

IPR PROTECTION AND ABSORPTIVE CAPACITY IN NORTH-SOUTH TRADE

Preliminary Draft
December 2010

Arghya Ghosh
University of New South Wales

Jota Ishikawa
Hitotsubashi University

ABSTRACT. We examine South's incentive to protect IPR in a North-South duopoly model where (i) the North firm owns a better technology and has the option of serving the South market via exports or FDI, and (ii) the South firm can invest in absorptive capacity to reduce the technology gap. While FDI by North firm makes absorption easier for South, investment in absorptive capacity by the South firm might be higher or lower with FDI. For a given level of trade cost, the North firm prefers FDI to exports if the IPR protection is sufficiently strong. We find a non-monotone relationship between trade cost and the degree of IPR protection that maximizes South welfare. Strengthening IPR protection improves South welfare by encouraging North's FDI for intermediate values of trade cost.

JEL classification numbers: F12, F13, D43

Keywords: imitation, absorptive capacity, intellectual property rights, FDI, international oligopoly

Ghosh: School of Economics, University of New South Wales, Sydney 2052, Australia, E-mail: a.ghosh@unsw.edu.au; *Ishikawa:* Faculty of Economics, Hitotsubashi University, Kunitachi, Tokyo 186-8601, Japan, E-mail: jota@econ.hit-u.ac.jp.

1. INTRODUCTION

There are many channels through which technology is transferred from developed countries (North) to developing countries (South). A typical channel of technology transfers/spillovers is imitation. Superior production technologies in North could be copied by South firms. It should be emphasized, however, that such copying is not automatic. Imitation involves active and costly operations. Thus, South's capacity to absorb North's superior technology (i.e., absorptive capacity) is crucial for imitation. When lacking absorptive capacity, South firms cannot effectively copy superior technologies.

South's imitation activities are also importantly affected by the South government and North firms. In particular, imitation is strongly influenced by the strength of intellectual property rights (IPR) protection in South. As long as IPR protection is in force, patented technologies cannot freely be copied. North firm's location choice affects South's imitation as geographical proximity plays an important role in technology spillovers (e.g., Eaton and Kortum, 1999; Branstetter, 2001, and Keller, 2002). When North firms serve South market, South's imitation is easier under foreign direct investment (FDI) than under exports.

In this paper, we examine South's incentive to protect IPR in a North-South duopoly model where a low-cost North firm competes with a high-cost South firm in the South market. The extent of effective cost difference between North and South specifically depends on South's imitation. As discussed above, South's imitation depends on South's absorptive capacity, South's IPR protection, and North firm's location choice, all of which are endogenously determined in our framework. We should mention that we deliberately ignore the North innovation which is presumably the source of North firm's cost advantage and could be affected by South's IPR protection. Instead we focus on *North firm's location choice* and *South firm's investment in absorptive capacity* and show that incorporating these two features have important IPR policy implications for South.

To understand these implications better, we present some more details of our North-South duopoly model. A North firm (firm N), in our framework, has zero cost of production while a South firm (firm S) starts with unit cost $c (> 0)$. South government chooses the level of IPR protection $\alpha \in [0, 1]$ where $\alpha = 0$ implies full protection of IPR while $\alpha = 1$ implies no protection of IPR. The strength of IPR protection declines as α increases. Following South government's choice of α , firm N decides whether to export to South market or serve it via FDI. If firm N opts to export to South market it incurs trade cost of t per unit. After the firm N 's location has been made, firm S chooses the level of investment $C(z)$ in absorptive capacity which reduces its unit cost from c to $c(1 - \alpha z)$ where $z \in [0, 1]$. As absorption is easier with FDI, $C(z)$ is lower under FDI.

Location choice and absorptive capacity are critical in determining the firms' effective unit costs. The former (i.e., the location choice decision) determines firm N 's effective unit cost of production—0 under FDI and t under exports—, while investment in absorptive capacity reduces firm S 's unit cost from c to $c(1 - \alpha z)$. Finally, with IPR policy, location and investment decisions in place, the two firms compete in quantities.

As Cournot analysis is standard, let us start with the export versus FDI decision. If firm N chooses FDI, it avoids per unit trade cost. However, FDI makes absorption of new technology easier for firm S which can partially erode North's cost advantage. When IPR protection is weak, the erosion of North's cost advantage is higher. This trade-off between trade cost savings and reduction in cost-advantage is key to the location choice decision by firm N .

The second and probably more important component of our analysis is endogenous determination of South's absorptive capacity. Cohen and Levinthal (1990) argue that a firm's absorptive capacity is critical to recognize the value of new external information and subsequently assimilate and apply it to commercial ends. Thus, if South's absorptive capacity is low, or equivalently its imitation costs are high, then South's IPR protection policy has little effect.

While a part of firm's absorptive capacity can be viewed as its innate ability to absorb new technology—and hence can be treated as exogenous—presumably, the capacity could be changed via investment. Trade facilitates absorption, but absorption is easier/less costly under FDI as technology transfer/spillover importantly depends on geographical proximity. Not surprisingly, South has been active in encouraging FDI. Endogenous determination of absorptive capacity provides rich insights and has important policy implications. By locating in South, FDI makes absorption easier for firm S which encourages investment in absorptive capacity. However, as firm N saves per unit trade cost, its effective unit cost of production declines with FDI. This reduces firm S 's output and consequently its incentive to invest in absorptive capacity. We find that absorptive capacity and consequently productivity spillovers—effective cost reduction in our framework—could be higher or lower with FDI.

