1 = [M(0) -)\Pi(0)]/r - C(\bar{K}(0)) = \Omega(0) > 0.$$

These two result indicate that $D > A_1$ for $T \leq \hat{T}$. Thus, if a temporary subsidy program lasts less than $\hat{T}$ the foreign firm prefers to deter entry.

Turn next to the case in which $T > \hat{T}$. Since $A_2 > A_1$, we consider the difference

(4) $$D - A_2 = e^{-rT}[M(0) - \Pi(0)]/r + [C(\bar{K}(s)) - C(\bar{K}(0)].$$

At $T = \hat{T}$, $A_2 = A_1$, and hence by the preceding analysis

$$D - A_2 = D - A_1 > 0.$$

However, as T is increased sufficiently, $D - A_2$ turns negative. To see this, note that the first term on the right-hand side of (4) becomes arbitrarily small as T approaches infinity, but the second term, the cost difference, remains unaffected and negative. Then, by continuity there is $\tilde{T}$ at which $D = A_2$, and for all $T \geq \tilde{T}$ we have $D \leq A_2$, i.e., the foreign firm accommodates entry. This competes the proof.

Now we state the intuition underlying Proposition 2. Since entry deterrence is costly, the foreign firm may prefer to allow for small-scale (or delayed) entry rather than deter entry completely. The home firm also prefers delayed entry to no entry at all. However, the home firm cannot make a credible commitment to delay entry, because if the foreign firm drops its guards and invests below $\bar{K}(0)$, believing that entry will be delayed, the home firm would have the incentive to enter at t = 0. It is in such a case that a temporary subsidy program can change the home firm's optimal entry strategy (lemma 1). Even if the foreign firm invests less than $\bar{K}$ (0), the prospect of making negative profits under the temporary subsidy program forces the home firm to delay entry, thereby making delayed entry a credible commitment. Not having to spend so much on anti-theft investment further boosts the foreign firm's profit, making entry accommodation more attractive than entry deterrence under a temporary subsidy program.

6. Optimal temporary subsidy programs

In the previous section we showed that a temporary subsidy changes the home firm's best responses from an aggressive top-dog strategy to a less aggressive puppy-dog ploy and prompts the foreign firm to accommodate entry. In this section we consider the optimal nature of a temporary subsidy program. The welfare-maximizing government has two policy instruments, T and s, to affect its welfare under the temporary subsidy program. We suppose that the goods are sold to home-country consumers. Then, home country welfare consists of the discounted sum of consumer surpluses and home firm profits less the subsidies. The case in which goods are sold exclusively in the export (third-country) market can be analyzed analogously by ignoring the consumer surpluses without affecting our results qualitativley.

Clearly, $\tilde{T}$ depends on the rate of subsidy, so write $\tilde{T} = \tilde{T}(s)$. Differentiating the defining equation, $D - A_2 = 0$, in (3) totally, we obtain

$$\tilde{T}'(s) = d\tilde{T}(s)/ds = G_1 / G_2 < 0.$$

where

$$G_1 \equiv \partial(D - A_2)/\partial s = C'(\bar{K}(s))\bar{K}'(s) < 0,$$

and

$$G_2 \equiv \partial(D - A_2)/\partial T = [\Pi(s) - M(s)]e^{-rT} < 0.$$

Thus, $\tilde{T}(s)$ is decreasing in s.

In Figure 1 we illustrate $\tilde{T}(s)$ by the locus DA_2. Any pair (T, s) to the right of the locus implies that $D < A_2$ so that the foreign firm accommodates entry. The opposite is true for any pair (T, s) to the left of the locus.

Let $CS^M(s)$ denote the flow consumer surplus when the foreign firm is a monopoly under the subsidy s. Similarly, let $CS^A(s)$ be the flow consumer surplus when entry is accommodated. Obviously, we have $CS^A(s) > CS^M(s)$.

