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Trade Liberalization, Absorptive Capacity and the Protection of Intellectual property rights

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TRADE LIBERALIZATION, ABSORPTIVE CAPACITY AND THE PROTECTION OF INTELLECTUAL PROPERTY RIGHTS

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ABSTRACT. We examine how trade liberalization affects South's incentive to protect intellectual property rights (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 depends on South's imitation, which in turn depends on South's IPR protection and absorptive capacity and North firm's location choice and masking effort, all of which are endogenously determined in our model. Even though innovation is exogenous to the model (and hence unaffected by South's IPR policy) we find that strengthening IPR protection in South can improve its welfare. The relationship between trade cost and the degree of IPR protection that maximizes South welfare is non-monotone. South does not have any incentive to protect IPR when trade costs are either zero or prohibitive, while for moderate values of trade cost, South government can strengthen IPR protection, induce FDI and increase South's welfare. In an extension of the model, where North firm can mask its technology, we show that, even when trade costs are zero or prohibitive, strengthening IPR protection can improve South's welfare by deterring the North firm from masking its technology. The relationships between location choice/masking decision and South's investment in absorptive capacity are also explored.

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1. Introduction

Globalization leads to technology transfers/spillovers from developed countries (North) to developing countries (South). A typical channel of technology transfers/spillovers is trade and foreign direct investment (FDI), which make it easier for South firms to imitate superior production technologies in North. However, such imitation is neither automatic nor costless (Grossman and Helpman, 1991; Helpman, 1993; Branstetter and Saggi, 2011). The extent of imitation depends crucially on South's absorptive capacity, i.e., South's ability to effectively copy the superior technologies of North.

South's imitation activities are also importantly affected by South government's policies and North firms' strategic decisions (e.g. location). In particular, imitation is strongly influenced by the strength of intellectual property rights (IPR) protection in South. If IPR protection is perfect and fully enforced, patented technologies cannot freely be copied. When IPR protection is imperfect, North firms may mask their technologies to deter South firms from copying them unless masking is too costly. Furthermore, North firm's location choice affects South's imitation, because geographical proximity plays an important role in technology spillovers (see, for example, Eaton and Kortum, 1999; Branstetter, 2001; Keller, 2002, and Bilir, 2012). When North firms serve the South market, South's imitation is easier under 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, imitation depends on North firm's location choice, its masking decision, South's absorptive capacity and most importantly South's IPR protection, all of which are endogenously determined in our framework.

Strengthening IPR protection boosts innovation. While that argument is well understood, critics of stronger IPR regimes in South argue that there is little appreciable effect of IPR protection in South on North innovation (Branstetter and Saggi, 2011). Furthermore, as argued by Maskus (2000) and Maskus and McDaniel (1999), imposing a strong IPR regime might retard industrial development of the developing countries. Taking these arguments seriously, we assume that North innovation, which is presumably the source of North's cost advantage, is exogenously given. Instead, we incorporate North firm's other decisions (e.g., location choice, masking behavior) into our model and show that incorporating these features and endogenizing South firm's investment in absorptive capacity have important IPR policy implications for South. In particular, we show that South can benefit from

strengthening its own IPR protection even when North innovation is unaffected by its IPR policy.

To make our analysis tractable, we assume that the trade liberalization is caused by a decrease in trade costs, which is beyond the control of the South government. That is, trade costs are declining as the result of a decrease in transport costs and a pre-commitment to the reduction of trade barriers. Hence, the policy instrument the South government can freely set is only the degree of IPR protection. We find that the relationship between trade costs and South's incentive to protect IPR can be subtle. In particular, we show that trade liberalization can mute or amplify the North-South conflict regarding IPR protection, depending on the trade costs.

To understand our implications better, we present 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 $c(> 0)$. Given trade costs, 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 a trade cost of t per unit. After the firm N's decision 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, we assume that $C(z)$ is lower under FDI.

Given that 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 the 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.[1]

The second and probably more important component of our analysis is the endogenous determination of South's absorptive capacity. Cohen and Levinthal (1990) argue that a firm's absorptive capacity is critical to recognizing the value of new external information and subsequently assimilating and applying 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 part of a 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.

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[1]In addition to trade cost savings, North firm can also enjoy other forms of cost advantage, e.g., low input cost in South, which might make FDI even more attractive for North. Incorporating other forms of cost advantage will not alter our analysis as long as the magnitudes of these cost-advantages are exogenously given.

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. Such ambiguity only arises when absorptive capacity is endogenously determined.

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, Redding and van Reenen (2003), 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 a 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 and not affected by South's IPR policy. As South strengthens its IPR protection, South's marginal cost increases which in turn reduces profits and consumer surplus for South. Thus, strengthening IPR protection might seem to reduce South's welfare. Indeed, if location choice or masking behavior is not an issue, this argument holds. For example, if trade costs are prohibitive with location choice, 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 saving trade costs. 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, the 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 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 the presence of location choice. 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. Strengthening IPR protection improves South's welfare only for moderate values of trade cost.

In section 3, we show that strengthening IPR protection can induce firm N to choose FDI over exports, which in turn improves South's welfare. However, this is not the only channel through which IPR can improve welfare. In section 4, we

abstract away from location choice decision (by assuming that there are no trade costs) and focus on masking decision because North firms often undertake a variety of costly activities to prevent the imitation of its technology (see section 4 for details). To capture costly masking, we consider a model where firm N's effective unit cost is m if it masks its technology and zero otherwise. Masking increases the cost of investment in absorptive capacity for firm S.