The ambiguity might seem surprising as it is often thought that FDI benefits South through technology and knowledge spillover to the local rivals (Keller, 2004). See, for example, Dimelis and Louri (2002), Griffith et al. (2002), Javorcik (2004), Chakraborty and Nunnekamp (2008) and Suyanto, Salim and Bloch (2009) for evidence on positive productivity spillovers. On the other hand, Aitken and Harrison (1999), Djankov and Hoekman (2000), and Barry, Gorg, and Strobl (2005) found negative relationship between FDI and spillovers. By endogenizing investment in absorptive capacity, our theoretical analysis offers an explanation for the ambiguous relationship.

Finally, we turn to IPR protection. Recall that firm N 's unit cost is exogenously given. Furthermore, South's marginal cost declines as South weakens its IPR protection. On both these counts, strengthening IPR protection might seem to reduce South welfare. Indeed, if location choice is not an issue, this argument holds. For example, if trade cost is prohibitive, firm N has no choice but to opt for FDI. In this case, it is optimal for South to offer no protection for IPR. However, if trade cost is not prohibitive, firm N 's losses under FDI from high spillovers (induced by weak IPR) might outweigh the gains from savings trade cost savings. Thus, weak IPR might lead firm N to opt for exports. If firm N chooses exports, it might be bad for South as well. As firm N incurs trade cost under exports, equilibrium price is higher, which hurts consumers. This negative effect is reinforced if investment in absorptive capacity is lower under exports. We find that indeed for a range of parameterizations, it is in South's interest to strengthen IPR protection just enough so that firm N opts for FDI.

Interestingly, we find a non-monotone relationship between trade cost and the level of IPR protection that maximizes South's welfare. In particular, we find that strengthening IPR protection improves South's welfare only for moderate values of trade cost. If the trade cost is too high, IPR protection (to induce FDI) is not necessary since in that case the North firm opts for FDI anyway. If the trade cost is too low, strengthening IPR protection does not improve welfare either. To understand the logic, consider the extreme case of zero trade cost. In that case, FDI does not save trade cost. Furthermore, firm S 's absorptive capacity is higher under FDI. Hence, irrespective of the strength of IPR protection, firm N always locates in North. Since firm N 's location choice does not change with a change in the degree of IPR protection, the South government chooses not to protect IPR at all.

For moderate values of trade cost, where some degree of IPR protection is worthwhile, a decline in trade cost leads to stronger IPR protection. As trade cost declines, export option becomes more attractive for firm N . This prompts South to tighten the IPR protection even further. Thus, even if innovation is not affected by the strength of IPR protection in South, it might still be optimal for South to offer some IPR protection.

The plan of the paper is as follows. Section 2 describes the relationship between our analysis and previous IPR literature. Section 3 describes the basic three-stage game: North firm's location choice, followed by South firm's investment in absorptive capacity, and finally Cournot competition between the two firms. Section 4 characterizes the Cournot equilibrium and South's investment in absorptive capacity. Section 5 analyzes the North firm's location choice. Section 6 discusses the optimal IPR policy from South's perspective taking into account the impact of the degree of IPR protection on absorptive capacity and location choice. Section 7 offers concluding remarks.

2. RELATION TO PREVIOUS LITERATURE

Helpman (1993) provided the first general equilibrium analysis of IPR policy in a North-South product cycle model with innovation, imitation and growth. The early works in this area (Helpman, 1993; Glass and Saggi, 2002) find that strengthening IPR protection in South reduces South welfare and may or may not benefit North. Lai (1998) argues that this finding critically depends on the assumption that imitation is the sole channel of production transfer from North to South. Instead of imitation, if FDI is the channel of production transfer then the conclusion no longer holds. Branstetter and Saggi (2009) push this literature based on North-South product cycle models further by making both imitation and FDI endogenous. Most papers in this literature evaluate the welfare consequence of marginal changes in imitation to analyze the impact of IPR protection. An exception is the paper by Grossman and Lai (2004). They explicitly consider both (i) simultaneous choice of IPR protection by trade partners and (ii) globally efficient regime of IPR protection in a multi-country, trading world where countries differ in their sizes and innovation capacities.

Despite offering valuable and rich insights, these dynamic North-South general equilibrium models often do not involve strategic interaction among firms which is often a key component of analysis in the oligopolistic markets. For detailed microeconomic analysis of firm and government behavior, we adopt a partial equilibrium, Cournot duopoly framework. This allows us to capture crucial firm level decision, e.g., where to locate, how much to invest, in a detailed fashion.

In a simple North-South duopoly model with Cournot competition, Chin and Grossman (1990) showed that no protection of IPR is better than the full protection of IPR for South welfare. Examining the welfare effects of the geographical scope of patent coverage, Deardorff (1992) reports similar results. Both Chin and Grossman (1990) and Deardorff (1992) consider binary choice regarding protection of IPR: full protection or no protection. Allowing for various degree of IPR protection as well as for differences in preference and technology, Diwan and Rodrik (1991) show that South might benefit from protection of IPR if the differences in preferences are substantial. Introducing R&D with spillovers into a North-South duopoly model, Žigić (1998) shows that the result obtained in Chin and Grossman (1990) is no longer robust. He specifically regards the intensity of spillover as an indicator of the strength of the IPR protection. He assumes that if North firm's cost-reducing R&D decreases its own marginal cost (MC) by 1, then it also lowers South's MC by $\alpha \in [0, 1]$, which is the indicator of the strength of the IPR protection.

