Intellectual property rights and North-South trade: Exports vs. foreign direct investment*

Derechos de propiedad intelectual y comercio Norte-Sur: exportaciones frente a inversión extranjera directa

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Abstract

This paper examines whether a Northern firm prefers to export or to engage in FDI to serve the South. If the firm engages in FDI, its technology is imitated, and a Southern firm enters the market that may sell in both markets. The Northern firm may invest to prevent product piracy in the North. The two markets may have different sizes. We find that when the cost of preventing product piracy in the North is great enough: (i) If the Southern market is large enough the Northern firm engages in FDI, allowing piracy in its home market, and the South obtains the greater welfare; (ii) If the Southern market is small enough the Northern firm exports and the government of the South imposes a strong Intellectual Property Rights protection, attracting the Northern firm and improving the welfare of both countries.

Key words: *Foreign direct investment, intellectual property rights (IPR), North-South trade, imperfect competition.*

JEL Classification: *L13, F13, O34.*

Resumen

Este trabajo examina si una empresa del Norte prefiere exportar o realizar inversión extranjera directa (IED) para servir al Sur. Si la empresa realiza IED, su tecnología es imitada y entra en el mercado una empresa del Sur que puede vender en ambos mercados. La empresa del Norte puede invertir para evitar la piratería del producto en el Norte. Los dos mercados pueden tener tamaños diferentes. Se observa que cuando el coste de impedir la piratería del producto en el Norte es lo suficientemente grande: (i) Si el mercado del Sur es lo suficientemente grande, la empresa del Norte realiza IED, permitiendo la piratería en su mercado nacional, y el Sur obtiene el mayor bienestar; (ii) Si el mercado del Sur es lo suficientemente pequeño, la empresa del Norte exporta y el gobierno del Sur impone una fuerte protección de los derechos de propiedad intelectual, atrayendo a la empresa del Norte y mejorando el bienestar de ambos países.

Palabras clave: *Inversión extranjera directa, derechos de propiedad intelectual, comercio Norte-Sur, competencia imperfecta.*

Clasificación JEL: *L13, F13, O34.*

1. Introduction

When a firm in the North serves the market of a Southern country with a less developed Intellectual Property Rights (IPR) regime, one of the main concerns is that its products may be pirated in the South.[1] Due to local knowledge spillovers, Southern firms can more easily imitate products produced by multinationals in the South than those produced in the North (see Glass and Saggi, 2002). In consequence, multinationals might choose a safer alternative to serve the South: investing to prevent product piracy at least in their home market. Moreover, in recent years the sources of pirated products are mainly labor intensive and are highly concentrated in those major producers.[2] Countries with lax labor regulations and high local demand levels such as China and India are among the

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[1] An example is provided by the case of Weining AG, a German firm that has been manufacturing machine tools for the Chinese market in its plant located in China since 1997, which claims that Chinese manufacturers are copying its machines. Similarly, Airbus has announced that it plans to build plants in China, which has set off a debate over the need to protect European aircraft construction secrets (Spiegel Online International, February 22, 2006).

[2] Data from customs seizures in OECD countries reveals that 58% of pirated and counterfeit products come from the five main sources, which are all located in Asia (OECD, 2008, pp. 101).

world's largest recipients of Foreign Direct Investment (FDI) and are also the key sources of pirated products.[3]

This paper examines the decision by a Northern firm on how to serve a market located in the South: by setting up a plant in the South (FDI) or by exporting. This market is characterized by potential piracy and little government motivation to strengthen local IPR protection.[4] To carry out this study we focus on several factors: the size of the Southern market compared to the Northern one, the difference in labor costs between the two countries, the IPR policy in the South, trade costs and the investment made by Northern firms to prevent product piracy in their domestic market.

The literature that analyzes North-South trade has considered how this trade is affected by IPR regimes assuming a strategic approach.[5] It is usually assumed that a Southern firm competes with a Northern firm in the South, which permits the Southern firm to imitate Northern technology. In this regard, Leahy and Naghavi (2010) analyze whether a Northern firm enters the Southern market by engaging in FDI or by setting up a joint venture with a local partner.[6] They assume that joint ventures permit local firms to imitate the Northern technology. They show that the joint venture is the equilibrium market structure when IPR is strong and R&D intensity is moderate. The South can gain from increased IPR protection because it encourages joint ventures. Naghavi (2007) analyzes

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[3]   See the 2022 Kearney Foreign Direct Investment Confidence Index, Global Business Policy Council (https://www.kearney.com/foreign-direct-investment-confidence-index).

[4]   There may be a big difference between approving IPR legislation and enforcing it in the South. An example is provided by the case of China: although it has implemented strong laws to protect IPR the country faces severe problems with enforcement which make it difficult for a foreign firm to protect its IPR in China (Keupp *et al*., 2010; Fink and Maskus, 2005, Chap. 12). In this regard, Grossman and Lai (2004) find that the South provides weaker patent protection than the North by assuming that both market size and innovation capacity in the North are greater than in the South. Moreover, using confidential microdata from the U.S. Census, Lin and Lincoln (2017) find that firms that hold patents are more likely to export to countries with strong IPR protection.

[5]   This literature has also analyzed this issue considering product cycle models. See, for example, Glass and Saggi (2002) and Yang and Maskus (2001). Markusen (2001) analyzes a related issue, focusing the analysis on moral hazard problems, assuming a multinational firm that hires a local agent in the host country who learn the technology in the first period and can start a rival firm in the second period.

[6]   Mattoo *et al*. (2004) also analyze this issue, but they do not consider technology spillovers. They differentiate between FDI and acquisition of existing domestic firms. Campi *et al*. (2019) find that the increase in mergers and acquisitions derived from a strengthening of IPR protection is greater in developing countries than in developed ones. Liao and Wong (2009) analyze how competition between a firm in the North and a firm in the South is affected by the North's subsidy on technology improvements and the South's IPR policy. Ghosh *et al*. (2018) show that when there is a tariff reduction between countries, the strength of IPR protection is affected by the possibility that the South may serve as an export platform to other markets for the Northern firm. Ghosh and Ishikawa (2018) analyze the case in which absorption capacity in the South affects the extent of imitation. Dong and Bárcena-Ruiz (2014) study a related issue assuming a mixed duopoly.

whether the Northern firm serves the Southern market through exports to prevent its technology from being exposed or by engaging in FDI to avoid trade costs. FDI causes a spillover of its technology to the Southern firm. The IPR regime determines the level of the spillover and thus the knowledge of technology than can be absorbed by the Southern firm. It is shown that a stringent IPR regime is always optimal for the South. Yang and Maskus (2009) consider a similar analysis assuming that a Northern firm competes with a Southern firm in both markets. The Northern firm invests in R&D and the Southern firm may imitate its technology. The Northern firm can prevent imitation by licensing its technology to the rival firm. They show that stronger IPR enhances technology transfer through licensing and reduces the Southern firm's marginal cost production, increasing its exports to the North. They show a strong IPR regime reduces welfare in the South.

In this paper we examine the factors that influence the decision of a Northern firm on whether to export or to engage in FDI to serve the South. Production costs are higher in the North since labor is only unionized there. We consider a quantity-setting duopoly in which a firm in the North competes with a potential pirate firm in the South.[7] Local investors may imitate the technology of this firm, setting up a new firm that enters the market. In the case of exporting it is not possible to imitate the Northern firm. We consider three cases: In the first case, the firm in the North exports to the South, thus preventing product piracy. In the second case the firm in the North engages in FDI but does not invest to prevent piracy. In this case the pirate firm enters the market and competes with the Northern firm in both countries. Note that both firms have to pay a trade cost when exporting products. In the third case the firm in the North engages in FDI and invests to prevent piracy in the domestic market. In this case the pirate firm can only sell its products in the South.[8] We assume initially that the Northern firm cannot prevent product piracy in the South if it engages in FDI. Later, we analyze whether the government of the South imposes a strong IPR protection.