In terms of effects, we find that masking is similar to exports, while non-masking is similar to FDI. Firm N engages in masking if and only if IPR protection in South is not sufficiently strong. In this setup we show that strengthening IPR protection can improve South's welfare by deterring firm N from masking its technology. As in the case of trade costs, we find that protection is optimal only for intermediate values of m. Irrespective of the strength of IPR protection, firm N masks its technology when m is low and does not mask when m is high. In the intermediate range of values of m however, strengthening IPR protection deters masking and improves South's welfare.

The plan of the paper is as follows. Section 2 describes the relationship between our analysis and previous IPR literature. Section 3 explores the four-stage game with North firm's location choice. We find 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 4 investigates a three-stage game with North firm's masking behavior instead of location choice. Section 5 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. If FDI is the channel of technology transfer instead of imitation, the conclusion no longer holds.

Branstetter and Saggi (2011) push this literature based on North-South product cycle models further by making both imitation and FDI endogenous. Branstetter, Fisman, Foley and Saggi (2011) show that while the imitation activities decline in South with the strengthening of its IPR regime, the expansion of multinational activity can more than offset the decline. Examining the responses of U.S.-based multinationals and domestic production to a set of IPR reforms in the 1980s and 1990s, they confirm that is indeed the case. 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) a globally efficient regime of IPR protection in a multi-country, trading world where countries differ in their size 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 (Yang and Maskus, 2009). 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 decisions such as where to locate or 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's 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 degrees 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, 2000) 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 an indicator of the strength of the IPR protection.

Recent empirical evidence shows that the presence of foreign firms does not automatically lead to technology spillovers, however. Rather, it depends importantly on local firms' investment in R&D related activities (Kathuria, 2000; 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. 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 in which 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 existing works in partial equilibrium based IPR literature in general, and Žigić(1998), Naghavi (2007) and Yang and

Maskus (2009) in particular, 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 the 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 2), that the absorptive capacity under FDI could be higher or lower than that under exports.

Grünfeld (2006) also explicitly models the concept of absorptive capacity in an international duopoly model. In his framework, both domestic and foreign firms engage in cost-reducing R&D, which also determines the R&D spillover rate. Except for the endogenous determination of absorptive capacity, however, there is little similarity between his work and ours. We are concerned with South's incentive to protect IPR in the process of trade liberalization, which is absent in Grünfeld (2006). Moreover, since he assumes two-way spillovers, his model is better suited to analyzing spillovers between developed countries. In contrast, we deal with one-way spillovers from North to South, which seems more appropriate for analyzing South's imitation of North. Also, the masking behavior of North firms is not explicitly considered in Grünfeld (2006).

Taylor (1993) explicitly incorporates North's masking efforts and South's reverse engineering efforts in a North-South duopoly model to examine the relationship between the IPR protection in South and technology transfers. Our model is related to Taylor's work as we also endogenize South's investment in absorptive capacity, and North's masking decision. However, in contrast to Taylor(1993), where masking is modelled as an increase in fixed costs for the North firm, we assume that masking increases the variable cost for the North firm.[2] An important implication of our specification is that as North firm switches from non-masking to masking, South firm can increase its investment in absorptive capacity. Also, as masking is a binary decision in our framework —see section 4 for details— strengthening of IPR protection in South can deter North firms from masking but it does not necessarily do so. Strengthening IPR protection deters masking and improves South's welfare only if the cost of masking is not too high or too low. Note that masking per se is

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[2]Whether masking is better modeled as an increase in fixed cost (as in Taylor, 1993) or an increase in marginal cost (like ours) depends on the context. Consider for example the list of masking activities mentioned in Taylor (1993): software programming traps, copy-protect schemes, the encryption of important codes, maintaining a vigilant legal department, and monitoring the imports of similar foreign products. While the last two activities can be captured via an increase in fixed costs, the others fit well with an increase in marginal cost.

not the main focus of our paper. In fact, as we show in section 3, a case for strengthening IPR protection in South exists when location (rather than masking) is the key decision variable for North firm. In section 4, we simply show that such a model with endogenous location choice could be translated to a model with endogenous masking decision without much substantive change.

3. MODEL WITH LOCATION CHOICE

3.1. **Setup.** 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

$$P = b - Q$$
$$(1) \qquad\qquad = b - (q_N + q_S),$$

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. Firm N can either locate in North and export to South, incurring a trade cost of $t > 0$ per unit of q_N. Otherwise, it 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 fixed costs for setting up a plant in South. [3]

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

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

where z denotes the 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 the *IPR* protection 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 consider $C(z) = kz^2$, where $k = k^E$ if firm N opts for export and $k = k^F$ if firm N opts for FDI.

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[3]To be precise, the cost of building a first plant in South is zero, while the cost of building a second plant is prohibitive. Thus, effectively, the number of North plants in South is either zero or one.

We assume that $k^E > k^F$. Several authors including Eaton and Kortum (1999), Branstetter (2001), and Keller (2002) among others have pointed out that proximity facilitates imitation. In other words, absorption is easier when firms are geographically closer to each other. This might be due to the possibility of worker mobility between firms N and S or other mechanisms (e.g., both firms buying local inputs from a common supplier).[4]

The timing of the events is as follows.

Stage 1 [Exports or FDI]: Given α— which we assume to be exogenous until subsection 3.5 — 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 the 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 the rival firm's output, q_j, as given ($i, j \in \{N, S\}, i \neq j$).