However, recent empirical evidence shows that the presence of foreign firms does not automatically leads to technology spillovers. Rather, it depends importantly on local firms' investment in R&D related activities (Kathuria, 2000; Kinoshita, 2001; Griffith, Redding and van Reenen, 2003; Suyanto, Salim and Bloch, 2009). Naghavi

(2007) extends Žigić (1998) by considering the possibility of FDI and decomposing the intensity of spillovers into the strength of the IPR protection and the extent of absorptive capacity just like αz in our model.¹ Naghavi (2007) shows that South can always gain from enforcing stringent IPR protection, either by attracting FDI in less R&D-intensive sectors or by stimulating innovation in high-technology sectors. Yang and Maskus (2009) also have absorptive capacity in their work. They focus on a scenario where the North firm chooses either exports or technology transfer through licensing. They show that by encouraging technology transfer, South's stronger IPR protection might improve the ability of South firms to break into export markets and that South's welfare depends on its absorptive capacity.

The key difference between our work and Naghavi (2007) and Yang and Maskus (2009) is that we treat absorptive capacity as *endogenous* by explicitly modelling South firm's investment in absorptive capacity. The endogeneity is important in our framework for two reasons. If the absorptive capacity is exogenous and the same under FDI and exports in our model, both location choice decision for North and the optimal IPR policy become trivial: North always chooses FDI and South offers no protection of IPR. Alternatively, appealing to common wisdom, one can assume that absorptive capacity is higher under FDI than exports. However, that would not be innocuous as we have discussed earlier (and formally demonstrate in Proposition 3), that the absorptive capacity under FDI could be higher or lower than that under exports.

In this regard, our work is related to Grünfeld (2006), as he also explicitly models the concept of absorptive capacity in an international duopoly model. He considers a three-stage game to explore the relationship between absorptive capacity and firm's supplying mode. In his model, the foreign firm decides whether to export to the domestic country or serve it via FDI. Given this decision, both domestic and foreign firms engage in cost-reducing R&D, which also determines the R&D spillover rate, and then in Cournot competition. It should be noted that in Grünfeld (2006), cost-reducing R&D not only reduces its own marginal cost directly but also facilitates the spillover from its rival. Thus, when each firm determines its R&D level, it explicitly takes both roles into account. Although our model structure is somewhat similar to Grünfeld (2006), our focus is completely different from his. We are concerned with South's incentive to protect IPR, which is absent in Grünfeld (2006). Moreover, since Grünfeld (2006) assumes two-way spillovers, his model is more appropriate for the analysis of spillovers between developed countries. In contrast, we deal with one-way spillovers from North to South, because we focus on South's imitation of North.

¹Leahy and Naghavi (2010) introduce joint venture into Naghavi (2007).

3. MODEL

There are two countries, North and South, each with one firm denoted by firm N and firm S respectively. These firms sell a homogenous product in the South. As we are primarily interested in the incentives and welfare consequences of strengthening IPR protection in South, we assume that all consumers are located in South. The inverse demand for the product in the South is

$$(1) \quad \begin{aligned} P &= b - Q, \\ &= b - (q_N + q_S); \end{aligned}$$

where q_i ($i = N, S$), $Q \equiv q_N + q_S$ and P respectively denote output of firm i , aggregate output and market price.

Firm N 's marginal cost of production is assumed to be zero. Concerning location choice there are two options. Firm N can locate in North and export to South incurring trade cost $t > 0$ per unit of q_N . Otherwise firm N can opt for FDI in South. That is, firm N can build a plant in South and serve the South market from that plant. In that case firm N does not incur the trade cost. For simplicity we assume that there are no plant-specific fixed costs.

Firm S is located in South. The initial unit cost of production for firm S is a constant $c > 0$. However, the effective unit cost for firm S is

$$(2) \quad c_S = c(1 - \alpha z); \quad \alpha \in [0, 1], \quad z \in [0, 1]$$

where z denotes absorptive capacity of firm S and α captures the degree of IPR protection in South. If $\alpha = 0$, intellectual property rights are fully protected while if $\alpha = 1$, there is no protection of IPR. As α increases from zero to unity the protection becomes weaker. Weakening of IPR in South reduces the cost advantage of firm N . However, even with no IPR protection (i.e., $\alpha = 1$) firm N enjoys some cost advantage as long as $z < 1$.

To attain absorptive capacity level z , firm S has to invest $C(z)$. We assume that $C(0) = 0$, $C'(z) > 0$ and $C''(z) > 0$ for all $z > 0$. Furthermore, to obtain closed-form solutions, we adopt the standard quadratic specification: $C(z) = \frac{kz^2}{2}$, where $k = k^E$ if firm N opts for export and $k = k^F$ if firm N opts for FDI. Absorption is easier when firms are geographically closer to each other. Accordingly, we assume that $k^E > k^F$.

The timing of the events is as follows:

Stage 1 [Exports or FDI]: Given α — which we assume to be exogenous until section 4 — firm N decides whether to serve the South market via exports or FDI. Let e denote the binary variable capturing the firm N 's mode of serving South market where

$$e = \begin{cases} 1, & \text{if firm } N \text{ exports to South;} \\ 0, & \text{if firm } N \text{ serves South by FDI.} \end{cases}$$

Stage 2 [Investment in absorptive capacity]: Given α and e , Firm S chooses the level of absorptive capacity z .

Stage 3 [Cournot competition]: Given α , e , and z , each firm i chooses q_i to maximize its profit taking rival firm's output, q_j , as given ($i, j \in \{N, S\}, i \neq j$).

Before we proceed to analyze the three-stage game described above few remarks are in order regarding the assumptions of the model. First, the assumption that firm N 's marginal cost is zero is innocuous. Second, the fact that there are no plant-specific fixed costs simplify the algebra but is not crucial for our results. Introducing a strictly positive plant-specific fixed cost would make FDI less preferable to exports. Finally, we have implicitly assumed that the North and the South markets are segmented and firm S does not sell in North. Introducing the possibility that firm S exports to the North does not qualitatively change our findings.

