

Intellectual Property Policy and International Technology

Diffusion

Amy Jocelyn Glass*

Department of Economics, Texas A&M University, College Station, TX 77843-4228

Abstract

Can a host country benefit from strengthening intellectual property (IP) protection in order to attract foreign direct investment (FDI)? Indeed, by limiting the degree that host firms may legally make use of technology spillovers, IP protection can succeed in attracting FDI. However, the FDI occurs in industries that generate the smallest benefits for the host country: industries with smaller technology gaps, smaller spillovers through FDI relative to exports, smaller absorption, fewer host rivals, and larger cost reductions for multinationals. Additionally, IP protection creates inefficiencies by raising the costs of host firms. Host countries should pursue other means of attracting FDI.

Keywords: Multinational firms; technology spillovers; absorption; intellectual property protection; foreign direct investment

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*Tel.: 1-979-845-8507; fax: 1-979-847-8757.
E-mail address: aglass@econmail.tamu.edu

1. Introduction

Developing countries have been pressured to harmonize their intellectual property (IP) protection to that of developed countries. One argument that tighter IP protection might benefit developing countries is that they could become more attractive locations for foreign direct investment (FDI). This paper addresses whether a potential host country can indeed gain from adopting stronger IP protection to attract FDI. This main question is split into two: can stronger IP protection attract FDI, and does the host country benefit?

We employ a simple model of a source firm's choice between FDI and exports together with a host country's choice of IP protection. A source firm decides whether to establish a production facility in a host country, knowing that more of its superior technology will leak out to host rivals as a result of FDI. The source firm may instead choose to keep production in the source country, a more expensive location, because physical distance reduces the spread of its technology to its rival.

While there are models of technology spillovers through FDI, little has been written about the impact of IP protection. Siotis (1999) notes that spillovers may deter foreign investment (what he calls the dissipation effect) and Petit and Sanna-Randaccio (2000) also consider the effect of spillovers on the FDI decision (when R&D is endogenous).

Haddad and Harrison (1993) and Kokko (1994) find evidence of technology spillovers from FDI. As Haddad and Harrison (1993) note, technology spillovers are a main reason why countries are interested in attracting FDI. Several empirical studies find some support for the ability of IP protection to attract FDI. Using data on U.S. FDI, Lee and Mansfield (1996) find that a country's choice of IP protection influences the volume and composition of FDI it receives. Javorcik (2004) finds weak IP protection deters FDI in technology-intensive sectors for transition economies. Smith (2001) also finds a link between patent protection and U.S. affiliate sales, especially in countries with strong imitative abilities. Nunnenkamp and Spatz (2004) find evidence of IP protection spurring higher quality FDI.

We find that IP protection can be used as a means of attracting FDI, as stronger IP protection reduces the degree that technology spillovers can legally be used by host firms. However, further findings cast doubt on whether IP protection should be used as a means of attracting FDI. While the profits of host firms are higher under FDI than exports at the level of IP protection required to induce FDI, they need not be higher than under exports with weak IP protection. IP protection adversely selects the worst types of FDI in terms of benefits for the host country. As IP protection is strengthened, FDI occurs first in industries with smaller technology gaps, smaller spillovers under FDI relative to exports, smaller absorption by host firms, fewer host rivals, and larger cost reductions for multinationals. Host firms in industries that switch to FDI might gain, but host firms in other industries are harmed by tighter IP protection raising their costs, so total host profits across all industries could rise or fall. Since any tightening of IP protection raises the host firm's costs, financial incentives are a more efficient means of attracting FDI.

2. Model of Intellectual Property

A source (S) firm and a host (H) firm produce a homogeneous good and compete as Cournot oligopolists. Multiple host firms will be considered later. Let the output of firm i be given by q_i , where $i \in \{S, H\}$ represents source or host, and let total output be $Q = q_H + q_S$. The demand function is linear for computational ease: $p(Q) = A - Q$. Each firm i picks its quantity q_i to maximize its profits $\pi_i = [p(Q) - c_i]q_i$, given the quantity chosen by the other firm, where the marginal cost c_i of each firm i depends on whether FDI occurs. The equilibrium outputs of the firms solve the standard first order conditions: $\partial\pi_i/\partial q_i = p(Q) + q_i p'(Q) - c_i = 0$. The outputs of the source and host firm are

$$q_S = \frac{A + c_H - 2c_S}{3}, \quad q_H = \frac{A + c_S - 2c_H}{3} \quad (1)$$

which yields profits of

$$\pi_S = \frac{(A + c_H - 2c_S)^2}{9}, \quad \pi_H = \frac{(A + c_S - 2c_H)^2}{9} \quad (2)$$

well-known equations for Cournot duopoly with asymmetric constant marginal costs and linear demand (with slope of one).