By proposition 2, there is entry under a temporary subsidy program at the rate s and with duration $T > \tilde{T}(s)$. Then, home country welfare is given by

$$W^A(T, s, \bar{K}(s)) = (1 - e^{-rT})\{CS^M(s) - sX^M(s)\}/r \tag{5}$$

$$+ e^{-rT}\{[CS^A(0) + \pi(0)]/r - f(\bar{K}(s))\}.$$

The first term on the right is the pre-entry home country welfare, consisting of the consumer surplus under monopoly less subsidy payments to the foreign firm (with $X^M(s, \bar{K}(s))$ denoting the foreign firm's flow output during the subsidy program.) The second is the post-entry welfare, comprising the consumer surplus under duopoly and the home firm profit less the one-time imitation cost.

Without subsidies, there is no entry, so the maximum home welfare is

$$W^D = CS^M(0)/r.$$

Focusing on welfare after T, subtracting $CS^M(0)/r$ from the corresponding expression under the subsidy program in (5) yields

$$e^{-rT}\{[CS^A(0) + \pi(0) - CS^M(0)]/r - f(\bar{K}(s))\}. \tag{6}$$

Since entry is accommodated we have

$$\pi(0)/r - f(\bar{K}(s)) > 0$$

(see the discussion leading to Lemma 1). We also have $CS^A(0) > CS^M(0)$. Thus, (6) is positive. A temporary subsidy generates profits for the home firm and increases consumer surplus. Further, differentiation of (5) with respect to T yields:

$$\partial W^A/\partial T = e^{-rT}\{CS^M(s) - sX^M(s) - CS^A(0) - \pi(0)\} < 0.$$

Thus, the optimal policy calls for the shortest possible T; i.e., $T = \tilde{T}(s)$.

Substituting $\tilde{T}(s)$ into (5) and differentiating with respect to s, we find

$$dW^A[\tilde{T}'(s), s, \bar{K}(s)]/ds = (\partial W^A/\partial T)(\partial\tilde{T}(s)/\partial s) + (\partial W^A/\partial K)\bar{K}'(s) + \partial W^A/\partial s. \tag{7}$$

The third term on the right-hand side of (7) describes the direct effect of a subsidy in the presence of a foreign monopoly:

$$\partial W^A/\partial s = (1/r)(1 - e^{-rT})\partial[CS^M(s) - sX^M(s)]/\partial s$$

This is the familiar expression in the literature on FDI, capturing the (static) welfare effect of subsidy (or tax) on the foreign firm. Let s^o denote the optimal subsidy (tax if negative) in the static sense. In the literature on FDI s^o is usually assumed negative (i.e., tax) but it could be positive, depending on the curvature of the demand function, as discussed in the classical analyses of Brander and Spencer (1984a, 1984b).

The first term on the right-hand side of (7) is positive because $\partial W^A/\partial T < 0$ as just shown above and also $\partial\tilde{T}(s)/\partial s < 0$. In the second term on the right of (7), we have

$$\partial W^A(T, s, \bar{K}(s))/\partial K = - e^{-rT}f'(K) < 0$$

and $\bar{K}'(s) < 0$, so the second term is also positive.

Since the first and the second term in (7) are positive, the expression in (7) is positive when evaluated at $s = s^o$. That implies that the optimal subsidy rate exceeds that in the static model. We have obtained the following result

Proposition 3: Let (s^*, T^*) denote the optimal temporary subsidy program. Then,

(A) $T^* = \tilde{T}'(s^*)$

(B) $s^* > s^o$

Part A says that under the optimal policy the subsidy program should be made as short as possible to induce accommodation. Part B says that the optimal program indeed involves subsidies or tax concession for the foreign firm relative to the static model.

The optimal FTZ program $(s^*, \tilde{T}(s^*))$ is illustrated in Figure 1. The curve W^* corresponds to the iso-welfare curve representing the maximum welfare under the optimal FTZ program. s^o ($< s^*$) is also indicated.