Our study differs from the papers cited above in several important points. First, they assume that when the Northern firm produces in the South it can prevent imitation by licensing its technology, by choosing the R&D level or by refusing to enter into a joint venture with local partners. However, we assume that when the Northern firm produces in the South it cannot prevent imitation in

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[7]   It is well established in the literature on FDI that labor market characteristics and institutions in the host country are major determinants for multinationals' choice of location when product piracy in the host country is not considered (Mucchielli and Saucier, 1997; Leahy and Montagna, 2000; Lommerud *et al.*, 2003; Dong and Bárcena-Ruiz, 2021). This also applies to the decision of a Northern firm on whether or not to engage in FDI when there is a threat of product piracy in the South.

[8]   We assume away the possibility of the Southern firm investing to produce in the North. Given that the Southern firm copies the products of the Northern firm the effort of this firm means that IPR policies in the North exclude this case. For example, the Northern firm may require its government to prohibit the importing or consuming of pirated products, or to enforce copyright legislation in the Northern country (Banerjee, 2006).

that market. Only if the government of the South imposes a strong IPR protection can imitation be prevented. Second, Leahy and Naghavi (2010) and Naghavi (2007) do not consider that the Southern firm may sell in the Northern market. Third, although Yang and Maskus (2009) assume that the Southern firm can sell in the Northern market, the Northern firm can prevent imitations without incurring any cost. However, to prevent the Southern firm from selling its pirated products in the North, the Northern firm usually needs to make an effort, which implies investing a certain amount of money.[9] The fact that the firm in the North often invests to protect its domestic market has been ignored. Finally, the relative size of the Southern market may be an important factor in this analysis, but it is not considered in the papers cited above.[10] This means that those papers fail to capture important aspects concerning FDI decisions with potential piracy in the South and cannot fully explain the coexistence of inward FDI and product piracy in big markets such as China and India.

We find that all three cases are possible in equilibrium. When the cost of preventing product piracy in the Northern market is low enough the Northern firm engages in FDI and invests to prevent piracy in its home market. This result does not depend on the relative sizes of the markets. In this case, the welfare of the North is never the highest. When both the cost of avoiding product piracy in the Northern market and the relative size of the Southern market are great enough, the Northern firm engages in FDI, allowing piracy in its home market. Thus, we obtain that Northern firms may allow product piracy in their domestic markets in order to gain access to large markets in the South. In this case the South obtains the greatest welfare. Finally, when the relative size of the Southern market is small enough and the cost of preventing product piracy in the Northern market is high enough, the Northern firm exports. In this case, as the foreign market is small, the Northern firm prefers to prevent product piracy in its domestic market by exporting rather than by engaging in FDI and investing to protect the domestic market. In this case, the South obtains the lowest welfare.

Next we analyze whether the government of the South prefers to strengthen the local IPR protection. To that end, we consider an alternative case in which the government of the South prohibits product piracy. We show that only when the Northern firm chooses to export does the government of the South impose a strong IPR protection, thus preventing product piracy. This policy permits the

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[9]   The investment includes the measures usually employed by firms to prevent piracy, such as costly holograms and packaging, watermarks and color change inks. It also includes enforcement efforts such as hiring full-time employees to work in anti-counterfeiting, efforts to identify and sue pirates, and investments in vertical integration of downstream retail stores (see, Qian, 2014; Zhang *et al.*, 2012). In this regard, Klein (2020) highlights the complementary relationship between the enforcement of IPR protection by the government and the enforcement investment by the intellectual property holder by considering that a firm that holds a patent bears the cost of identifying the source of piracy.

[10] It should be noted that the size of the host country's market is important for a firm's decision to establish foreign production when it does not compete with a local pirate firm (Norbäck, 2001; Belderbos *et al.* 2008).

Southern country to attract FDI while avoiding exports from the North. When the Northern firm engages in FDI (with or without piracy), the government of the South does not strengthen IPR protection. This is because the Northern firm locates a plant in the South regardless of what IPR policy is implemented in the South. This result helps to explain why some countries in the South are sometimes reluctant to strengthen their IPR protection enforcement even though an IPR regime could be used as a way of attracting inward FDI.

The rest of the paper is organized as follows: Section 2 presents the model. Section 3 compares results under the three IPR regimes to examine how the firm in the North decides to serve the South and the resulting welfare consequences. Section 4 examines the incentives of the government of the South to strengthen local IPR protection. Section 5 considers several extensions of the basic model and Section 6 concludes.

2. Model

We consider a world market that comprises two countries: the North (N) and the South (S). Firm 1, owned by investors from the North, produces in the North to serve domestic consumers. This firm wants to expand its market by selling products in a foreign market S. To serve the South, firm 1 has two options: to set up a plant to produce in the South (i.e. to engage in FDI) or to export products from the North. If firm 1 chooses to serve the South by engaging in FDI a pirate firm, firm 2, enters the market of country S; this firm is owned by investors from the South. This second firm unlawfully uses the technological know-how of firm 1 to produce the same product. In this case firm 2 may compete with firm 1 not only in the South but also in the North by exporting to the Northern country. Anticipating the entry of the pirate firm in the host country, firm 1 considers investing a fixed amount f to prevent firm 2 from selling pirated products in the North. However, if firm 1 exports products to the South it is assumed that firm 2 cannot copy its technology and thus cannot pirate the products of firm 1, which means that firm 2 does not enter the market. To simplify the analysis, we assume that products are homogenous, and that firm 2 cannot engage in FDI in the North.

Firms must incur a trade cost to export the product: the cost of delivering one unit of output from one country to the other is denoted by t, $t<1/3$.[11] Moreover, to simplify the model we assume that the cost of setting up a production facility in the South is zero when firm 1 engages in FDI, and that firm 2 incurs no cost in its illegal copying or counterfeiting.

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[11]   We assume that $t<1/3$ (which means that the transport cost is not high enough) to reduce the number of cases that arise in the model, thus simplifying the presentation of results. This assumption does not affect the main results of the model. Moreover, Geng and Saggi (2022) find that constraining tariffs between countries helps to facilitate the coordination of international IPR protection.

The markets are segmented and the inverse demand functions in the North and the South, respectively, are:

(1) $$p_N = 1 - q_{N1} - q_{N2}, \; p_S = k - q_{S1} - q_{S2},$$

where pj is the price of the product in country j and q_{ji} is the output sold by firm i in country j, $i=1, 2; j=N, S$. Parameter k measures the market size of the South, which may be different from that of the North. Thus $k=1$ means that the two countries have markets of the same size, while $k>1$ ($k<1$) means that the market is larger (smaller) in the South. We assume that $k > \max\{\underline{k}, t\}$, $\underline{k} = 3\sqrt{f}$, ,[12] to ensure that firm 1 produces a positive output and obtains no losses in any cases.

In both countries, labor is the only factor used in the production process, and each unit of output requires one unit of labor. Both firms have the same technology and exhibit constant returns to scale such that $q_{ji} = L_{ji}$, where L_{ji} denotes the workers hired by the plant ji, $j=N, S; i=1, 2$. We assume that only the workers in the North are unionized. Because workers are not unionized in the South, wage costs there are lower than in the North. To simplify the analysis, and with no loss of generality, we assume that the wage paid in the South is normalized to zero. In the North, unionized workers set up independent unions at plant level. We consider that firm 1 builds a new plant whether it decides to serve market S through exports or FDI. If firm 1 decides to exports the new plant is located in country N, where workers are unionized, while if it decides to engage in FDI the new plant is located in country S, where the wage is zero. To determine the wage set in the North we consider the monopoly-union model, which assumes that the unions set the wage while the firm chooses the employment level once the wage has been set by unions (see Booth, 1995). The utility function of the union at plant j in firm 1 is its wage bill:[13]

(2) $$U_{j1}(w_j, L_{j1}) = w_j L_{j1}, \; j=N, S,$$

where w_j denotes the wage paid to the workers in the plant of firm 1 that produces the goods sold in country j.[14]

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[12]   Specifically, we assume that $k>\underline{k}$ to assure that firm 1 obtains profits when it engages in FDI and invests to prevent piracy.