FDI confers cost savings to the source firm. To produce one unit of output, the source firm needs one unit of labor. The wage in the host country is normalized to one. The source firm has costs of one if it produces in the host country. If the source firm produces elsewhere, its marginal cost is $\Omega > 1$, which may include any higher costs of supplying the market from this location such as higher wages or trade costs. The host country offers potential cost savings to the source firm, but with greater technology spillovers to the rival.

The source firm's technology is superior, requiring less labor per unit of output than the host firm. Let $\Gamma > 1$ be the unit labor requirement for the host firm's existing technology. The existence of the source firm's superior technology and the degree of superiority of that technology are taken as given. We do not include any effect of IP protection on the size or arrival rate of new innovations.

Tightening IP protection increases the unit labor requirement for the host firm by reducing the degree that the host firm may legally use its rival's technology. Of the entire process, only the fraction μ

may be legally imitated according to the host country's IP protection.

Tighter IP protection means a reduction in μ .

Some of the source firm's superior technology leaks out to the host firm and these spillovers are largest when the source firm locates in the host country. Of the fraction μ that may be legally imitated, only the fraction σ_j , $j \in \{X, F\}$, has technology spillovers. Technology spillovers are assumed to be larger under FDI than under exports: $\sigma_F > \sigma_X$. Define $\Psi > 1$ as a parameter capturing the degree that spillovers are higher with FDI than exports: $\sigma_F = \Psi\sigma_X$ or $\sigma_X = \sigma_F/\Psi$. FDI may involve demonstration effects that generate greater knowledge flows than exports.

Technology spillovers represent knowledge flows: the knowledge must be absorbed to be used. Of the fraction $\mu\sigma_j$ that may legally be imitated and has spillovers, only the fraction α is absorbed by host firms. Absorption α may implicitly be a function of the imitation capacity of host firms, the education and experience level of the workforce or other host country factors, but it is modeled as an exogenous

parameter here.

The unit labor requirement for the host firm is a convex combination of the source firm's superior technology and the host firm's existing technology. The fraction $\alpha\mu\sigma_j$ is the superior technology and the remaining $1 - \alpha\mu\sigma_j$ is the existing technology. Thus, to produce one unit of output, the host firm needs

$$\Theta = \alpha\mu\sigma_X + (1 - \alpha\mu\sigma_X)\Gamma \quad (3)$$

units of labor with technology spillovers under exports, or

$$\theta = \alpha\mu\sigma_F + (1 - \alpha\mu\sigma_F)\Gamma \quad (4)$$

units of labor when taking advantage of technology spillovers under FDI. Since spillovers are larger under FDI relative to exports, $\sigma_F > \sigma_X$, costs for the host firm are lower under FDI than exports $\theta < \Theta$. The host firm remains less productive than the source firm $\theta \geq 1$ due to the host country's protection of intellectual property, lack of complete spillovers, and lack of full absorption.

Increased imitation lowers costs for the host firm under FDI by more than under exports

$$\frac{\partial \theta}{\partial \mu} = -\alpha \sigma_F (\Gamma - 1) < 0, \quad \frac{\partial \Theta}{\partial \mu} = -\alpha \sigma_X (\Gamma - 1) < 0 \quad (5)$$

due to higher spillovers with FDI than exports.

$$\sigma_F > \sigma_X \rightarrow \left| \frac{\partial \theta}{\partial \mu} \right| > \left| \frac{\partial \Theta}{\partial \mu} \right| \quad (6)$$

This property will be vital for the ability of IP protection, by reducing imitation, to attract FDI. If reducing imitation were to raise costs for the host firm to the same degree under FDI as under exports, the incentives for the source firm to engage in FDI would not be affected.