4. ANALYSIS

We characterize the unique Subgame Perfect Nash Equilibrium (SPNE) of the game. To facilitate this characterization we make some simplifying assumptions regarding the upper and lower bounds of different parameters:

Assumption 1: (i) $c < \frac{b}{2}$, (ii) $t < \frac{b}{2}$, and (iii) $k_F > \frac{bc}{3}$.

Assumption 1 implies that the initial marginal cost of firm S is low enough so that it produces a strictly positive amount of output for all (α, e, z) satisfying $\alpha \in [0, 1]$, $e \in \{0, 1\}$ and $z \in [0, 1]$. The bound for t in Assumption 1(ii) ensures that firm N sells a strictly positive amount in South even when it chooses to export. Assumption 1(iii) ensures that the second-order condition of the stage 2 optimization problem is satisfied and the equilibrium value of z is strictly interior (i.e. lies between zero and unity).

4.1. Cournot equilibrium. First consider the stage 3 game where the two firms compete in quantities. Prior to this stage, the degree of IPR protection in South (α), North firm's mode of entry (e) and the South firm's absorptive capacity (z) have been chosen. So, both firms S and N take these variables as given.

For a given (α, e, z) , firm S chooses q_S to maximize $(b - q_N - q_S - c(1 - \alpha)z)q_S$ while firm N chooses q_N to maximize $(b - q_N - q_S - et)q_N$. Routine computation yields:

$$(3) \quad \tilde{q}_N(\alpha, e, z) = \frac{b - 2et + c(1 - \alpha z)}{3}, \quad \tilde{q}_S(\alpha, e, z) = \frac{b - 2c(1 - \alpha z) + dt}{3},$$

$$(4) \quad \tilde{Q}(\alpha, e, z) \equiv \tilde{q}_N(\alpha, e, z) + \tilde{q}_S(\alpha, e, z) = \frac{2b - et - c(1 - \alpha z)}{3},$$

$$(5) \quad \tilde{\pi}_N(\alpha, e, z) = \frac{(b - 2et + c(1 - \alpha z))^2}{9}, \quad \tilde{\pi}_S(\alpha, e, z) = \frac{(b - 2c(1 - \alpha z) + et)^2}{9},$$

where $\tilde{q}_i(\alpha, e, z)$, and $\tilde{\pi}_i(\alpha, e, z)$ denote quantity and profit of firm $i (= N, S)$ in the Cournot equilibrium. The following lemma records some comparative statics results for future reference.

Lemma 1. *For any given location choice (i.e., $e = 0$, or $e = 1$),*

(i) $\tilde{q}_N(\alpha, e, z)$ and $\tilde{\pi}_N(\alpha, e, z)$ are decreasing in α and z .

(ii) $\tilde{q}_S(\alpha, e, z)$ and $\tilde{\pi}_S(\alpha, e, z)$ are increasing in α and z .

(iii) $\tilde{Q}(\alpha, e, z)$ is increasing in α and z .

Both weakening of IPR protection (i.e., an increase in α) and increase in absorptive capacity (i.e., an increase in z) reduces unit cost of firm S . This in turn increases firm S 's output and profit. Firm N 's output and profit decline since $\tilde{q}_S(\alpha, e, z)$ and $\tilde{q}_N(\alpha, e, z)$ are strategic substitutes. Part (iii) is a standard result from Cournot competition: aggregate output increases as unit cost declines (through an increase in α or z in our framework).

4.2. Absorptive Capacity. Consider stage 2 where firm S chooses the level of absorptive capacity z . For a given degree of IPR protection, α , and firm N 's location choice, e , firm S chooses the z to maximize

$$\tilde{\pi}_S(\alpha, e, z) - \frac{k(e)z^2}{2} \equiv \pi_S(\alpha, e, z),$$

where $k(e) \equiv ek^E + (1 - e)k^F$. The marginal cost of investment in z is

$$k(e)z,$$

while the marginal benefit from investment in absorptive capacity, given by $\frac{\partial \tilde{\pi}_S(\alpha, e, z)}{\partial z}$ is:²

$$(6) \quad \frac{\partial \tilde{\pi}_S(\alpha, e, z)}{\partial z} = 2\tilde{q}_S(\alpha, e, z) \frac{\partial \tilde{q}_S(\alpha, e, z)}{\partial z} = \frac{2\alpha c(b - 2c(1 - \alpha z) + et)}{9}.$$

Equating marginal cost with marginal benefit of investment in z gives the South firm's absorptive capacity in stage 2 equilibrium:

$$(7) \quad z = \frac{2\alpha c(b - 2c + et)}{9k(e) - 4\alpha^2 c^2} \equiv z(\alpha, e)$$

where $\alpha \in [0, 1]$ and $e \in \{0, 1\}$.

Observe that that numerator of $z(\alpha, e)$, i.e., $2\alpha c(b - 2c + et)$, is strictly increasing in α , while the denominator, $9k(e) - 4\alpha^2 c^2$ is strictly decreasing in α . This observation leads to our first proposition.

PROPOSITION 1. *Absorptive capacity increases as the degree of IPR protection weakens. More precisely, for a given $e \in \{0, 1\}$, $\frac{dz(\alpha, e)}{d\alpha} > 0$.*

Proof: Immediate from the discussion prior to the proposition.

²The first equality in (6) follows from differentiating $\tilde{\pi}_S(\alpha, e, z) \equiv (q_S(\alpha, e, z))^2$,

To understand Proposition 1, recall the effective cost of production for firm S: $c_S = c(1 - \alpha z)$. As z increases, c_S declines which raises firm S's profit. The weaker the IPR protection (i.e., the higher the α) the larger is the decline in c_S and consequently the larger the increase in firm S' profit. Thus the marginal benefit from an investment in z increases as the degree of IPR protection weakens. This logic, together with the fact that marginal cost of investment, $k(e)z$, is independent of degree of IPR protection imply Proposition 1.