[13]   The main results of the paper hold if it is consider that workers are organized in a firm union, whose objective function is $U_N = U_{N1} + U_{S1} = w_N L_{N1} + w_S L_{S1}$. This is because when firm 1 exports it is a monopolist in both markets. As there is no competition and markets are segmented, the wage paid to workers at plant $N1$ does not depend on that paid at plant $S1$ and vice versa. As a result, when firm 1 exports, the wage paid at each plant is the same regardless of whether workers are organized in plant unions or in a firm union. When firm 1 engages in FDI it has one plant located in each market so the result does not change if a firm union is considered.

[14]   The main results hold if wages are decided by Nash bargaining between unions and firm 1 in the North.

Firm 1 may serve market S by exporting or engaging in FDI. Firm 1 builds a new plant in both cases.[15] If firm 1 exports to country S, firm 2's profit is zero since it cannot pirate the products of firm 1. This means that firm 1's profit is the sum of the monopoly profits in both markets:

(3) $\pi_1 = (1 - q_{N1} - w_N) q_{N1} + (k - q_{S1} - w_S - t) q_{S1}.$

If firm 1 engages in FDI in the South it saves the wage costs of serving the Southern country but it competes with firm 2 at least in one market (depending on whether or not it invests to prevent piracy). Thus its total profit is given by:

(4) $\pi_1 = (1 - q_{N1} - q_{N2} - w_N) q_{N1} + (k - q_{S1} - q_{S2}) q_{S1} - f.$

Given that firm 2 has zero costs in regard to both production and illegal copying, when firm 1 engages in FDI firm 2's total profit if it serves the two markets is given by:

(5) $\pi_2 = (1 - q_{N1} - q_{N2} - t) q_{N2} + (k - q_{S1} - q_{S2}) q_{S2},$

where, in expressions (4) and (5), q_{N2} and q_{S2} are positive if firm 1 does not invest to prevent product imitation (i.e. if $f = 0$). Besides, $q_{S2} > 0$ and $q_{N2} = 0$ if firm 1 invests to prevent piracy (i.e. if $f > 0$).

As usual, social welfare comprises the consumer surplus, CS, the producer surplus, PS, and the rents obtained by the workers, U. Specifically we assume that the welfare of country j is given by:

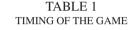(6) $W_j = CS_j + PS_j + U_j,$

where $CSj = (q_{j1} + q_{j2})^2/2$, $PS_j = \pi_j$ and U_j is the wage bill of the workers in country j; $j=N, S$. $U_S = 0$ since the wage in the South is normalized to zero and U_N is the wage bill of the workers of firm 1 who produce in country N, where $U_N = U_{N1} + U_{S1} = w_N L_{N1} + w_S L_{S1}$ if firm 1 exports and $U_N = U_{N1} = w_N L_{N1}$ if firm 1 engages in FDI.
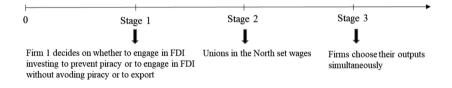
The objective of this paper is to study the factors that influence firm 1's decision on whether to engage in FDI in the South when there is a potential pirate firm located there. To that end we compare three cases: First we assume that firm 1 chooses to serve the South by exporting and thus firm 2 cannot produce (we denote this case by E). In the second case, firm 1 engages in FDI to serve country S, but does not invest to prevent piracy. Thus piracy is accommodated in

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[15]   As the markets are segmented we consider that products are not homogeneous and that they differ in some characteristic that adapts them to the local market. Thus, firm 1 sets up a new plant to produce the goods to export. It can be shown that the main results of the paper hold if we consider that firm 1 produces goods (which are homogeneous) for both markets in a single plant.

both countries (we denote this case by *FP*). In this case firm 2 can freely pirate the original products and the two firms compete in both countries. Finally, in the third case, firm 1 engages in FDI in the South and invests a fixed amount *f* to prevent piracy in the North (we denote this case by *F*). This investment enables firm 1 to successfully prevent firm 2 from exporting pirated products to country *N*, thereby forcing it to sell only in country *S*.

We propose a three stage game with the following timing. In the first stage, firm 1 chooses whether to engage in FDI in the South or to export there. If it decides to engage in FDI, firm 1 then decides whether or not to invest to prevent product piracy in its home market. In the second stage, unions in the North set wages. Finally, in the third stage firms simultaneously choose their outputs. The timing of the game is summarized in Table 1. We solve the game by backward induction to obtain a subgame perfect Nash Equilibrium.

TABLE 1
TIMING OF THE GAME

0	Stage 1	Stage 2	Stage 3
	Firm 1 decides on whether to engage in FDI investing to prevent piracy or to engage in FDI without avoding piracy or to export	Unions in the North set wages	Firms choose their outputs simultaneously

3. RESULTS

Next we solve the third and second stages in the three cases considered in the model.

3.1. Firm 1 Exports (E)

When firm 1 exports products to the South, the technology or know-how is protected from exposure to firm 2 and, thus, product piracy is prevented in both markets. In the third stage firm 1 chooses quantities q_{N1} and q_{S1} to maximize its profit given by (3). Solving this stage the following is obtained:

$$(7) \qquad q_{N1}(w_N) = \frac{1 - w_N}{2}, \; q_{S1}(w_S) = \frac{k - t - w_S}{2}.$$

In the second stage, plant unions set wages that maximize wage bills, U_{N1}, U_{S1}, given by (2). By solving this stage we obtain the following.

Lemma 1. *When firm 1 exports to country S, in equilibrium:*

$$w_N^E = \frac{1}{2}, \ w_S^E = \frac{k-t}{2}, \ q_N^E = \frac{1}{4}, \ q_S^E = \frac{k-t}{4}, \ \pi_1^E = \pi_{N1}^E + \pi_{S1}^E = \frac{1}{16} + \frac{(k-t)^2}{16},$$

$$U_N^E = \frac{1}{8} + \frac{(k-t)^2}{8}, \ CS_N^E = \frac{1}{32}, \ CS_S^E = \frac{(k-t)^2}{32}, W_N^E = \frac{7+6(k-t)^2}{32}, W_S^E = \frac{(k-t)^2}{32}.$$

This Lemma shows that firm 1 sells more abroad than at home if the foreign market is large enough (i.e. if $k > 1 + t$). In that case, the plant that sells abroad pays higher wages. Country S obtains a greater consumer surplus if firm 1 sells more abroad than at home. Moreover, country N obtains greater welfare since firm 1 is owned by investors from country N, and the workers of this country get higher incomes.

3.2. Firm 1 Engages in FDI and does not Invest to Prevent Piracy (FP)

In this case the two firms compete in both countries since firm 2 can export the pirated products to country N. In the third stage firm 1 chooses q_{N1} and q_{S1} that maximize its profit given by (4) with $f = 0$, and firm 2 chooses q_{N2} and q_{S2} that maximize its profit given by (5). By solving this stage we obtain the following:

$$(8) \qquad q_{N1}(w_N) = \frac{1+t-2w_N}{3}, \ q_{S1} = q_{S2} = \frac{k}{3}, \ q_{N2}(w_N) = \frac{1-2t+w_N}{3}.$$

In the second stage, the union in country N chooses the wage that maximizes $UN1$ given by (2). By solving this stage we obtain the following.

Lemma 2. *When firm 1 engages in FDI but does not invest to prevent piracy, in equilibrium:*

$$w_N^{FP} = \frac{1+t}{4}, \ q_{N1}^{FP} = \frac{1+t}{6}, \ q_{S1}^{FP} = q_{S2}^{FP} = \frac{k}{3}, \ q_{N2}^{FP} = \frac{5-7t}{12},$$

$$\pi_1^{FP} = \pi_{N1}^{FP} + \pi_{S1}^{FP} = \frac{(1+t)^2}{36} + \frac{k^2}{9}, \pi_2^{FP} = \pi_{N2}^{FP} + \pi_{S2}^{FP} = \frac{(5-7t)^2}{144} + \frac{k^2}{9}, U_N^{FP} = \frac{(1+t)^2}{24},$$

$$CS_N^{FP} = \frac{(7-5t)^2}{288}, CS_S^{FP} = \frac{2k^2}{9}, W_N^{FP} = \frac{69+32k^2-30t+45t^2}{288}, W_S^{FP} = \frac{48k^2+(5-7t)^2}{144}.$$

Lemma 2 shows that the two firms sell the same quantity of output in country S since both firms produce there with the same technology and labor costs. However, firm 2 sells more in country N than firm 1 since the transport cost is lower than the wage paid by firm 1 $\left(w_N^{FP} > t\right)$.