A 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 fixed costs for FDI simplifies the algebra but is not crucial for our results. Introducing a strictly positive plant-specific fixed cost would make FDI less preferable to exports. Third, we have implicitly assumed that the North and South markets are segmented and that firm S does not sell in North. Introducing the possibility that firm S exports to North does not qualitatively change our findings unless North government sets policy strategically. Finally, our cost specifications, i.e. $c_S = c(1 - \alpha z)$ and $C(z) = kz^2$, suggest that unless firm S invests in absorptive capacity, the cost difference between firms N and S stays at c. An alternative specification could be $c_S = c(z_0)(1 - \alpha z)$ where $0 < c(z_0) < c = c(0)$ holds for all $z_0 > 0$. The term z_0 could be interpreted as the innate imitation ability of firm S. We chose to work with $c(z_0) = c$ because this greatly simplifies the algebra.

Now we turn to characterizing the unique Subgame Perfect Nash Equilibrium (SPNE) of the game. To facilitate this characterization, we make a number of 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) $k^F > \frac{b^2}{9}$.

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[4]For some products, it is possible that $k^E = k^F$, e.g., if reverse-engineering is equally effective irrespective of the location of the North firm. We ignore this special case since then the North firm would always choose FDI in our framework.

Assumption 1 implies that the initial marginal cost of firm S is such 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).

3.2. 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 $(b - q_N - q_S - c(1 - \alpha)z)q_N$ while firm N chooses q_N to maximize $(b - q_N - q_S - et)q_N$. Routine computation yields:

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

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

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

where $\tilde{q}_i(\alpha, e, z)$, and $\tilde{\pi}_i(\alpha, e, z)$ denote the quantity and profit of firm $i(= N, S)$ in the Cournot equilibrium. The following lemma records 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 the weakening of IPR protection (i.e., an increase in α) and an increase in absorptive capacity (i.e., an increase in z) reduces the 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 this case).

3.3. 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 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:

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

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

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

where $\alpha \in [0, 1]$ and $e \in \{0, 1\}$. The following proposition follows immediately from the expression of $z(\alpha, e)$.

PROPOSITION 1. *Absorptive capacity, given by $z(\alpha, e)$,*
(i) increases as the degree of IPR protection weakens;
(ii) decreases as (a) the cost of investment ($k(e)$) rises and, (b) the trade cost (t) falls.

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, the larger is the decline in c_S and consequently the larger the increase in firm S's stage 3 profit. This logic, together with the fact that marginal cost of investment, $k(e)z$, is independent of the degree of IPR protection imply Proposition 1(i).

The relationship between the cost of investment, $k(e)$, and absorptive capacity is straightforward. Concerning trade cost, note that $z(\alpha, 0)$ is independent of t. Thus trade cost t matters only if firm N exports. As the trade cost falls, firm N's effective unit cost declines. It produces more, and since quantities are strategic substitutes, firm S produces less. A reduction in $\tilde{q}_S(\alpha, 1, z)$ lowers South's marginal benefit from investment in absorptive capacity which in turn reduces $z(\alpha, 1)$.

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

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

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

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 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.

Lemma 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.

As the strength of IPR protection weakens, South firm's investment in absorptive capacity increases. The 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 implies lower q_N and consequently lower π_N. 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). Part (iii) is easy to understand once we recognize that in a Cournot setup the aggregate output increases as the unit cost declines.

Now we turn to the comparison between z^F and z^E. If *IPR* protection is perfect, i.e., $\alpha = 0$, there is no incentive to invest in absorptive capacity and hence $z^F = z^E = 0$. However, with imperfect IPR protection (i.e., $\alpha > 0$), absorptive capacity could be lower or higher under FDI. Using (8) and (9) we get

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

which implies

(10) $$z^F > (<)z^E \Leftrightarrow t < (>)\frac{9(k^E - k^F)(b - 2c)}{9k^F - 4\alpha^2 c^2}.$$

That z^F could be lower than z^E might sound surprising, since the marginal cost of investment in absorptive capacity is lower under FDI. However, the marginal benefit from investment in z under FDI is smaller as well:

$$\frac{\partial \tilde{\pi}_S(\alpha, 0, z)}{\partial z} - \frac{\partial \tilde{\pi}_S(\alpha, 1, z)}{\partial z} = -\frac{2\alpha ct}{9} < 0.$$

To understand why, note that firm N's unit cost of production is lower under FDI because it saves trade cost t per unit. The reduction in firm N's unit cost leads to higher q_N and lower q_S which in turn reduces firm S's incentive to invest in z. As both marginal benefit and marginal cost of investment in absorptive capacity are

lower under FDI, z^F could be higher or lower than z^E. Using (10), Proposition 3 gives a more precise characterization.

PROPOSITION 2. *For any given degree of IPR protection, absorptive capacity is strictly higher under FDI if and only if trade cost is sufficiently low. More formally, for all $\alpha \in [0, 1]$, there exists a threshold value $\tilde{t}(\alpha) \equiv \min\{\frac{9(k^E - k^F)(b - 2c)}{9k^F - 4\alpha^2 c^2}, \frac{b}{2}\}$ such that $z^F > z^E$ holds if and only if $t < \tilde{t}(\alpha)$. Furthermore, $\tilde{t}(\alpha)$ is weakly increasing in α.*

To understand the logic behind Proposition 2, consider the extreme case, $t = 0$. As there is no trade cost saving from FDI, North firm's output in the Cournot equilibrium is the same under FDI and exports for a given z, as is the South firm's output. This in turn implies that South firm's marginal benefit from investment in absorptive capacity is the same under FDI and exports. Since the marginal cost of investment is strictly lower under FDI, it follows that $z^F > z^E$. By standard continuity argument, it follows that $z^F > z^E$ holds if the trade cost is sufficiently low. Now consider the other extreme when t is almost prohibitive. For exogenously given z, South's Cournot output is higher under exports which implies that the marginal benefit of investment in absorptive capacity is higher under exports. If $k^E \approx k^F$, the marginal cost of investment is similar under FDI and exports, and consequently $z^E > z^F$ holds. Once again, by continuity argument, it follows that $z^F < z^E$ holds if the trade cost is sufficiently high.