Let z^F (z^E) denote the equilibrium absorptive capacity of firm S when firm N serves the South market via FDI(exports). Using (7) we get:

$$(8) \quad z^F \equiv z(\alpha, 0) = \frac{2\alpha c(b - 2c)}{9k^F - 4\alpha^2 c^2}$$

$$(9) \quad z^E \equiv z(\alpha, 1) = \frac{2\alpha c(b - 2c + t)}{9k^E - 4\alpha^2 c^2}$$

Define $q_i^F \equiv \tilde{q}_i(\alpha, 0, z^F)$, $\pi_i^F \equiv \tilde{\pi}_i(\alpha, 0, z^F)$ and $Q_i^F \equiv \tilde{Q}_i(\alpha, 0, z^F)$ where $i = N, S$. Thus q_i^F , π_i^F and Q_i^F respectively denote firm i 's quantity, firm i 's profit and aggregate output in stage 2 equilibrium when the North firm opts for FDI in stage 1. Similarly $q_i^E \equiv \tilde{q}_i(\alpha, 1, z^E)$, $\pi_i^E \equiv \tilde{\pi}_i(\alpha, 1, z^E)$ and $Q_i^E \equiv \tilde{Q}_i(\alpha, 1, z^E)$ respectively are firm i 's output, firm i 's profit and aggregate output in stage 2 equilibrium when the North firm chooses to export in stage 1. Using Lemma 1 and Proposition 1 we can establish the following relationships between the equilibrium outcomes in stage 2 and the strength of IPR protection.

PROPOSITION 2. *The North firm's profit declines while the South firm's profit and aggregate output increases as the strength of IPR weakens in South. These results hold for both modes of North entry into the South market— exports as well as FDI. More formally,*

- (i) π_N^F and π_N^E are decreasing in α .
- (ii) π_S^F and π_S^E are increasing in α .
- (iii) Q^E and Q^F are increasing in α .

Proof: See Appendix.

As the strength of IPR protection weakens (i.e., as α increases), South firm's investment in absorptive capacity (z) increases. Effective unit cost of production for South, $c_S \equiv c(1 - \alpha z)$, declines. Part (i) follows from the logic that lower c_S leads to higher q_S , which in turn imply lower q_N and consequently lower π_N . Part (iii) is easy to understand once we recognize that the aggregate output increases as unit cost declines. To understand part (ii), write

$$\frac{d\pi_S}{d\alpha} = \frac{\partial \pi_S}{\partial \alpha} + \frac{\partial \pi_S}{\partial z} \frac{dz}{d\alpha}$$

and observe that $\frac{\partial \pi_S}{\partial z} = 0$ (envelope theorem) and $\frac{\partial \pi_S}{\partial \alpha} > 0$ (Lemma 1).

Now we turn to the comparison between z^F and z^E . The comparison for two cases are immediate—perfect IPR protection, and zero trade costs.

- If IPR protection is perfect, i.e., $\alpha = 0$, there is no incentive to invest in absorptive capacity and hence $z^F = z^E = 0$.
- If IPR protection is imperfect but there are no trade costs, i.e., $t = 0$ then $z^F > z^E$.

Except for these two cases the results are less clear-cut. Marginal cost of investment in absorptive capacity, $k(e)z$, is lower under FDI since $k(0)(\equiv k^F) < k(1)(\equiv k^E)$. However, the marginal benefit from investment in z is smaller as well. To understand why, note that firm N 's unit cost of production is lower under FDI as it saves trade cost t per unit. The reduction in firm N 's unit cost leads to higher q_N and lower q_S . Lower output (i.e., lower q_S) in turn reduces firm S 's incentive to invest in z .

As both marginal benefit as well as marginal cost of investment in absorptive capacity are lower under FDI, z^F could be higher or lower than z^E depending on the degree of IPR protection (α) and per unit trade cost (t). Proposition 3 compares z^F with z^E and relate the comparison to the degree of IPR protection as well as per unit trade cost.

PROPOSITION 3. *Absorptive capacity is strictly higher under FDI if IPR protection is weak enough. More formally, for all $t > 0$, there exists a threshold value $\tilde{\alpha}(t) \in [0, 1]$ such that $z^F > z^E$ holds for all $\alpha > \tilde{\alpha}(t)$. Furthermore $\tilde{\alpha}(t)$ is increasing in t .*

Proof: Using (8) and (9) we get

$$z^F - z^E = \frac{2ac(b-2c)}{(k^E - 4\alpha^2c^2)(9k^F - 4\alpha^2c^2)} \left(9(k^E - k^F) - \frac{t(9k^F - 4\alpha^2c^2)}{b-2c} \right).$$

(i) If $9(k^E - k^F) - \frac{9tk^F}{b-2c} > 0$, then $9(k^E - k^F) - \frac{t(9k^F - 4\alpha^2c^2)}{b-2c} > 0$ for all $\alpha \in [0, 1]$ and hence $z^F \geq z^E$ holds for all $\alpha \in [0, 1]$.

(ii) If $9(k^E - k^F) - \frac{t(9k^F - 4\alpha^2c^2)}{b-2c} < 0$, then $9(k^E - k^F) - \frac{t(9k^F - 4\alpha^2c^2)}{b-2c} < 0$ for all $\alpha \in [0, 1]$ and hence $z^F > z^E$ does not hold for any $\alpha \in [0, 1]$.

(iii) If $9(k^E - k^F) - \frac{9tk^F}{b-2c} < 0$, but $9(k^E - k^F) - \frac{t(9k^F - 4\alpha^2c^2)}{b-2c} > 0$, then $z^F \geq z^E$ holds for all $\alpha \geq \frac{3\sqrt{k^F - \frac{(b-2c)(k^E - k^F)}{t}}}{2c}$.