7. Eventual entry

We have assumed up to this point that the foreign firm can forever deter entry by investing enough in "masquing." While some firms successfully keep their trade secrets and technologies hidden from the competitors for decades or more (e.g., the Coca-Cola formula), it is also conceivable that technologies and products are copied eventually. The objective of this section therefore is to relax the assumption of the basic model and examine the consequence of eventual entry.

7.A. Model setup

Assuming that the foreign firm's technology will eventually spill over to the public domain and become available to the entrant, we model that eventuality by supposing that the imitation cost gradually declines to zero over time. More specifically, we suppose that the imitation cost now comprises two multiplicative components in the form of f(K)h(t).[3] The first component is familiar from the basic model. The second component h(t) declines over time at a diminishing pace, that is, $h'(t) < 0$ and $h''(t) > 0$. We assume that h(t) goes to zero as t goes to infinity so that, no matter what K is, the imitation cost eventually becomes zero. The foreign firm can only delay entry by investing in theft preventive measures.

Otherwise, the analysis here closely resembles that of the previous sections. We begin by solving the model by assuming that there are subsidies at constant rate s at each instant. Once entry occurs the game is exactly the same that we described earlier. In the second stage, the home firm chooses an entry time t to maximize its profit:

$$[\pi(s)/r - f(K)h(t)]e^{-rt},$$

given the component f(K) of the imitation cost as given. The first-order condition can be arranged to yield

$$- \pi(s) + f(K)[rh(t) - h'(t)] = 0, \tag{9}$$

[3] A more general functional form, e.g. f(K, t), with appropriate assumptions about cross-partial effects ,can be used to get the same results as we do here.

which determines the optimal entry date $t^*(s, K)$, which depends both on K and s. The second-order condition holds since

$$rh'(t) - h''(t) < 0.$$

It is easy to show that

$$dt^*(s, K)/ds = \pi'(s)/\{f(K)(rh' - h'')\} > 0$$

and

$$dt^*(s, K)/dK = - f'(K)(rh - h')/\{f(K)(rh' - h'')\} > 0.$$

In the first stage the foreign firm chooses K to maximize

$$(1 - e^{-rt^*})M(s)/r + e^{-rt^*}\Pi (s)/r - C(K),$$

knowing that K influences the home firm's entry date via $t^* = t^*(s, K)$. The first-order condition is

$$e^{-rt^*}[M(s) - \Pi (s)]dt^*/dK - C'(K) = 0, \tag{10}$$

which determines the optimal level of investment $K^*(s)$. The second-order condition is satisfied if $d^2t^*/dK^2 < 0$; that is, $ff'' - f'^2 < 0$, which we assume. This completes the description of the model with eventual entry.

Now, we evaluate the equilibrium outcome at s = 0. This is depicted in Figure 2. With the foreign firm investing $K^*(0)$ optimally in the first stage, the locus labeled A traces the marginal imitation cost, $f(K^*(0))[rh(t) - h'(t)]$. According to the first-order condition (9), the home firm optimally enters at $t^*(0) = t^*(K^*(0), 0)$. The corresponding profit to the foreign firm is given by

$$(1 - e^{-rt^*(0)})M(0)/r + e^{-rt^*(0)}\Pi (0)/r - C(K^*(0)).$$

7.B. Permanent subsidies

We next examine the effect of a permanent subsidy program. The effect on the equilibrium date of entry is obtained from total differentiation of the first-order condition (9):

$$- \pi'(s) + f'(K)[rh(t) - h'(t)]dK/ds + f(K)[rh'(t) - h''(t)]dt/ds = 0.$$

Thus,

$$dt^*/ds = [\pi'(s) - f'(K)[rh(t) - h'(t)]\partial K/\partial s]/\{f(K)[rh'(t) - h''(t)]\}. \tag{11}$$

Thus, the effect of a permanent subsidy is decomposed into two effects: the direct effect through a permanent change in flow profits, and the indirect effect that operates through a change in K by the foreign firm. Given that the denominator is negative by the second-order condition, and $\pi'(s) < 0$, the direct effect is negative. This is intuitive. Since the flow profit for the home firm is smaller under the permanent subsidy, it is worthwhile delaying entry till the entry cost falls more.