We conclude this subsection by presenting a non-monotonicity result.

PROPOSITION 3. *(i) Absorptive capacity under FDI, z^F, is inverted U-shaped in firm S's initial unit cost of production c. For all $\alpha \in (0, 1]$ there exists $c^F(\alpha) > 0$ such that*

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

The absorptive capacity under exports, z^E, displays similar non-monotonicity with respect to c as long as $t < \min\{\frac{b(9k^E - \alpha^2 b^2)}{9k^E + \alpha^2 b^2}, \frac{b}{2}\}$.
(ii) A higher initial unit cost of production does not necessarily imply a higher effective unit cost. More formally, there exist values of c, namely c^1 and c^2 such that $c^1 > c^2$ and yet $c_S^1 \equiv c^1(1 - \alpha z^1) < c^2(1 - \alpha z^2) \equiv c_S^2$ where z^1 and z^2 denote absorptive capacities in stage 2 equilibrium corresponding to initial unit costs c^1 and c^2 respectively.

The logic underlying Proposition 3(i) is as follows. Consider the FDI case and suppose $c \approx 0$. The cost difference is very small to start with, and the incremental change in output due to additional investment in z is negligible. If the cost difference is large, $\lim_{c \to \frac{b}{2}} \tilde{q}_S(\alpha, 0, z) = 0$ which in turn implies $\lim_{c \to \frac{b}{2}} \frac{\partial \tilde{\pi}_S(\alpha, 0, z)}{\partial z} = 0$. Thus, for both extremes — cost difference that is 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 generates the non-monotonicity. Unless the trade cost is large, the same logic works when firm N opts to export.

To understand part (ii), note that, for $c > c^F(\alpha)$, investment in absorptive capacity decreases as c increases. Hence, higher c does imply higher c_S. However, for $c < c^F(\alpha)$, absorptive capacity declines as c declines. Thus lower initial marginal cost does not necessarily translate to lower effective marginal cost once investment in absorptive capacity is taken into account. In the Appendix, we show that there are indeed parameterizations where this occurs. Sawada (2010) finds a similar result in a North-South duopoly model where both North and South firms put effort into reducing its cost. However, IPR protection and location choice, which play an important role in the remainder of this paper, are absent from Sawada (2010).

The finding has an important implication. Suppose there are two South countries, S_1 and S_2 which do not trade with each other. Also, assume that the initial marginal cost is lower in S_1. Despite having an initial cost advantage, firm S_1 might end up with a higher marginal cost, following FDI by a North firm (in both South countries) and the investment in absorptive capacity. While firm S_1 always earns more profits, the consumers in S_1 might be worse off than the consumers in S_2.

3.4. **Exports versus FDI.** 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 if $z^F > z^E$. So, when does firm N choose to export ($e = 1$) and when does it choose FDI ($e = 0$)? Assume that in the 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

$$\pi_N^F - \pi_N^E \geq 0 \quad \Leftrightarrow \quad q_N^F - q_N^E \geq 0$$

(11)
$$\Leftrightarrow \quad \alpha c(z^F - z^E) - 2t \leq 0.$$

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 (11).

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 the 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 implies that $\alpha c(z^F - z^E) - 2t > 0$. In the case of zero trade costs, firm N's unit cost is the 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. Thus firm N's optimal choice is to locate in North and export to South.

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 an 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 (11) above and analyzing the inequality further gives the following proposition.

PROPOSITION 4. *The North firm prefers FDI to exports if IPR protection is strong enough. 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 $\bar{t} \equiv \min\{\frac{9c^2(k^E-k^F)(b-2c)}{(9k^F-4c^2)(9k^E-3c^2)}, \frac{b}{2}\}$ such that $\alpha(0) = 0$, $\alpha(t) < 1$ for $t < \bar{t}$ and $\alpha(t) = 1$ for $t \geq \bar{t}$. Furthermore, $\alpha(t)$ is continuous (in t) and $\alpha'(t) > (=)0$ for all $t < (\geq)\bar{t}$.*

Proposition 4 says how the exports versus FDI decision of firm N depends on trade cost and the strength of IPR protection in South. Assume that $\bar{t} = \frac{9c^2(k^E-k^F)(b-2c)}{(9k^F-4c^2)(9k^E-3c^2)}$. In that case, according to Proposition 4, the North firm locates in South for all $t \in (\bar{t}, \frac{b}{2})$ even if there is no protection of IPR in South. This finding reflects the tariff-jumping motive of FDI, except that we use trade cost instead of tariff. To ensure that motive dominates—at least for the high values of trade cost—we assume that the following condition holds for the remainder of section 3:[5]

(12)
$$k^F > \frac{b^2}{27} + \frac{2}{3}k^E.$$

As firm N might locate in South even if there is no protection of IPR (i.e., $\alpha = 1$), it might seem 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 the same under FDI and exports (i.e., $z = z^F = z^E$), (11) 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 implies 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 plays an important role in determining optimal IPR policy for South.