Define $\tilde{\alpha}(t) = 0, 1$, and $\frac{\sqrt{9k^F - \frac{(b-2c)(k^E - k^F)}{t}}}{2c}$ respectively for cases (i), (ii), and (iii) and the claim follows. The last statement of proposition 3 follows from noting that $\tilde{\alpha}(t)$ does not vary with t for (i) and (ii), and is strictly increasing with t for (iii). \square

We conclude this section by presenting an interesting non-monotonicity result.

PROPOSITION 4. (i) Absorptive capacity is non-monotone in firm S 's initial unit cost of production. That is, for all $\alpha \in (0, 1]$ there exists $c(\alpha, e) > 0$ such that

$$\frac{dz(\alpha, e)}{dc} > (=, < 0) \Leftrightarrow c < (=, >)c(\alpha, e)$$

provided $e = 0$ (FDI), or $e = 1$ (exports) but t is not too large.

(ii) Higher initial unit cost of production does not necessarily imply higher effective unit cost. More formally, there exists values of c , namely c^1 and c^2 such that $c^1 > c^2$ and yet $c^1_\zeta \equiv c^1(1 - \alpha z^1) < c^2(1 - \alpha z^2) \equiv c^2_\zeta$ where z^1 and z^2 denote absorptive capacities in stage 2 equilibrium corresponding to initial unit costs c^1 and c^2 respectively.

Proof: See Appendix.

Consider the FDI case (i.e., $e = 0$). If cost difference is too small to start with, the incremental change in output due to additional investment in z is negligible. More precisely, $\lim_{c \rightarrow 0} \frac{\partial \tilde{q}_S(\alpha, 0, z)}{\partial z} = \lim_{c \rightarrow 0} \frac{2\alpha c}{3} = 0$. Consequently, $\lim_{c \rightarrow 0} \frac{\partial \tilde{\pi}_S(\alpha, 0, z)}{\partial z} = 0$. On the other hand, if the cost difference is too large (i.e., c close to $\frac{b}{2}$), $\lim_{c \rightarrow \frac{b}{2}} \frac{\partial \tilde{\pi}_S(\alpha, 0, z)}{\partial z} = 0$ since $\lim_{c \rightarrow \frac{b}{2}} \tilde{q}_S(\alpha, 0, z) = 0$. Thus, for both extremes — cost differences too large or too small — the benefit from an additional unit of investment in z is negligible and consequently $z \approx 0$. For intermediate values of c however $\frac{\partial \tilde{\pi}_S(\alpha, 0, z)}{\partial z}$ is strictly positive which suggests that the relationship between absorptive capacity z and the initial unit cost c is non-monotone.

For $c > c(\alpha, d)$, as c increases z declines and hence higher c does imply higher c_ζ . However, for $c < c(\alpha, d)$, z increases as c increases. This creates the possibility that $c^1 > c^2$ but $c^1_\zeta < c^2_\zeta$ where c^1_ζ and c^2_ζ are effective unit cost of production corresponding to the initial unit cost c^1 and c^2 respectively. Proposition 4(ii) says that indeed there are parameter values for which this holds.

5. EXPORTS VERSUS FDI

Two considerations are important for the firm N 's optimal location choice: trade cost and absorptive capacity of firm S . FDI lowers firm N 's effective unit cost by saving per unit trade cost t . However, under FDI, firm S 's unit cost $c_S \equiv c(1 - \alpha z)$ might be lower as well if $z^F > z^E$. While the former effect favors FDI, the latter one favors exports. So, when does firm N choose to export ($e = 1$) and when does it choose FDI ($e = 0$)? Assume that in case of indifference between exports and FDI firm N opts for FDI. Firm 1 opts for FDI in SPNE if and only if $\pi_N^F - \pi_N^E \geq 0$. We have that

$$\begin{aligned} \pi_N^F - \pi_N^E \geq 0 &\Leftrightarrow q_N^F - q_N^E \geq 0 \\ (10) \quad &\Leftrightarrow \alpha c(z^F - z^E) - 2t \leq 0. \end{aligned}$$

where the first \Leftrightarrow follows from using that $\pi_N^F = (q_N^F)^2$, $\pi_N^E = (q_N^E)^2$, and the second \Leftrightarrow follows from substituting the expression for $q_N^F \equiv \tilde{q}_N(\alpha, 0, z^F)$ and $q_N^E \equiv \tilde{q}_N(\alpha, 0, z^E)$ in (10).

First, consider the case $\alpha = 0$. IPR protection is perfect which implies $z^F = z^E = 0$. Firm N chooses FDI for all $t > 0$ since $\alpha c(z^F - z^E) - 2t = -2t < 0$. In case of perfect IPR protection, firm N 's only consideration (while making location choice) is trade cost. By choosing FDI firm N avoids trade cost and hence it prefers FDI to exports.

Now consider the case $t = 0$. From (8) and (9) we know that $z^F - z^E > 0$ which imply $\alpha c(z^F - z^E) - 2t > 0$. Thus firm N 's optimal choice is to locate in North and export to South. In case of zero trade costs, firm N 's unit cost is same no matter where it locates but firm S 's unit cost $c_S \equiv c(1 - \alpha z)$ is higher if firm N chooses to export since $z^E < z^F$.

The discussion above casts the trade-off involved in firm N 's location choice in terms of trade cost and absorptive capacity. However note that, absorptive capacity is endogenous variable. The equilibrium value of absorptive capacity depends on trade cost parameter, t , and the degree of IPR protection, α — see (8) and (9). Substituting the expression for z^F and z^E from (8) and (9) in (10) above and analyzing the inequality further gives the following proposition.