However, the foreign firm will also react to a change in the permanent subsidy rate. If the foreign firm reacts by investing more ($\partial K/\partial s > 0$), then the right-hand side of (11) is positive, implying that the home firm delays entry. Even if the foreign firm reduces investment in theft prevention ($\partial K/\partial s < 0$), entry will be delayed if the direct dominates the indirect effect. We therefore take the case in which $dt^*/ds > 0$ as the normal case.[4]

7.C. Temporary subsidies

[4] Differentiating the first-order condition (10) yields the expression for $\partial K^*(s)/\partial s$, whose sign, however, is in general ambiguous. As s is increased, there is more of an incentive to defend the monopoly status. But since an increase in s causes entry to delay, less investment is needed to keep the home firm out for as long.

Given that a permanent subsidy delays entry, this subsection shows that granting a temporary subsidy program can still speed up entry by the home firm. To show that, begin with a temporary subsidy program that ends exactly t*(0), i.e., set T = t*(0). Then, the home firm's profit is decreased from $\pi(0)$ to $\pi(s)$ between t = 0 and t = T, but returns to $\pi(0)$, as indicated in figure 2. Thus, if K remains at K*(0), earlier entry is even less profitable, so the optimal entry date remains at t*(0). With this, the foreign firm's profit equals

$$(1 - e^{-rt^*(0)})M(s)/r + e^{-rt^*(0)}\Pi\,(0)/r - C(K^*(0)).$$

However, K*(0) is not an optimal choice for the foreign. Since T = t*(0) satisfies the first-order condition for the optimal entry by the home firm:

$$-\,\pi(0) + f(K^*(0))[rh(T) - h'(T)] = 0,$$

we have that

$$-\,\pi(s) + f(K^*(0))[rh(T) - h'(T)] > 0,$$

implying that the foreign firm can decreases K a little without speeding up entry. In fact, the foreign firm can decrease K to $\tilde{K}$, which satisfies

$$-\,\pi(s) + f(\tilde{K})[rh(T) - h'(T)] = 0$$

while keeping entry at T = t*(0). In figure 2, the locus B represents the corresponding marginal imitation cost, $f(\tilde{K})[rh(t) - h'(t)]$, which equals $\pi(s)$ at T, indicating the optimality of entry at T. With this reduction in investment, the foreign firm's profit is increased to

$$(1 - e^{-rt^*(0)})M(s)/r + e^{-rt^*(0)}\Pi\,(0)/r - C(\tilde{K}),$$

the saving of $C(K^*(0)) - C(\tilde{K}) > 0$.

Now, consider offering a shorter subsidy program $T_1 < T = t^*(0)$. The home firm's flow profit now jumps from $\pi(s)$ to $\pi(0)$ at T_1 instead of T. By the preceding argument, the foreign firm can reduce investment even below $\widetilde{K}$ (say, $\widetilde{K}_1$) so that the corresponding marginal imitation cost is given by the locus C and entry occurs at T_1. This results in profit

$$(12) \qquad (1 - e^{-rT_1})M(s)/r + e^{-rT_1}\Pi(0)/r - C(\widetilde{K}_1).$$

But this profit is less than the obtainable when the program lasted until T, not only because the foreign firm receives subsidies for a shorter period but because entry occurs earlier.

The foreign firm of course always accommodate entry at $t^*(0)$ by investing $K^*(0)$ and earning the profit

$$(13) \qquad (1 - e^{-rT_1})M(s)/r + (e^{-rT_1} - e^{-rt^*(0)})M(0) + e^{-rt^*(0)}\Pi(0)/r - C(K^*(0)).$$

Subtracting (13) from (12) and rearranging, we obtain

$$(14) \qquad C(K^*(0)) - C(\widetilde{K}_1) - (e^{-rT_1} - e^{-rt^*(0)})[M(0) - \Pi(0)]/r$$

If this expression is positive, the foreign firm prefers to accommodate entry at T_1 than at $t^*(0) = T$. The first term in (14) is the cost saving from accommodating at T_1 and is strictly positive. The second term in (14) is also positive but can be made arbitrarily small by making T_1 sufficiently close to $t^*(0)$. Thus, one can always make (14) positive by taking T_1 sufficiently slow to $t^*(0)$. We have established the following result.