Both firms obtain the same profit in country S, but firm 2 makes more than firm 1 in country N since the advantage of lower labor costs has a greater effect

than paying a transport cost. Thus, the pirate firm obtains a greater total profit. Moreover, country S obtains a greater consumer surplus if $k > (7-5t)/8$ since in that case the output sold in country S is greater than that sold in country N. Finally, country S obtains greater welfare than country N if the market of country S is great enough (i.e. if $k > (19+110t–53t2)1/2/8$).

3.3. Firm 1 Engages in FDI and Invests to Prevent Piracy in Country N (F)

In this case firm 1 engages in FDI and invests a fixed amount f to prevent firm 2 from selling pirated products in country N, so firm 2 can only compete with firm 1 in country S. If firm 1 chooses to engage in FDI it makes a positive profit in country S since $k > 3\sqrt{f} = \underline{k}$.

In the third stage firm 1 chooses the output of the two plants, q_{N1} and q_{S1}, that maximizes its profit given by (4) and firm 2 chooses the output sold in country S, q_{S2}, that maximizes (5), with $f > 0$ and $q_{N2} = 0$. By solving this stage we obtain the following:

$$(9) \qquad q_{N1}(w_N) = \frac{1 - w_N}{2}, \ q_{S1} = q_{S2} = \frac{k}{3}, \ q_{N2} = 0.$$

In the second stage, the union in the plant serving country N sets the wage that maximizes its wage bill $UN1$ given by (2). Solving this stage the following result is obtained.

Lemma 3. *When firm 1 engages in FDI and invests to prevent firm 2 from exporting pirated products to country N, in equilibrium:*

$$w_N^F = \frac{1}{2}, \ q_{N1}^F = \frac{1}{4}, \ q_{S1}^F = q_{S2}^F = \frac{k}{3}, \ q_{N2}^F = 0, \ \pi_1^F = \pi_{N1}^F + \pi_{S1}^F - f = \frac{1}{16} + \frac{k^2}{9} - f,$$

$$\pi_2^F = \pi_{S2}^F = \frac{k^2}{9}, U_N^F = \frac{1}{8}, \ CS_N^F = \frac{1}{32}, CS_S^F = \frac{2k^2}{9}, \ W_N^F = \frac{63 + 32k^2}{288} - f, W_S^F = \frac{k^2}{3}.$$
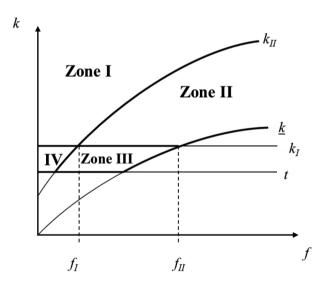
As both firms obtain the same profit in country S, it is obtained that $\pi_1^F > \pi_2^F$ if $f < 1/16$; i.e. if the amount invested to prevent piracy is lower than the profit obtained in country N. The consumer surplus is greater in country S than in country N if its market is big enough (i.e. if $k > 3/8$). Welfare is greater in country N if f is low enough and the market in S is small enough ($W_N^F > W_S^F$ if $288f + 64k^2 < 63$); otherwise welfare is greater in country S.

Once the third and the second stages of the game are solved, it remains to analyze the first stage of the game.

3.4. FDI vs. Exports

Before solving the first stage of the game we analyze whether firm 1 prefers to export or to engage in FDI (with or without piracy). To that end we use the results obtained in Lemmas 1 to 3. Let k_I denote the value of parameter k such that $\pi_1^{FP} = \pi_1^E$, where $\pi_1^{FP} > \pi_1^E$ if $k > k_I$. Therefore, if $k > k_I$ firm 1 prefers to engage in FDI and allow piracy, while if $k < k_I$ it prefers to export. Let k_{II} denote the value of parameter k such that $\pi_1^F = \pi_1^E$,, where $\pi_1^F > \pi_1^E$ if $k > k_{II}$. Therefore, if $k > k_{II}$ firm 1 prefers to engage in FDI and prevent piracy, while if $k < k_{II}$ it prefers to export. Comparing k_{II} with k_I we obtain that $k_{II} = k_I$ if $f = f_I$. Moreover, $k_{II} > k$ and $k_I = k$ if $f = f_{II}$, where $f_I < f_{II}$. The values of k_I, k_{II}, f_I and f_{II} are relegated to the Appendix and are shown in Figure 1.

FIGURE 1
ILLUSTRATION OF PROPOSITION 1 FOR A GIVEN VALUE OF T

Next we define the following zones: Zone I comprises the value of the parameters such that $k \geq \max\{k_I, k_{II}\}$; Zone II comprises the value of the parameters such that $k_{II} > k \geq \max\{k_I, \underline{k}\}$; Zone III comprises the value of the parameters such that $\min\{k_I, k_{II}\} > k \geq \max\{t, \underline{k}\}$; finally, Zone IV comprises the value of the parameters such that $k_I > k \geq \max\{t, k_{II}\}$.

We consider a given value of t to represent Figure 1. As t varies k_I and k_{II} vary, so the sizes of the zones change. If t increases k_I decreases, so the zone in which firm 1 prefers to export rather than to engage in FDI and allow piracy becomes smaller. Moreover, k_{II} decreases (grows) with t if $f > t^2/9$ ($f < t^2/9$).

Thus, if $f > t^2/9$ the area in which firm 1 prefers to exports rather than to engage in FDI and forbid piracy decreases as t increases; if $f < t^2/9$ the opposite is true as t increases.

Proposition 1. *In equilibrium*:

(i) *in Zone I firm* 1 *engages in FDI under both piracy and non piracy;*
(ii) *in Zone II firm* 1 *engages in FDI under piracy and exports under non piracy*;
(iii) *in Zone III firm* 1 *exports under both piracy and non piracy*;
(iv) *in Zone IV firm* 1 *exports under piracy and engages in FDI under non piracy*.

Proposition 1 is illustrated in Figure 1. The proof is in the Appendix. Compared with the export case, engaging in FDI means that firm 1 has lower labor costs and saves the costs of delivering the goods to country S. However, under FDI if firm 1 wants to prevent piracy in the domestic market it has to invest the amount f. Moreover, if firm 1 engages in FDI it confronts firm 2 in at least one market: the firms compete in the two markets if no investment to prevent piracy is made, while firm 1 competes with firm 2 only in market S if it invests to prevent piracy. Finally, if firm 1 exports it is a monopolist in the two markets.

When firm 1 engages in FDI under piracy, the two firms compete in both markets. In this case firm 1 gains more in the domestic market when it exports $\left(\pi_{N1}^E > \pi_{N1}^{FP}\right)$ since it is better to be a monopolist in the domestic market than to compete with firm 2 there with its higher production cost.[16] Moreover, firm 1 gains less in the foreign market in the export case $\left(\pi_{S1}^E < \pi_{S1}^{FP}\right)$ because even though duopoly competition is entailed in the foreign market under FDI, the costs saved (and thus the increase in profit) outweigh the loss in the monopolistic profit in the export case. Thus, when firm 1 engages in FDI rather than exporting, it loses (gains) profits in the domestic market (foreign market). Given that the profit obtained in the foreign market depends on the size of that market, when the market in country S is large enough $(k > k_I)$ the increase in profit in that country outweighs the decrease in profit in country N and firm 1 prefers to engage in FDI. When the market in country S is small enough $(k < k_I)$ the opposite result holds and firm 1 prefers to export.