PROPOSITION 5. *The North firm prefers FDI to exports if IPR protection is strong enough and trade cost is not too high. The minimum degree of IPR protection that induces FDI increases as trade cost declines. More formally, for all $t > 0$, there exists $\alpha(t) \in [0, 1]$ such that firm N opts for FDI in stage 1 if and only if $\alpha \leq \alpha(t)$. There exists \bar{t} such that $\alpha(t) < 1$ for $t \leq \bar{t}$. Furthermore, $\alpha(t)$ is strictly increasing in t .*

Proposition 5 says how the exports versus FDI decision of firm N depends on trade cost and the strength of IPR protection in South. Even in absence of any protection of IPR (i.e., $\alpha = 1$) firm N might locate in South if trade cost is large enough. This might suggest that endogenous absorptive capacity and consequently the strength of IPR protection has little role to play. However, note that if absorptive capacity were exogenous and same under FDI and exports (i.e., $z = z^F = z^E$), (10) implies that firm N would prefer FDI for all $t > 0$ and not just high t . This observation highlights the importance of *endogenous* absorptive capacity in firm N 's choice between FDI versus exports.

The second part of the Proposition unravels a complementary relationship between trade liberalization and South's IPR protection. As trade cost declines, the option of exporting becomes more attractive to North. This imply that the critical level of IPR protection needs to be stronger in South so that the North firm prefers FDI to exports. As we show below, the impact of IPR protection on North's location decision play an important role in determining optimal IPR policy for South.

6. INTELLECTUAL PROPERTY RIGHTS

Stronger IPR protection in South leads to higher profit of the North firm (see Proposition 2). Since North welfare consists solely of North firm's profit in our framework, $\alpha = 0$ is optimal for North.

South welfare (W_S) is the sum of consumer surplus (CS) and the South firm's profits (π_S). Corresponding to the demand function $P = b - Q$, consumer surplus (CS) is $\frac{Q^2}{2}$. Let CS^F (CS^E) and W^F (W^E) respectively denote the consumer surplus and welfare when firm N chooses FDI (exports) in stage 1. By definition,

$$W^F = CS^F + \pi_S^F; \quad W^E = CS^E + \pi_S^E.$$

Firm N chooses FDI for $\alpha \leq \alpha(t)$ which imply

$$\begin{aligned} W &= W^F & \text{if } \alpha \leq \alpha(t), \\ &= W^E & \text{if } \alpha > \alpha(t). \end{aligned}$$

South welfare under FDI, W^F , increases as α increases since both $CS^F \equiv \frac{Q^F{}^2}{2}$ and π_S^F are increasing in α (Proposition 2). South welfare under exports, W^E , increases with α for analogous reasons. Given the relationship between W^E , W^F and α it is immediate that the optimal α for South is either 1 or $\alpha(t)$ (which can be 1 as well for some parameter values). That is, the degree of IPR protection that maximizes South welfare is either nil (i.e., $\alpha = 1$) or just enough (i.e., $\alpha = \alpha(t)$) so that the North firm opts for FDI in South. The proposition below provides a sharper characterization.

PROPOSITION 6. *Let $\alpha^*(t)$ denote the level of IPR protection that maximizes South welfare. There exists t_1 and t_2 satisfying $0 < t_1 < t_2 < \infty$ such that*

$$\alpha^*(t) = \begin{cases} 1, & \text{if } t < t_1 \\ \alpha(t) \in (0, 1), & \text{if } t \in [t_1, t_2] \\ 1 & \text{if } t > t_2 \end{cases}$$

Proof: See Appendix.

Proposition 6 implies a non-monotone relationship between trade cost and the strength of IPR protection. If trade cost is too high or too low, South's welfare is maximized when it does not offer any IPR protection at all. Else, the optimal degree of protection is strictly interior. The logic of the result is as follows. Suppose trade cost is prohibitive. This implies that firm N undertakes FDI anyway. As location choice is not affected by α , it is optimal to set $\alpha^*(\cdot) = 1$ since both CS^F and π_S^F are strictly increasing in α . Now consider the other extreme, $t = 0$. Firm N locates in North irrespective of α since North cost-advantage is higher if it opts for exports. Once again, since α does not affect firm N 's location choice, it is optimal to set $\alpha^*(\cdot) = 1$ since both CS^E and π_S^E are strictly increasing in α . For intermediate values of t , choice

of α affects the location choice of firm N . In particular, there are parameterizations (in particular k^E and k^F) such that the South government finds it optimal to choose $\alpha \in (0, 1)$ to attract FDI.

7. CONCLUDING REMARKS

We examined South's incentives to protect IPR in an environment where the strength of IPR protection in South has no bearing on North firm's incentives to innovate. In the presence of (i) endogenous absorptive capacity, and (ii) North firm's location choice—both endogenously determined in our framework—we find that South can benefit from having a strict IPR protection depending on the level of trade cost. Interestingly, we find that the relationship between optimal strength of IPR protection in South and trade cost is non-monotone. If the trade cost is too high or too low then there is no incentive to protect IPR in South. For moderate values of trade cost, however it is optimal for South to protect IPR to some extent. In this range (of values for trade costs) the IPR protection becomes stronger as the trade cost declines.

Our analysis also offers an explanation for the ambiguous relationship between FDI and spillovers often observed in the data. Key to our explanation is the role of absorptive capacity. Under FDI, absorption is less costly but the South firm faces stronger competition since North firm saves trade cost when it opts for FDI. As a consequence we find that absorptive capacity/spillovers can be higher or lower under FDI.