3.5. **Intellectual Property Rights (IPR).** Consider an extended game where in Stage 0, prior to location choice of firm N, South government chooses α to maximize South

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[5]Equation 12 ensures that $\frac{9c^2(k^E-k^F)(b-2c)}{(9k^F-4c^2)(9k^E-3c^2)} < \frac{b}{2}$.

welfare. Would it ever choose $\alpha \in (0, 1)$? In other words, would South welfare ever be higher with some protection of IPR? [6]

South welfare (W) 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 $Q^2/2$. Let $CS^F(\alpha)$ and $W^F(\alpha)$ respectively denote the consumer surplus and welfare when firm N chooses FDI in stage 1. Similarly define $CS^F(\alpha)$ and $W^F(\alpha)$ when firm N chooses exports. By definition,

$$W^F(\alpha) = CS^F(\alpha) + \pi_S^F(\alpha); \ W^E(\alpha) = CS^E(\alpha) + \pi_S^E(\alpha).$$

For a given α, South welfare (W) is $W^F(\alpha)$ if firm N chooses FDI and $W^E(\alpha)$ if firm N chooses exports. Since Firm N chooses FDI for $\alpha \leq \alpha(t)$ we have that

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

South welfare under FDI, W^F, increases as α increases since both $CS^F \equiv Q^{F2}/2$ 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 immediately follows that the optimal α for South is either 1 or $\alpha(t)$ (which can be 1 for some parameter values). Thus the South government either offers no protection ($\alpha = 1$) or just enough ($\alpha = \alpha(t)$) so that the North firm opts for FDI in South. The proposition below provides a sharper characterization.

PROPOSITION 5. *For a given trade cost $t \geq 0$, let $\alpha^*(t)$ denote the level of IPR protection that maximizes South welfare. The relationship between t and $\alpha^*(t)$ is non-monotone. More formally, there exists t_1 and t_2 satisfying $0 < t_1 \leq t_2 < \bar{t} < \frac{b}{2}$ such that $\alpha^*(t) = 1$ for $t < t_1$ and $t \geq \bar{t}$ while $\alpha^*(t) = \alpha(t) < 1$ for $t \in (t_2, \bar{t})$. Furthermore, $\alpha^*(t)$ is strictly increasing in t for all $t \in (t_2, \bar{t})$.*

Proposition 5 says that if the trade cost is too high or too low, South does not have any incentive to protect IPR. For a range of intermediate values of trade cost, some protection of IPR is optimal. Consider first $t \geq \bar{t}$. From Proposition 4, we know that, for those high values of trade cost, firm N undertakes FDI irrespective of the strength of IPR protection. Thus $W = W^F(\alpha)$ for all $\alpha \in [0, 1]$. As the North firm's location choice is not affected by α and $W^F(\alpha)$ is increasing in α it immediately follows that $\alpha^*(.) = 1$ for $t \geq \bar{t}$.

Now consider the other extreme: $t = 0$. Proposition 4 says that $\alpha(0) = 0$ which implies that firm N's exports to South only if IPR in South is fully protected. Thus $W = W^F(\alpha)$ for $\alpha = 0$ and $W = W^E(\alpha)$ for $\alpha \in (0, 1]$. Suppose $\alpha = 0$, i.e., IPR is

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[6]We are primarily interested in South's incentive to protect IPR. North always prefers stronger IPR protection in South because it leads to higher profit for the North firm (see Proposition 2). Since, in our framework, North's welfare consists solely of the North firm's profit in South, its welfare is maximized when IPR protection in South is full, i.e. $\alpha = 0$.

fully protected. Then there is no incentive to invest in absorptive capacity. Since $t = 0$ and $z^E = z^F = 0$, South welfare under exports and FDI regime are identical; $W^E(0) = W^F(0)$. Now for any increase in α from zero, firm N opts for export. Since $W^E(\alpha)$ is continuous and strictly increasing in α it follows that welfare is maximized by setting $\alpha = 1$. Thus, as in the case of high trade cost, we find that no protection is optimal when $t = 0$. Standard continuity argument implies that there exists $t_1 > 0$ such that no protection of IPR continues to optimal for $t < t_1$.

For intermediate values of t, i.e. $t \in (t_1, \bar{t})$, taking account of location decision by firm N, we get $W = W^F(\alpha)$ for $\alpha \in [0, \alpha(t)]$ and $W = W^E(\alpha)$ for $\alpha \in (\alpha(t), 1]$. As both $W^E(\alpha)$ and $W^F(\alpha)$ are increasing in α, the choice of optimal degree of IPR protection effectively reduces to the comparison between $W^F(\alpha(t))$ and $W^E(1)$. In the Appendix, we show that $\lim_{t \to \bar{t}} [W^F(\alpha(t)) - W^E(1)] > 0$. This implies that there exists a range of trade costs, $t \in (t_2, \bar{t})$, such that $\alpha^*(t) = \alpha(t)$. For those values of t, the South government finds it optimal to offer some IPR protection, in fact, just enough to attract FDI. As the trade cost declines, exporting becomes more attractive for firm N. Attracting FDI requires more protection of IPR from South which explains the last part of Proposition 5: $\alpha^*(t)$ is strictly decreasing in t.