Proposition 4: With eventual entry, suppose that a permanent subsidy can delay entry. Then, one can always design a temporary subsidy program that results in earlier entry by the home firm than without subsidies.

Since we assumed that a permanent subsidy delays entry, proposition 4 implies that we can find a temporary subsidy program that results in earlier entry than under the permanent subsidy at the same subsidy rate s.

Earlier, however, we showed that we could not rule out the possibility that a permanent subsidy program can also speed up entry. We close this section with a brief discussion of this case. For concreteness, suppose that under a permanent subsidy the foreign firm chooses investment such that the marginal cost of entry is presented by the locus C. This results in entry at $t^*(s) = T_1$. In this case, granting a temporary subsidy that ends at T_1 reduces profit to the foreign firm, prompting it to increase K so as to delay entry. However, for delaying entry, the optimal strategy is to invest $K^*(0)$ and accommodate entry at $t^*(0)$, as we argued earlier. Thus, the foreign firm faces two options: allow entry at T_1 or $t^*(0)$. Although the foreign firm may not necessarily prefer T_1, here we can always raise the rate of subsidy under a temporary subsidy program so as to make accommodation at T_1 more attractive than under a permanent subsidy or without subsidy programs.

8. Concluding Remarks

The main conclusion of this paper is that, when a multinational makes investment aimed to preventing unintended transfer of its technology, granting of tax holiday status, as is customary for FDI in FTZs, induces transfer of foreign technology and facilitates entry by indigenous firms. Our welfare analysis indicates that an optimal subsidy program should be made as short as possible to induce entry and the subsidy rate should be adjusted to achieve the optimum. We also find that the optimal tax policy calls for tax rate reductions relative to the standard static welfare analysis.

Our results are based on the fact that a temporary subsidy granted to a foreign firm makes entry less profitable to a potential entrant and induces the latter to delay entry. The commitment to delayed entry combined with receipt of subsidies upfront makes deterrence less important for the foreign firm. As a result, the foreign firm allows for delayed entry. A permanent subsidy does not change any incentive to enter over time, and has no such entry-inducing effect.

It is possible to relax some assumptions of the model without qualitative effect on our main result. First, suppose that there are many potential local entrants. This really does not affect our main conclusion. For simplicity, assume that there are an infinite number of potential entrants, which will behave perfectly competitively upon entry. The implication is that the post-entry profit to the foreign firm is zero. Nonetheless, a temporary subsidy program can boost the profit to the foreign monopoly initially and delay entry the same way as described in the text. Thus it is possible to find a policy structure that increases profit to the monopoly enough so that the monopoly prefers to abandon the costly entry-prevention strategy.

Secondly, some FTZs are created with export markets in mind, so that all output produced in the zones are exported. As consumer surpluses are no longer part of home country welfare, what matters is the profit to the entrant. Thus, our conclusions remain valid.

Finally, the model can be extended to include the government or governments among players. Once the multinational makes investment so that entry occurs at T under a temporary subsidy program, the home government may have the incentive to renege and terminate the temporary subsidy program earlier to speed up entry or save subsidy payments. The multinational is likely to see through this and will invest the level of investment necessary to deter entry. This time-inconsistency problem could be avoided in a repeated-game setting, however, because such myopic governmental behavior would turn off future investors.