When firm 1 engages in FDI and invests to prevent piracy, the two firms compete only in market S. In that case, in plant $N1$ firm 1 obtains the same profit as in the export case since piracy is prevented there $\left(\pi_{N1}^E = \pi_{N1}^F\right)$. In plant $S1$, firm 1 makes more profit (net of f) in the FDI case $\left(\pi_{S1}^E < \pi_{S1}^F\right)$ for the same reason as in the case of FDI without piracy. However, to prevent piracy firm 1 has to pay a fixed amount f. Moreover, the profit obtained in the foreign market increases with the size of that market. Therefore, when the market in country S is large enough $(k > k_{II})$ the increase in the profit in that country outweighs

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[16]   Note that when competing with firm 2 under FDI the wage paid by firm 1 is lower than in the export case, but it is greater than the transport cost of its rival ($w^E > w^{FP} > t$).

the investment to prevent piracy and firm 1 prefers to engage in FDI. When the market in country S is small enough ($k < k_{II}$) the opposite result holds and firm 1 prefers to export.[17]

Parameter k_{II} is lower than k_I unless the fixed cost f is high enough ($f > f_I$) since k_I does not depend on f whereas k_{II} increases with f. As a result, $k_{II} > k_I$ for a high enough parameter f.

Therefore, in Zone I firm 1 engages in FDI in both FDI cases (i.e. under piracy and non piracy) because the size of the foreign market, k, is large enough ($k \geq \max\{k_I, k_{II}\}$). In Zone III firm 1 exports since k is small enough in both FDI cases ($k < \min\{k_I, k_{II}\}$). In Zone II, the market in country S is only large enough under piracy (since k is larger than k_I but smaller than k_{II}). Therefore, firm 1 exports under non piracy and engages in FDI under piracy. That is, in this zone FDI appears only when firm 1 does not fight piracy. Finally, in Zone IV, the market in country S is only large enough under non piracy (since k is larger than k_{II} but smaller than k_I). Therefore, firm 1 exports under piracy and engages in FDI under non piracy. Thus, FDI appears when piracy is prevented in the domestic market.

3.5. Firm 1's Decision on Whether to Engage in FDI or to Export

In the first stage, firm 1 decides whether or not to engage in FDI and whether or not to invest to prevent piracy if it engages in FDI. From Lemmas 1 to 3 and Proposition 1 the following result is obtained.
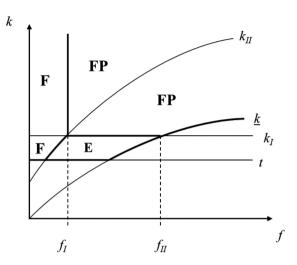
Proposition 2. *In equilibrium:*

i) *If $f \leq f_I$ and $k \geq \max\{t, k_{II}\}$, firm 1 engages in FDI and invests to prevent piracy;*
ii) *If $f > f_I$ and $k \geq \max\{k_I, k\}$, firm 1 engages in FDI and allows piracy;*
iii) *For the remaining values of the parameters firm 1 exports.*

Proposition 2 is illustrated in Figure 2. The proof is in the Appendix. The results are obtained by comparing the profit obtained by firm 1, in the different cases, within each zone. In Figure 2, F denotes the area in which, in equilibrium, firm 1 engages in FDI and allows piracy; FP denotes the area in which, in equilibrium, firm 1 engages in FDI and invests to avoid piracy; and, finally, E denotes the area in which, in equilibrium, firm 1 exports.

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[17]   Note that as the cost of the investment to prevent piracy increases, firm 1 needs to serve a larger market to obtain more profits that can offset that investment. This implies that k_{II} increases with f.

FIGURE 2
ILLUSTRATION OF PROPOSITION 2 FOR A GIVEN VALUE OF *T*

As in Figure 1, k_I and k_{II} vary with t. The variations of k_I and k_{II} with t are the same as in Figure 1, which affects the size of the different areas. If t increases f_I decreases, so the area in which firm 1 chooses to engage in FDI forbidding (allowing) piracy becomes smaller (greater).

As in Proposition 1, in Zone III firm 1 prefers to export rather than to engage in FDI. In Zone I firm 1 engages in FDI rather than exporting. In this case, if firm 1 chooses to engage in FDI with piracy (without piracy) it competes with firm 2 in both markets (only in market S). By comparing the profit obtained by firm 1 in the two FDI cases, we obtain that firm 1 obtains the same profit in market S $\left(\pi_{S1}^{FP} = \pi_{S1}^{F}\right)$ and a higher profit in market N by investing to prevent piracy $\left(\pi_{N1}^{F} > \pi_{N1}^{FP}\right)$.. Considering the amount f spent to prevent piracy, we obtain that when the fixed cost f is low enough $(f < f_I)$ firm 1 invests to prevent piracy, otherwise $(f > f_I)$ it does not do so.

In Zone IV, firm 1 exports under piracy and engages in FDI under no piracy. By comparing the profits obtained by firm 1 in these two cases, we obtain that it makes the same profit in market N $\left(\pi_{N1}^{F} = \pi_{N1}^{E}\right)$ and a higher profit (net of f) when engaging in FDI in market S $\left(\pi_{S1}^{F} > \pi_{S1}^{E}\right)$. But to prevent piracy under FDI firm 1 has to spend the amount f. Given that in Zone IV market S is large enough $(k > k_{II})$ and the cost of the investment to prevent piracy is low enough $(f < f_I)$, firm 1 obtains more profit by engaging in FDI and investing to prevent piracy.

Finally, in Zone II firm 1 engages in FDI under piracy and exports under non piracy. By comparing the profit obtained by firm 1 in these two cases, we obtain that in the export case the profit in market N is greater $\left(\pi_{N1}^{E} > \pi_{N1}^{FP}\right)$ and

the profit in market S is lower $\left(\pi_{S1}^{E} < \pi_{S1}^{FP}\right)$. In Zone II market S is large enough $(k > k_I)$, so firm 1 obtains more profit by engaging in FDI and allowing piracy.

Next we compare the equilibrium welfares obtained by the two countries in the three cases discussed so far (E, FP and F). To that end we first compare the consumer surplus and the utility of workers obtained in the three cases.

Lemma 4. *In equilibrium:*

i) $CS_S^{FP} = CS_S^F > CS_S^E$ and $\pi_2^{FP} > \pi_2^F > \pi_2^E = 0$;

ii) $CS_N^{FP} > CS_N^F = CS_N^E$ and $U_N^E > U_N^F > U_N^{FP}$.

Proof: See the Appendix.

The consumer and producer surpluses in country S can be compared straightforwardly. Under FDI with and without piracy, the consumer surplus is the same $\left(CS_S^F = CS_S^{FP}\right)$ since the two firms sell in market S in both cases. However, the producer surplus is greater under piracy $\left(\pi_2^{FP} > \pi_2^F\right)$ since firm 2 can export to country N and it thus obtains more profit. Moreover, under FDI without piracy the two firms compete in market S with zero costs while in the case of exports firm 1 monopolizes with positive costs. Thus, both the producer surplus and the consumer surplus are higher in the first case $\left(CS_S^F > CS_S^E, \pi_2^F > \pi_2^E\right)$.

Next we compare consumer surpluses in country N. When firm 1 engages in FDI and prevents piracy the same consumer surplus is obtained as when it exports $\left(CS_N^F = CS_N^E\right)$ since only firm 1 sells in country N in both cases. However, when firm 1 engages in FDI and allows piracy the consumer surplus is greater than in the other two cases since firm 2 has access to market N and, thus, competition in this market is stronger.

In country N the utility of domestic workers is the higher (lower) when firm 1 exports (engages in FDI allowing piracy): $U_N^E > U_N^F > U_N^{FP}$. . When firm 1 exports the utility of domestic workers is greater than if firm 1 engages in FDI since in the first case the firm has two plants producing in country N and is a monopolist in both markets. Moreover, when firm 1 engages in FDI and prevents piracy the workers obtain the same utility (zero) in the foreign market and more utility in the domestic market than when firm 1 engages in FDI and allows piracy. The reason is that competition in market N is weaker by avoiding product piracy and firm 1 obtains greater profit in market N which allows workers to get greater wages.

Let $k_{III} = \left(54t + \sqrt{6(22 - 110t - 453t^2)}\right)/22$. From Lemma 4 and Proposition 1 the following result is obtained.

Proposition 3. *In equilibrium:*

i) Social welfare in the South is the greatest when firm 1 engages in FDI and allows piracy, and the lowest when firm 1 exports $\left(W_S^{FP} > W_S^F > W_S^E\right)$.

ii) When $k < k_{III}$ social welfare in the North is highest if firm 1 engages in FDI and allows piracy; when $k > k_{III}$ social welfare in the North is highest if firm 1 exports. Social welfare in the North is never the greatest if firm 1 engages in FDI and invests to prevent piracy.