4. Masking

We have shown that strengthening IPR protection can improve Southern welfare by affecting the location choice of the North firm. However, in two extreme but important cases considered in the trade literature —free trade and prohibitive tariffs— location choice is invariant to the IPR policy. Under free trade, FDI does not save any trade costs because there is no costs to save. North firm is better off by opting for exports because imitation is more costly for the South firm under exports. If tariffs are prohibitive, clearly, North firm always opts for FDI. In those cases, where location choices are pre-determined by other factors, can some protection of IPR be optimal for South? According to our model in the previous section, the answer is no. As we show below, however, the answer can change once we introduce the possibility of masking. For the remainder of this section we assume that $t = 0$ and firm N always chooses exports. [7] As location choice is unaffected by the strength of IPR protection, we assume away that stage.

Suppose prior to firm S's investment in absorptive capacity, firm N hinders firm S from imitating technology by undertaking a variety of costly activities such as creating software programming traps, encrypting important codes, or using special material to make imitation difficult. We use masking to denote all such activities. Masking raises firm N's unit cost from $c_N = 0$ to $c_N = m$. At the same time, it increases

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[7]The analysis is analogous when t is prohibitive and firm N chooses FDI.

firm S's cost of investment in absorptive capacity. In the absence of masking, firm S's cost of investment is k while it becomes $k^M > k$ under masking.

The timing of the events is as follows:

Stage 1 [Masking decision]: Given the degree of IPR protection α and trade cost t, firm N determines whether or not to engage in masking. Let d denote the binary variable capturing the masking decision by firm N:

$$d = \begin{cases} 1, \text{if firm } N \text{ masks its technology} \\ 0, \text{otherwise} \end{cases}$$

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

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

The Cournot equilibrium in stage 3 is now given by

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

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

For given α, d, firm S's absorptive capacity in stage 2 is

$$z = \frac{2\alpha c(b - 2c + dm)}{9k(d) - 4\alpha^2 c^2} \equiv z(\alpha, d)$$

Observe that outputs and profits in stage 2 equilibrium and absorptive capacity in stage 3 equilibrium are exactly the same as those obtained in section 3 once we write $d = e$ and $m = t$. Then, in fact, the game in this section is equivalent to the game described in section 3. Whether firm N masks or not in this game is effectively based on the same calculations that determine whether firm N exports or not in the game described in section 3. As we found, contrary to expectation, that equilibrium absorptive capacity might be higher under exports, here also, we find that absorptive capacity might be higher under masking. Masking increases the marginal cost of investment in absorptive capacity which discourages investment. At the same time, masking increases firm N's unit cost by m which raises rival firm S's output and encourages firm S to invest in absorptive capacity. Thus absorptive capacity might be higher or lower under masking. This result is similar in spirit to Proposition 2 where we showed that absorptive capacity might be higher or lower under FDI.

When will firm N engage in masking in stage 1? If IPR protection is perfect, i.e., $\alpha = 0$, firm S has no incentive to invest in absorptive capacity irrespective of the masking decision. As its technology is fully protected by IPR policy, firm N does not

have any incentive to mask its technology. The following result is immediate from invoking standard continuity argument.

Lemma 3. *Firm N does not mask its technology if IPR protection in South is strong enough. More formally, for all $m > 0$, there exists $\alpha(m) \in [0, 1]$ such that firm N chooses not to mask in stage 1 if and only if $\alpha \leq \alpha(m)$.*

Now we are ready to examine the IPR policy. For any given choice of firm N in stage 1 — masking ($d = 1$) or non-masking ($d = 0$) — weakening IPR protection reduces the unit cost of production for firm S which in turn implies higher consumer surplus as well as higher profits for firm S. Thus, IPR protection does not play any role unless it affects the masking decision. If m is large, firm N will not mask anyway, while if m is small, firm N will always mask. Thus, South's *IPR* policy affects the masking decision only for the intermediate values of m. By inducing firm N not to mask, South's government can improve South's welfare.

PROPOSITION 6. *For a given $m \geq 0$, let $\alpha^*(m)$ denote the level of IPR protection that maximizes South's welfare. The relationship between m and $\alpha^*(m)$ is non-monotone. There exist m_1 and m_2 satisfying $0 < m_1 < m_2 < \infty$ such that[8]*

$$\alpha^*(m) = \begin{cases} 1 & \text{if } m < m_1 \\ \alpha(m) \in (0, 1) & \text{if } m \in [m_1, m_2] \\ 1 & \text{if } m > m_2 \end{cases}$$

5. DISCUSSION

We have made several simplifying assumptions for tractability. Here, we briefly explore what happens when we relax some of those assumptions.

5.1. **Enforcement costs:** We have assumed that the South government does not incur any costs for enforcing IPR. Adding enforcement costs to the model does not qualitatively affect our results. Let $G(\alpha)$ denote the cost of enforcing α where $G(\alpha)$ is continuous and strictly decreasing in α and $G(1) = 0$. This specification captures the idea that, except for the case of no IPR protection, enforcement is costly and this cost increases as the degree of IPR protection (to be enforced) increases. Taking enforcement costs into account we can write South's welfare (W) as

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

Since $W^i(\alpha)$, $i \in \{E, F\}$ is strictly increasing in α and $G(\alpha)$ is strictly decreasing in α it follows that welfare maximizing α continues to be either $\alpha(t)$ or 1. However, the

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[8]The proof as well as the logic underlying Proposition 6 is similar to that corresponding to Proposition 5 and hence is omitted.

presence of costly enforcement shrinks the range of parameterizations where some *IPR* protection occurs in equilibrium.