Appendix

If K is less than to $\widetilde{K}$, the home firm will enter at $t^*(s) < T$, which satisfies the first-order condition:

$$- \pi(s) + f(K)[rh(t) – h'(t)] = 0,$$

and the foreign firm's profit will be

$$(1 – e^{-rt^*(K)})M(s)/r + (e^{-rt^*(K)} – e^{-rT})\Pi(s)/r + e^{-rT}\Pi (0)/r – C(K).$$

Differentiating the above with respect to K yields

$$e^{-rt^*(K)}[M(s) - \Pi (s)]dt^*/dK – C'(K).$$

Given that $t^*(s) < T$, and the fact that the permanent subsidy results in entry later than $T = t^*(0)$, we conclude that the above derivative is positive. Thus, a further decrease in investment below $\widetilde{K}$ decreases the profit to the foreign firm.

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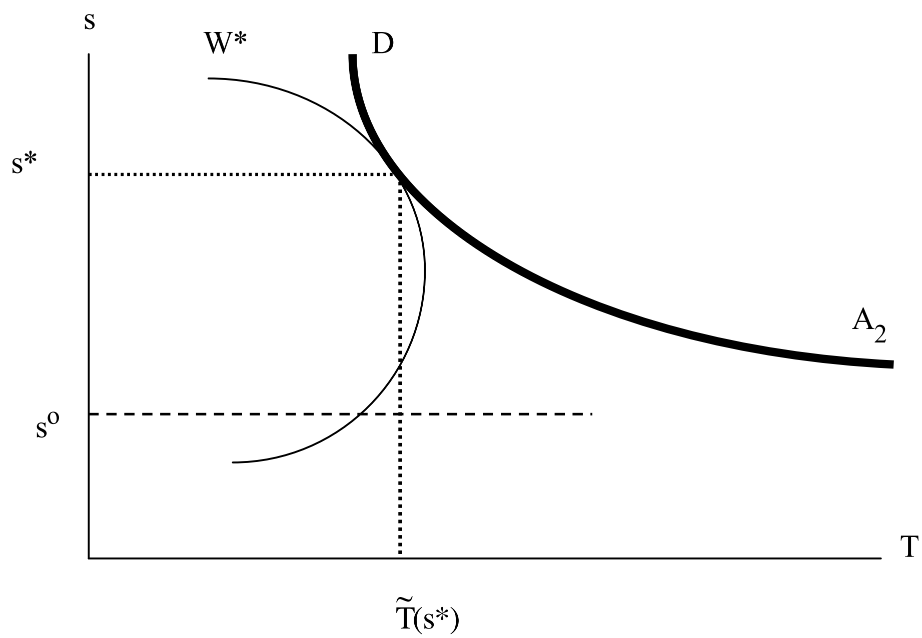

Figure 1

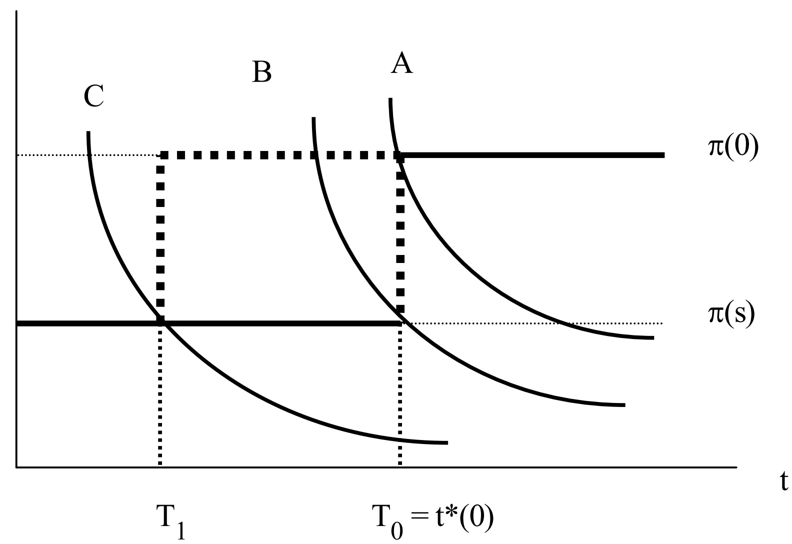

Figure 2