Proof: See the Appendix.

Lemma 4 shows that $CS_S^{FP} = CS_S^F > CS_S^E$ and $\pi_2^{FP} > \pi_2^F > \pi_2^E = 0$. Thus, it is easily obtained that $W_S^{FP} > W_S^F > W_S^E$ since when firm 1 engages in FDI and allows piracy country S obtains the greater consumer and producer surpluses while when firm 1 exports country S obtains the lower consumer and producer surpluses. As a result, government S prefers FDI to exports. In the FDI case, this government prefers firm 1 not to invest to prevent piracy in the North.

The comparisons of welfare in country N are more complex. They depend on the size of the foreign market, k, and the transport cost, t. Note first that compared to the case of FDI under piracy, the case of FDI under non piracy gives the lower consumer surplus, the higher income of unions (by Lemma 4), and the higher or lower producer surplus depending on the value of f (by Proposition 2). In this case the effect of a lower consumer surplus on social welfare outweighs the net effect of the producer surplus and utility of workers. Social welfare in the case of FDI under non piracy is therefore lower than that in FDI under piracy. Therefore, welfare in country N is never at its highest if firm 1 engages in FDI and invests to prevent piracy. Next we compare the social welfare levels obtained in the other two cases.

Proposition 1 shows that π_1^{FP} is greater than π_1^E if $k > k_I$. Moreover, Lemma 4 shows that $CS_N^{FP} > CS_N^E$ and $U_N^E > U_N^{FP}$. Note that $CS_N^{FP} - CS_N^E$ does not vary with k since it depends only on the size of market N. Moreover, π_1^{FP} increases more with k than π_1^E. Finally, U_N^E increases with k while U_N^{FP} does not vary with k and thus $U_N^E - U_N^{FP}$ increases with k.

It is obtained that when $k < k_{III}$ ($k > k_{III}$) social welfare in the North is greatest if firm 1 engages in FDI and allows piracy (exports). Comparing k_{III} with k_I (see the Appendix) we obtain that $k_{III} > k_I$ if $t > 0.0940$.

We consider first that the transport cost is great enough ($t > 0.0940$). If $k < k_I$, given that parameter k is low enough, greater welfare is obtained under FDI with piracy allowed since the greater consumer surplus outweighs the lower utility of workers and producer surplus. If $k_I < k < k_{III}$, greater welfare is obtained under FDI allowing piracy. In this case, when firm 1 engages in FDI and allows piracy, although the consumer surplus does not vary with k, the greater consumer and producer surpluses outweigh the lower utility of workers. If $k > k_{III}$, since k is now great enough, when firm 1 exports the greater utility of workers outweighs

the lower consumer and producer surpluses and, as a result, social welfare in the North is greatest if firm 1 exports.[18]

If the transport cost is low enough ($t < 0.0940$), we obtain that if $k < k_{III}$ social welfare in the North is greatest if firm 1 engages in FDI allowing piracy; given that k is low enough, when firm 1 engages in FDI allowing piracy the greater consumer surplus outweighs the lower utility of workers and producer surplus. If $k_{III} < k < k_I$ when firm 1 exports the greater producer surplus and utility of workers outweighs the lower consumer surplus. Finally, if $k > k_I$ the greater utility of workers when firm 1 exports outweighs the lower producer and consumer surpluses.

4. Does government S want to impose strong IPR protection?

Next we analyze whether government S decides to prohibit piracy by legislation (or by enforcing the copyright legislation), thus preventing the pirate firm from appearing in its country, and whether this decision is in the interest of country N. We denote this case by superscript P. For this purpose we compare the welfare of the two countries in each Zone. Note that in this case if government S acts to prevent piracy, firm 1 does not need to invest the fixed amount f to prevent piracy in its domestic market when it engages in FDI.

Proposition 4. *In equilibrium, in Zone III government S prohibits piracy and firm 1 engages in FDI. Both countries obtain greater welfare in that case.*[19]

The proof is in the Appendix. When government S prohibits piracy, firm 1 has two options: export or engage in FDI without investing to prevent piracy. It is easy to show that firm 1 makes more profit (and thus the producer surplus is higher) than in the other three cases discussed so far. This is because in this case when serving country S firm 1 can save both transport cost and labor costs without confronting the pirate firm in both markets. Therefore when government

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[18]   Note that the difference in the union incomes plays an important role in this comparison. Under FDI the plant that remains in country N does not export and so U_N^{FP} does not vary with k; however, the exports and thus U_N^E increases with k. Therefore, the difference between union incomes in the two cases $\left(U_N^E - U_N^{FP}\right)$ increases with k and this effect dominates when k is great enough. This might help to explain why some firms have been encouraged to switch to exporting or back off from investing in countries with piracy problems, such as China, in past financial crises.

[19]   When prohibiting piracy in the South is costless, we find that $W_S^{FP} > W_S^F > W_S^P > W_S^E$, , so the Southern government is interested in attempting to prevent piracy when firm 1 chooses to export. If preventing piracy has a fixed cost f_S we find that it is better to prevent piracy than to export if $W_S^{FP} - f_s > W_S^E$, , i.e. if $f_s < W_S^{FP} - W_S^E$ (if the cost of avoiding piracy is sufficiently small). In that case firm 1 does not export and prefers to engage in FDI. However, if f_S is sufficiently large, it does not pay to make the effort to prevent piracy.

S prohibits piracy it is a dominant strategy for firm 1 to engage in FDI without investing the amount f, thereby monopolizing both markets.

To compare the welfare of country S when its government prohibits piracy with that obtained in the other cases, first note that the producer surplus of country S is the same as in the export case, zero, since firm 1 is a monopoly $\left(PS_S^P = PS_S^E = 0 \right)$. On the other hand the consumer surplus is higher than in the export case $\left(CS_S^P > CS_S^E \right)$ since engaging in FDI means a greater output in market S. It follows that welfare is higher than in the export case $\left(W_S^P > W_S^E \right)$. Moreover, the producer and consumer surpluses when government S prohibits piracy are smaller than under FDI without piracy $\left(PS_S^P < PS_S^F, CS_S^P < CS_S^F \right)$ in which firm 2 enters and the two firms compete in country S. Therefore, when government S prohibits piracy the welfare of country S is lower than when firm 1 engages in FDI and invests to prevent piracy in the domestic market $\left(W_S^P < W_S^F \right)$. Finally, according to Proposition 3, as $W_S^{FP} > W_S^F$ it is obtained that when government S prohibits piracy the welfare of country S is lower than when firm 1 engages in FDI and allows piracy; thus: $W_S^{FP} > W_S^F > W_S^P > W_S^E$. This implies that government S prohibits piracy only in Zone III, since it is only in this zone that firm 1 decides to export.

To show that the decision taken by government S increases welfare in country N, we have to compare W_N^P with W_N^E. Compared with the export case, it can be shown that in country N the decrease in union income $\left(U_N^P < U_N^E \right)$ is outweighed by the increase in the producer surplus $\left(PS_N^P > PS_N^E \right)$ when the South prohibits piracy. Note that the consumer surplus is the same in both cases $\left(CS_N^P = CS_N^E \right)$. Thus, welfare in country N is higher than in the export case $\left(W_N^P > W_N^E \right)$.

5. EXTENSIONS

In order to analyze the robustness of the results obtained in the above Sections, we now consider some extensions of the basic model. A scheme of the proof of the results shown in this section is given in the Appendix.

5.1. The cost of preventing piracy depends on the market size

The cost of preventing piracy from the potential Southern rival could depend on the size of the market to be protected. This is because the larger the market, the greater the investment needed to prevent piracy. In order to analyze this case we extend the model by considering that $p_N = a - q_{N1} - q_{N2}$ and $p_S = a\,k - q_{S1} - q_{S2}$. The cost of preventing piracy is now af, so it increases with the size of the Northern market. In Section 2 we analyze the case in which $a = 1$. We find that the results of the paper hold for values of a other than from 1. As it is now less attractive to engage in FDI and prevent piracy, the range of values of parameters such that firm 1 prefers this option to the other two becomes smaller.