Throughout the analysis we have treated trade cost as resource cost instead of tariff. Except for section 6 (where we consider South welfare) the analysis and the results are invariant to the particular interpretation of trade cost. Incorporating tariff revenues in welfare function does not change the main result on non-monotone relationship (Proposition 6) in section 6. Both for zero and prohibitive tariff, tariff revenues do not matter. For both these cases—which correspond to zero trade cost and prohibitive trade cost in the previous section—it is optimal for South to offer no IPR protection at all. However, for intermediate values of t , tariff can impact South's incentive to protect IPR in a subtle way. Strengthening IPR protection improves welfare in our framework when it prompts North to opt FDI. Tariff revenues leads to higher South welfare under export option while welfare under FDI remains unchanged. This reduces the relative attractiveness of FDI and weakens South's incentive to protect IPR. On the other hand, under exporting option, strengthening IPR protection has an additional benefit. It increases North output which in turn leads to higher tariff revenues and consequently higher welfare for South. Thus the range of values for which optimal $\alpha^* \in (0, 1)$ as well as the value of α^* will generally be different when we treat t as per unit tariff instead of trade cost.

8. APPENDIX (TO BE COMPLETED)

9. REFERENCES

- Aitken, B.J., Harrison, A.E., 1999. Do domestic firms benefit from direct foreign investment? evidence from Venezuela. *American Economic Review* 89, 605-18
- Barry, F., Gorg, H., Strobl, E., 2005. Foreign direct investment and wages in domestic firms in Ireland: productivity spillovers versus labor market crowding out. *International Journal of Business and Economics* 12, 67-84.
- Branstetter, L.G., 2001. Are knowledge spillovers international or intranational in scope? Microeconomic evidence from the U.S. and Japan. *Journal of International Economics* 53, 53-79.
- Branstetter, L., Saggi, K., 2007. Intellectual property rights, Foreign Direct Investment, and industrial development. NBER working paper 15393
- Chakraborty, C., Nunnenkamp, P., 2008. Economic reforms, FDI, economic growth in India: a sector level analysis. *World Development* 36, 1192-212.
- Chin, J.C., Grossman, G.M., 1989. Intellectual Property Rights and North-South Trade in R. Jones and A. Krueger (eds.), *The Political Economy of International Trade-Policy*, Basil Blackwell.
- Cohen, W.M., Levinthal, D. A., 1990. Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly* 35, 128-52.
- Deardorff, A., 1992. Welfare effects of global patent protection. *Economica* 59, 35-51.
- Diwan, I., Rodrik, D., 1991. Patents, appropriate technology, and North-South trade. *Journal of International Economics* 30, 27-47.
- Dimelis, S., Louri, H., 2002. Foreign ownership and production efficiency: a quantile regression analysis. *Oxford Economic Press* 54 (3): 449-69.
- Djankov, S., Hoekman, B., 2000. Foreign investment and productivity growth in Czech enterprises. *World Bank Economic Review* 14, 49-64.
- Eaton, J., Kortum, S., 1999. International patenting and technology diffusion: theory and measurement. *International Economic Review* 40, 537-70.
- Glass, A.J., Saggi, K., 2002. Intellectual Property Rights and Foreign Direct Investment. *Journal of International Economics* 56, 387-410.
- Grossman, G., Lai, E., 2004. International protection of intellectual property. *American Economic Review* 94, 1635-53.

Griffith, R., Redding, S., Van Reenen, J., 2003, R&D and absorptive capacity: Theory and empirical evidence. *Scandinavian Journal of Economics* 105, 99-118.

Grünfeld, L. A., 2006, Multinational production, absorptive capacity, and endogenous R&D spillovers. *Review of International Economics* 14, 922-40.

Haddad, M., Harrison, A.E., 1993. Are there positive spillovers from foreign direct investment? Evidence from panel data for Morocco. *Journal of Development Economics* 42, 51-74.

Ishikawa, J. and Horiuchi, E., 2010, Strategic foreign direct investment in vertically related markets. mimeo, Hitotsubashi University.

Helpman, E., 1993. Innovation, imitation, and intellectual property rights. *Econometrica* 61, 1247-80.

Kathuria, V., 2000. Productivity spillovers from technology transfer to Indian manufacturing firms. *Journal of International Development*. 12, 343-69

Keller, W., 2002. Geographic localization of international technology diffusion. *American Economic Review* 92, 120-42.

Keller, W., 2004. International technology diffusion. *Journal of Economic Literature* 42, 752-82.

Kinoshita, Y., 2001. R&D and technology spillovers through FDI: Innovation and absorptive capacity. CEPR Discussion Paper 2775.

Lai, Edwin L.-C., 1998, International intellectual property rights protection and the rate of product innovation. *Journal of Development Economics* 55, 133-53.

Leahy, D., Naghavi, A., 2010, Intellectual property rights and entry into a foreign market: FDI versus joint ventures. *Review of International Economics* 18, 633-649.

Naghavi, A., 2007, Strategic intellectual property rights policy and North-South technology transfer. *Review of World Economics* 143, 55-78.

Javorcik, B., 2004. Does foreign direct investment increase the productivity of the domestic firms? in search of spillovers through backward linkages. *American Economic Review* 94, 605-27.

Suyanto, Salim, R., Bloch, H., 2009. Does Foreign Direct Investment Lead to Productivity Spillovers? Firm Level Evidence from Indonesia *World Development* 37, 1861-76.

Yang, G., Maskus, K.E., 2009. Intellectual property rights, technology transfer and exports in developing countries. *Journal of Development Economics* 90, 231-36.

Žigić, K., 1998. Intellectual property rights violations and spillovers in North-South trade. *European Economic Review* 42, 1779-99.

Žigić, K., 2000. Strategic trade policy, intellectual property rights, and North-South trade. *Journal of Development Economics* 61, 27 - 60.