5.2. **Tariff versus Transportation Cost.** Implicitly, we have treated trade cost as transportation cost which involves loss of resources (as in Brander and Krugman, 1981). Except for subsection 3.5 (where we consider South's welfare), the analysis and the results remain unchanged if we interpret t as tariff rather than trade cost. Incorporating tariff revenues in welfare function does not affect the non-monotone relationship between t and α highlighted in Proposition 5.

When the tariff rate is zero or prohibitive, tariff revenues do not matter. For both these cases—which correspond to zero trade cost and prohibitive trade cost in the previous section—it remains optimal for South to offer no IPR protection at all. For intermediate values of t, the FDI option becomes less attractive for South. Welfare under FDI remains same as before, whereas welfare under exports is higher because of tariff revenues. 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. Nevertheless, the non-monotonicity remains.

5.3. **Licensing.** In our model, FDI facilitates imitation which in turn reduces the production cost of firm S. However, anticipating imitation, firm N might license and transfer its technology to firm S. Earlier papers in the literature on trade and licensing assume that licensing is costless. See, for example, Kabiraj and Marjit (1993, 2003), Mukherjee and Pennings (2006) who assume that licensing does not involve resource costs. These papers primarily focus on the interaction between tariff and licensing decisions (and payments). The role of IPR in the context of trade and licensing is discussed in Yang and Maskus (2009). Introducing costly licensing in an oligopoly framework, they convincingly argue that strengthening IPR protection can benefit South by reducing the costs of technology transfer.

To focus on location choice, we have implicitly assumed that such licensing costs, or more generally, contracting costs are prohibitive. Incorporating licensing in our model, and setting the trade cost to zero (to assume away location choice), we find that, like Yang and Maskus (2009), that strengthening IPR protection can improve South's welfare in a range of parameterizations. In particular, we find that IPR protection can improve South welfare when the difference in the unit costs between firm N and firm S is not too high or not too low. If the cost difference is too low, firm N will always license its technology to firm S. If the cost difference is too high, firm N will never license its technology irrespective of the the strength of IPR protection. For moderate differences in costs, strengthening IPR protection improves welfare for South because it induces firm N to license.

6. 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 strict IPR protection depending on the level of trade cost. Interestingly, we find that the relationship between the optimal strength of IPR protection in South and trade cost is non-monotone. If the trade cost is too high or too low, 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. In the presence of masking, we show that, even when the trade costs are zero, some protection of IPR might be optimal for South.

Our analysis also offers an explanation for the ambiguous relationship between FDI and spillovers which is 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 the 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.

Note that a common theme across all three stories referred to in this paper — location choice, masking, licensing— is that IPR protection improves South welfare by inducing a switch of regimes: from export to FDI in section 3, from masking to non-masking in section 4, and from no licensing to licensing in subsection 5.3. To highlight these channels, we have abstracted away from the innovation incentives of the South firms. More efficient South firms, who are likely to innovate, might favour stronger IPR protection, while inefficient South firms might want weak IPR protection. Analyzing the impact of trade liberalization on South's incentive to protect IPR in the presence of firms with heterogenous innovation abilities is left for future research.

Appendix

Proof of Lemma 2: (i) Using (5) and (7) we get

$$\pi_N^F = \tilde{\pi}_N(\alpha, 0, z(\alpha, 0)) = \frac{(b + c(1 - \alpha z(\alpha, 0)))^2}{9}.$$

By Proposition 1(i), $z(\alpha, 0)$ is increasing in α. This implies that $c_S = c(1 - \alpha z(\alpha, 0))$ is decreasing in α which in turn implies that π_N^F decreases as α increases. The proof is analogous for π_N^E.

(ii) See the paragraph after Lemma 2 in the text.

(iii) Using (4) and (7) we get $Q^F = \frac{2b - c(1 - \alpha z(\alpha, 0))}{3}$ and $Q^E = \frac{2b - t - c(1 - \alpha z(\alpha, 1))}{3}$. Then, applying the argument presented in the proof of (i) gives the results. □

Proof of Proposition 2: The first part of the proof essentially restates (10). That $\tilde{t}(\alpha)$ is increasing in follows directly from observing the expression of $\tilde{t}(\alpha)$ in first part of the Proposition. □

Proof of Proposition 3: (i) Differentiating $z(\alpha, e)$ with respect to c we get:

$$\frac{dz(\alpha, e)}{dc} = \frac{2\alpha[4\alpha^2 bc^2 + (8\alpha^2 et - 36k(e))c + 9k(e)(b + et)]}{(9k(e) - 4\alpha^2 c^2)^2}.$$

Consider $z^F = z(\alpha, 0)$. For all $\alpha > 0$, $\lim_{c \to 0} \frac{dz(\alpha, 0)}{dc} = \frac{2\alpha b}{9k^F} > 0$ while $\lim_{c \to \frac{b}{2}} \frac{dz(\alpha, 0)}{dc} = -\frac{2\alpha b}{9k^F - \alpha^2 b^2} < 0$. These limit values together with the fact that $4\alpha^2 bc^2 - 36k(e)c + 9k(e)b$ is quadratic in c imply that there exists a unique $c^F(\alpha) \in (0, \frac{b}{2})$ such that $\frac{dz(\alpha, 0)}{dc} > (=, <)0 \Leftrightarrow c < (=, >)c^F(\alpha)$. Now consider $z^E = z(\alpha, 1)$. We have that $\lim_{c \to 0} \frac{dz(\alpha, 1)}{dc} = \frac{2\alpha(b + t)}{9k^E} > 0$ and $\lim_{c \to \frac{b}{2}} \frac{dz(\alpha, 0)}{dc} = -\frac{2\alpha(9k^E + \alpha^2 b^2)}{(9k^E - \alpha^2 b^2)^2}[t - \frac{b(9k^E - \alpha^2 b^2)}{9k^E + \alpha^2 b^2}]$ which is strictly negative if and only if $t < \min\{\frac{9k^E - \alpha^2 b^2}{9k^E + \alpha^2 b^2}, \frac{b}{2}\}$. The claim then follows from applying argument similar to the ones used for the FDI case. □