5.2. Positive fixed costs of setting up a new production plant

Next we extend the model to consider that the Northern firm has a fixed cost of setting up a new production plant in the South. This cost is equal to that of market entry for the Southern firm, and is denoted as C. As this cost is fixed, the total profits of both firms in cases F and FP, shown in Lemmas 2 and 3 respectively, are reduced by C. The profit of firm 1 if it exports does not change. Thus, as C increases k_I and k_{II} are shifted upwards as the market size of the South has to be larger to offset the decrease in firm 1's profits when it engages in FDI. As a result, if C is zero there are parameter values such that firm 1 chooses to engage in FDI, both under piracy and non piracy, while if C is positive firm 1 exports for those parameter values. Therefore, the existence of a positive fixed cost for setting up a production plant which is equal for both firms encourages exporting.

5.3. FDI subsidies

In order to carry out the analysis and focus on the decision as to whether to export or to engage in FDI, some alternative policies such as FDI subsidies are left behind. If we consider that either the government of the North or the government of the South grants a fixed subsidy to firm 1 in case of FDI, the main result of the paper holds. As shown in the above section, if there is a positive fixed cost of setting up a new production plant which is equal for both firms the main result of the paper holds and a fixed subsidy only reduces that fixed cost. The existence of a fixed subsidy is an incentive for firms to engage in FDI since it is now more attractive than exporting.

Tanaka and Iwaisako (2014) analyze how IPR protection affects innovation and FDI using a North-South quality-ladder model incorporating the exogenous and costless imitation of technology and subsidy policies for both R&D and FDI. They assume that the Southern government pays each multinational firm a percentage of its profits as FDI subsidies. Considering FDI subsidies as a percentage of the multinational's profit is beyond the scope of this article and is left for future research.

5.4. Governments set an import tax

The cost of delivering one unit of output from one country to the other, t, can also be interpreted as an import tax per unit of output that firms have to pay when exporting. We extend the model to consider that governments optimally choose t (intended as an import tax) to extract part of the rents of the firms.

The decision by firms to engage in FDI is a long-term decision since it may extend over time and affect how they act in the future. In addition, the decision by governments on optimal import taxes is a short-term decision since it may change from one period to another. Therefore, in our model, firm 1 decides whether to engage in FDI or export before the optimal import tax is chosen by

governments. Solving the game taking this into account we find that the main results of the paper hold since when t is exogenous the results of the model are satisfied for all t.

5.5. The wage paid in the South is positive

We finally analyze how the results of the paper change if the wage in the South (denoted now by w) is positive rather than zero. The main results obtained in the paper hold except when w and t are sufficiently high. In the extreme case where w and t are sufficiently high (e.g., for $t = 0.2$ and $w = 0.35$) it is obtained that firm 1 always prefers to engage in FDI and allow piracy. This is because firm 2 is at a strong disadvantage when competing in the Northern market, given that w and t are sufficiently high. In addition, half of the sales in the South are accounted for by each firm since both firms face the same costs. Therefore, it is not worth paying the cost of preventing piracy in the case of FDI as firm 2 gets a small share of the Northern market. Nor does it pay to export, since what is gained in the South by engaging in FDI and allowing piracy more than offsets what is lost by competition in the North.

6. Conclusion

Recently the sources of product piracy in the world have been highly concentrated in large Southern countries that are recipients of inward FDI from the North. This phenomenon cannot be fully explained by the relevant studies. Seeking to fill this gap, in this paper we examine a Northern firm's decision, with export and FDI as options, on how to serve a Southern country with potential piracy and lax local IPR protection. We also examine the Southern government's motivation to strengthen its local IPR protection.

To study whether a Northern firm prefers to export or to engage in FDI to serve the South where there is piracy, we consider a quantity-setting duopoly in which a Northern firm competes with a potential pirate firm in the South where the market size may differ from the North. We assume that production costs are lower in the South and compare the Northern firm's profits in equilibrium outcomes under its different decisions on how to serve the South.

Compared to the case where the Northern firm exports, if it engages in FDI its technology may be imitated by a Southern firm, which may compete with it in both countries. In this case the Northern firm may invest to prevent piracy in its domestic market. We find that the Northern firm engages in FDI and invests to prevent piracy in the North when the cost of that investment is low enough. When that cost is high enough, the Northern firm engages in FDI and allows piracy in its home market, provided that the Southern market is relatively large enough. Thus Northern firms may allow product piracy in their domestic markets in order to enter a large Southern market. We also show that when the cost of preventing product piracy is great enough, the Northern firm exports

to avoid potential piracy in both markets, provided that the Southern market is relatively small enough.

To analyze the Southern government's motivation to strengthen local IPR protection, we compare welfare in the Southern country when its government prohibits and allows product piracy. We show that only when the Northern firm prefers to export does the Southern government prohibit product piracy, thereby attracting inward FDI and improving welfare in both countries in comparison to the export case. The Southern government does not prohibit piracy when the Northern firm engages in FDI, because when the Northern firm chooses FDI its decision is not affected by the IPR regime in the host country. This result helps to explain why some Southern governments may be reluctant to strengthen local IPR protection enforcement even though their IPR regime could be used as a means of attracting inward FDI.

In order to analyze the robustness of the results obtained in the paper we consider some extensions of the basic model. We consider that the Northern firm has a fixed cost of setting up a new production plant in the South that is equal to that of market entry for the Southern firm, and we find that this encourages exporting. We also analyze how the results of the paper change if the wage in the South is positive. We find that the main results obtained in the paper hold except when the wage in the South and the transport cost are sufficiently high. In that case the Northern firm always prefers to engage in FDI and allow piracy. Finally, we have checked that the results of the paper hold in several cases: If the cost of preventing piracy depends on the market size, on whether the Northern firm can obtain a fixed subsidy in case of FDI, and on whether governments set an import tax.

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<div align="center">**APPENDIX**</div>

Proof of Proposition 1

$$\pi_1^{FP} - \pi_1^E = \left(7k^2 - 5 + 8t + 18kt - 5t^2\right)/144 > 0 \text{ if } k > k_I, \text{ and}$$

$$\pi_1^F - \pi_1^E = \left(7k^2 - 144f + 18kt - 9t^2\right)/144 > 0 \text{ if } k > k_{II}, \text{ where}$$

$$k_I = \left(\sqrt{35 - 56t + 116t^2} - 9t\right)/7 \text{ and } k_{II} = 3\left(4\sqrt{7f + t^2} - 3t\right)/7.$$

Comparing k_{II} with k_I we obtain: $k_{II} - k_I = \left(12\sqrt{7f + t^2} - \sqrt{35 - 56t + 116t^2}\right)/7 > 0$ if $f > f_I$. Besides, $k_{II} > \underline{k}$ and $k_I > \underline{k}$ if $f < f_{II}$, where $f_I = \left(5 - 8t - 4t^2\right)/144$,

$$f_{II} = \left(35 - 56t + 197t^2 - 18t\sqrt{35 - 56t + 116t^2}\right)/441. \qquad \text{F i n a l l y},$$

$$f_I - f_{II} = \left(-35 - 372t^2 + 8t\left(7 + 4\sqrt{35 - 56t + 116t^2}\right)\right)/784 < 0 \text{ since } t < 1/3.$$

Proof of Proposition 2

By comparing the results obtained within each zone in Proposition 1, we obtain the following. In Zone I, $\pi_1^{FP} - \pi_1^F = \frac{1}{144}\left(144f - 5 + 8t + 4t^2\right) < 0$ if $f < f_I$. In Zone II $\pi_1^{FP} > \pi_1^E$ since $k > k_I$. In Zone III, as shown in Proposition 1, when firm 1 exports the profit is higher than in FDI in both cases. Finally, in Zone IV, $\pi_1^F > \pi_1^E$ since $k > k_{II}$.