(ii) Consider the following set of parameterizations: $b = 4, k^F = 1, \alpha = 1$. For $c^1 = \frac{4}{5}$ and $c^2 = \frac{11}{10}$ we find that $z^1 = \frac{96}{161}$ and $z^2 = \frac{99}{104}$ and $c_S^1 = c^1(1 - \alpha z^1) = \frac{52}{161}$ and $c_S^2 = c^2(1 - \alpha z^2) = \frac{11}{208}$. Observe that $c^1 < c^2$ and yet $c_S^1 > c_S^2$.

Proof of Proposition 4: Substituting $z^F - z^E$ from the proof of Proposition 2 in (10) and simplifying we find that $\pi_N^F - \pi_N^E \geq 0 \Leftrightarrow h(\alpha, t) \leq 0$ where

$$h(\alpha, t) = 2\alpha^2 c^2[9(k^E - k^F)(b - 2c) - t(9k^F - 4\alpha^2 c^2)] - 2t(9k^F - 4\alpha^2 c^2)(9k^E - 4\alpha^2 c^2).$$

We have that

(a) $h(0, t) = -162k^E k^F < 0$,

(b) $h_t(\alpha, t) = -[2\alpha^2 c^2(9k^F - 4\alpha^2 c^2) + 2(9k^F - 4\alpha^2 c^2)(9k^E - 4\alpha^2 c^2)] < 0$,

(c) $h_\alpha(\alpha, t) = 9(k^E - k^F)(b - 2c) + 4t(9k^E - 4\alpha^2 c^2) + 2t(9k^F - 4\alpha^2 c^2) + 9tk^F > 0$.

Together (a),(b) and (c) imply there exists $\alpha(t) \in (0, 1]$ such that $\alpha \leq \alpha(t) \Rightarrow \pi_N^F - \pi_N^E \geq 0$. We find that $h(1, t) > 0$ for all $t < \frac{9c^2(k^E - k^F)(b - 2c)}{(9k^F - 4c^2)(9k^E - 3c^2)} \equiv \bar{t}$ which implies that $\alpha(t) < 1$ for

$t < \bar{t}$. Also, for all $t < \bar{t}$, $\alpha'(t) = -\frac{h_t(\alpha,t)}{h_\alpha(\alpha,t)} > 0$ which implies $\alpha(t)$ is strictly increasing in t. For $t \geq \bar{t}$, $\alpha(t) = 1$ and consequently $\alpha'(t) = 0$. □

Proof of Proposition 5: In the main text we showed that $\alpha^*(t) = 1$ for $t \geq \bar{t}$. We also proved that there exists $t_1 > 0$ such that $\alpha^*(t) = 1$ for $t \leq t_1$. Here, first we prove that there exists $t_2 < \bar{t}$ such that $\alpha^*(t) = \alpha(t) < 1$ for all $t \in (t_2, \bar{t})$. Suppose $t_1 < t < \bar{t}$ and let $t \to \bar{t}$. From Proposition 4 we already know that for all such t firm N chooses FDI if $\alpha \leq \alpha(t)$ and $\alpha(t) < 1$. It suffices to show that $\lim_{t\to\bar{t}}[W^F(\alpha(t)) - W^E(1)] > 0$. Denote z^F and z^E in equations (8) and (9) as $z^F(\alpha)$ and $z^E(\alpha)$ respectively. For any given $\alpha \in [0,1]$,

$$W^F(\alpha) = \frac{[2a - c(1 - \alpha z^F(\alpha))]^2}{18} + \frac{[a - 2c(1 - \alpha z^F(\alpha))]^2}{9} - k^F z^F(\alpha)^2,$$

$$W^E(\alpha) = \frac{[2a - c(1 - \alpha z^E(\alpha)) - t]^2}{18} + \frac{[a - 2c(1 - \alpha z^F(\alpha)) + t]^2}{9} - k^E z^E(\alpha)^2.$$

Continuity of $\alpha(t)$ in t implies that $\lim_{t\to\bar{t}} \alpha(t) = \alpha(\bar{t}) = 1$. This finding, together with continuity of $W(\alpha)$ in α implies that

$$\lim_{t\to\bar{t}} W^F(\alpha(t)) - W^E(1) = [W^F(1) - W^E(1)]_{t\to\bar{t}} = \frac{\bar{t}[16b - 14c - cz^F(1) + 3cz^E(1) + 3\bar{t}]}{18} > 0.$$

That $\alpha^{*\prime}(t) > 0$ for all $t \in (t_2, \bar{t})$ follows from noting that (a) $\alpha^{*\prime}(t) = \alpha'(t)$ for these values of t and (b) $\alpha'(t) > 0$ (by Proposition 4).

Proofs of Lemma 3 and Proposition 6: These proofs are analogous to those of Propositions 4 and 5 respectively once we treat m as t and $k^E(k^F)$ as the coefficient in the cost function, $C(z) = kz^2$ in case of masking (non-masking).

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