Proof of Lemma 4

$$CS_S^{FP} = CS_S^F = \frac{2k^2}{9} > CS_S^E = \frac{(k-t)^2}{32}; \ CS_N^{FP} = \frac{(7-5t)^2}{288} > CS_N^F = CS_N^E = \frac{1}{32}.$$

Proof of Proposition 3

In country S we obtain: $W_S^{FP} - W_S^F = (5 - 7t)^2/144 > 0$; $W_S^F - W_S^E = \left(29k^2 + 6kt - 3t^2\right)/96 > 0$ since $k > t$. Then: $W_S^{FP} > W_S^F > W_S^E$. In country N we obtain: $W_N^{FP} - W_N^F = f + \left(2 - 10t + 15t^2\right)/96 > 0$ since $t < 1/3$; $W_N^{FP} - W_N^E = \left(6 - 22k^2 - 30t + 108kt - 9t^2\right)/288 > 0$ if $k < k_{III}$, where $k_{III} = \left(54t + \sqrt{6\left(22 - 110t + 453t^2\right)}\right)/22$; $W_N^E - W_N^F = f + \frac{1}{144}\left(11k^2 - 54kt + 27t^2\right)$, this expression is positive if $k > k_{III}$. It can easily be shown that $k_{III} > k_I$ if $t > 0.0940$.

Proof of Proposition 4

When firm 1 engages in FDI and there is no piracy in either markets, in the third stage firm 1 chooses q_{N1} and q_{S1} to maximize its profit given by $\pi_1 = (1-q_{N1}-w_N)q_{N1} + (k-q_{S1})q_{S1}$. Solving this we obtain: $q_{N1}(w_N) = L_N(w_N) = \dfrac{1-w_N}{2}$, $q_{S1} = L_S = \dfrac{k}{2}$. In the second stage, the union sets the wage that maximizes the wage bill. By solving this stage we obtain the equilibrium wage. The following result is thus obtained: $w_N^P = \dfrac{1}{2}$, $q_N^P = \dfrac{1}{4}$, $q_S^P = \dfrac{k}{2}$, $\pi_1^P = \pi_{N1}^P + \pi_{S1}^P = \dfrac{1}{16} + \dfrac{k^2}{4}$, $U_N^P = \dfrac{1}{8}$, $CS_N^P = \dfrac{1}{32}$, $CS_S^P = \dfrac{k^2}{8}$, $W_N^P = \dfrac{7+8k^2}{32}$, $W_S^P = \dfrac{k^2}{8}$.

It is easy to verify that $\pi_1^P > \pi_1^E$. By comparing the equilibrium welfare in the different cases, we obtain for country S that: $W_S^F - W_S^P = 5k^2/24 > 0$; $W_S^P - W_S^E = (3k-t)(k+t)/32 > 0$; so: $W_S^{FP} > W_S^F > W_S^P > W_S^E$. This means that welfare in country S is greater if government S prohibits piracy (and firm 1 engages in FDI) than if firm 1 exports. As a result, government S prohibits piracy in Zone III. In country N we obtain $W_N^P - W_N^E = \left(k^2 + 6kt - 3t^2\right)/16 = \left(k^2 + 3t(2k-t)\right)/16 > 0$. Therefore, country N obtains greater welfare in Zone III if government S prohibits piracy.
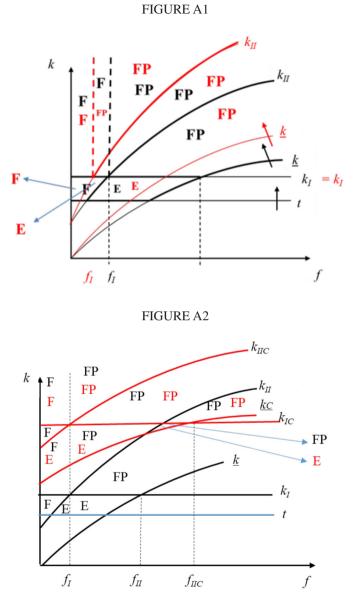
Extensions of the basic model

The cost of preventing piracy depends on the market size

If the cost of preventing piracy increases with market size, k_{II} turns upward since it is now less attractive to engage in FDI avoiding piracy. However, k_I does not change since when exporting and engaging in FDI without preventing piracy firm 1 does not make the expense af. Figure A1 shows how the zones of Proposition 2 change when the cost of preventing piracy is af (in red) rather than f (in black). If the cost of preventing piracy increases with market size, for $k > k_I$ the zone in which firm 1 engages in FDI and invest to prevent piracy (F) becomes smaller, and the zone in which firm 1 engages in FDI and allows piracy (FP) becomes larger. This is due to the higher cost of preventing piracy. Similarly, when $k < k_I$, the zone in which firm 1 exports (E) increases, and the zone in which it engages in FDI and invests to prevent piracy becomes smaller.

Positive fixed costs of setting up a new production plant

Figure A2 shows how the zones shown in Proposition 2 change when we consider a positive fixed cost of setting up a production plant for both firms (in red). We denote this case by the subscript C. We assume that $k > \max\{\underline{k_C}, t\}$, $k_C = 3\sqrt{f+C}$, to ensure that neither firm obtains any losses in any case.
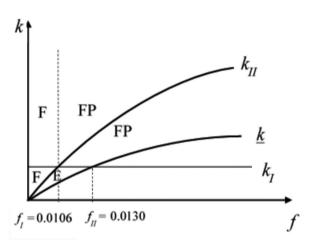
FIGURE A1

FIGURE A2

As Figure A2 shows, if C is zero (in black) there are parameter values such that firm 1 chooses to engage in FDI both under piracy and non piracy while if C is positive (in red) firm 1 exports for those parameter values.

Governments set an import tax

We consider a four-stage game with the following timing: In the first stage, firm 1 chooses whether to engage in FDI in the South or to export there. If firm 1 decides to engage in FDI, it then decides whether or not to prevent product piracy in its home market. In the second stage, both governments choose the import tax in case of exports. The government of country N chooses the import tax t_N when firm 1 engages in FDI and does not prevent product piracy since in that case firm 2 can export pirated products to country N. The government of country S chooses the import ta t_S when firm 1 exports to country S. In the third stage, unions in the North set wages and, finally, in the fourth stage firms simultaneously choose their outputs. On solving this four-stage game we find that the main results of the paper hold, because when t is exogenous the results of the model are satisfied for all t. The results of this four-stage game are shown in Figure A3.

FIGURE A3

$f_I = 0.0106$ $f_{II} = 0.0130$

The wage paid in the South is positive

When the wage in the South (denoted by w) is positive rather than zero the results hold, except when w and t are sufficiently high. For a sufficiently high given t, increasing w reduces the area in which firm 1 chooses to engage in FDI and invest to prevent piracy. For example, for $t = 0.2$ and $w = 0.3$ (case in red in Figure A4) the area in which firm 1 engages in FDI and invests to prevent piracy disappears. The situation when $t = 0.2$ and $w = 0$ is shown in black.
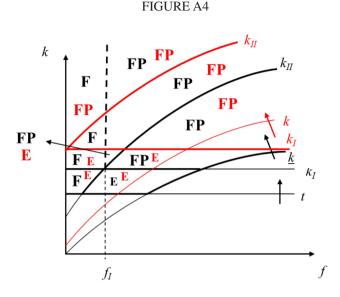
FIGURE A4

Figure A4 shows (in red) that for high k, firm 1 prefers to engage in FDI and allow piracy. For low k, exporting is preferred. The area in which firm 1 engages in FDI and invests to prevent piracy disappears. The explanation is the following: The transportation cost t only affects the firm selling in the other market. Thus, when t is low firm 1 can choose any of the three options, which is the case analyzed in the paper. When t is high and w is not high enough (e.g., for $t = 0.2$ and $w = 0.3$) firm 1 does not engage in FDI and prevent piracy. If it allows piracy it pays the cost f, but firm 2 is at a strong disadvantage in the North since w and t are high. Firm 1 continues to prefer to export for low k. It is better to be a monopolist in the North than to share a small market in the South, where costs are high.

In the extreme case where w and t are sufficiently high (e.g., for $t = 0.2$ and $w = 0.35$) it is obtained that firm 1 always prefers to engage in FDI and allow piracy. Therefore, the area in which firm 1 exports disappears.