Under exports (X), the source firm's marginal cost equals $c_S^X = \Omega > 1$ and the host firm's marginal cost equals $c_H^X = \Theta$. Under FDI (F), the source firm's marginal cost equals $c_S^F = 1$ and the host firm's marginal cost equals $c_H^F = \theta < \Theta$. The source firm can either produce at marginal cost 1 and have its rival's marginal cost be θ or produce at marginal cost Ω and have its rival's marginal cost be Θ . The exporting equilibrium involves higher costs of production for both firms. Denote

each profit function π_i^j by $\pi_i^j(c_S^j, c_H^j)$ to highlight the marginal cost of each firm, with $i \in \{S, H\}$ representing source or host firm and $j \in \{X, F\}$ representing exports or FDI, or by $\pi_i^j(\mu)$ to highlight the level of imitation.

The timing is as follows. First, the host government picks its IP protection policy μ . Second, the source firm chooses between FDI or exporting. Technology spillovers σ_j and absorption α lower costs for the host firm. Finally, firms pick their quantities in a Cournot fashion and prices, profits, consumer surplus, and any other measures of interest are realized.

3. Source Firm

When will the source firm choose FDI? Consider the profits of the source firm under FDI and exports, $\pi_S^F(1, \theta)$ and $\pi_S^X(\Omega, \Theta)$, to determine when the two equilibria arise. Source profits under exports and source profits under FDI are strictly decreasing in μ due to the reduction in cost for the host firm. At the lower boundary where

$\mu = 0$, the host firm has the same marginal cost under FDI and exports $\Theta = \theta = \Gamma$, but the source firm has lower costs with FDI as $\Omega > 1$ so the source firm is more profitable under FDI than exports $\pi_S^F(1, \Gamma) > \pi_S^X(\Omega, \Gamma)$. For both FDI and exports to arise under different parameter values, need an intersection of the two profit functions at some threshold μ_S where $0 < \mu_S < 1$. For such a threshold to exist, the source firm must be more profitable under exports than FDI at the upper boundary where $\mu = 0$: $\pi_S^F(1, \theta) < \pi_S^X(\Omega, \Theta)$. Assume that the cost savings of FDI are sufficiently small for exports to dominate FDI in the absence of any intellectual property protection. Otherwise, FDI would occur and there would be no role for IP protection to be used to attract FDI.

Definition (Source Imitation Threshold) *The source imitation threshold μ_S is the level of legal imitation μ such that source profits under FDI equal source profits under exports: $\pi_S^F(\mu_S) = \pi_S^X(\mu_S)$. The source imitation threshold indicates the minimum level of IP protection required for the source firm to choose FDI.*

Figure 1 illustrates the two equilibria: S^F depicts profits of the source firm under FDI π_S^F and S^X depicts profit of the source firm under exports π_S^X . At $\mu = 0$, source profits are higher under FDI than exports. So when IP protection is strong, imitation is low and the source firm opts for FDI. Source profits fall with increases in μ faster under FDI than under exports due to the greater degree of spillovers under FDI than exports. Source profits under FDI equal source profits under exports at the source imitation threshold $\mu = \mu_S$. Thereafter, as imitation μ rises, source profits under exports are higher than under FDI. So when IP protection is weak, imitation is high and the source firm exports. Figure 1 is drawn for $A = 15$, $\Gamma = 4$, $\Psi = 3$, $\sigma_X = 1/3$, $\sigma_F = 1$, $\alpha = 1$, and $\Omega = 1.5$, which implies $\mu_S = 1/2$. NB, for IP protection to be effective in attracting FDI, technology spillovers must be greater under FDI than under exports $\Psi > 1$.

Proposition 1 *IP protection can be used to attract FDI. FDI occurs when imitation is sufficiently low $\mu \leq \mu_S$, where*

$$\mu_S = \frac{2(\Omega - 1)}{\alpha\sigma\left(1 - \frac{1}{\Psi}\right)(\Gamma - 1)}. \quad (7)$$

This expression for the source imitation threshold indicates how the threshold is affected by the various parameters of the model. First consider the size of the technology gap Γ . The larger the technology gap, the more the host firm stands to gain from technology spillovers. Since spillovers are larger under FDI than exports, a larger technology gap means IP protection will need to be tighter in order to lower imitation enough to keep the source firm willing to engage in FDI.

$$\frac{\partial \mu_S}{\partial \Gamma} = -\frac{2(\Omega - 1)}{\alpha\sigma\left(1 - \frac{1}{\Psi}\right)(\Gamma - 1)^2} < 0 \quad (8)$$

For the parameters described for Figure 1, a decrease in the technology gap from $\Gamma = 4$ to $\Gamma' = 3.25$ increases the source imitation threshold from $\mu_S = 1/2$ to $\mu'_S = 2/3$.

Second, consider the degree that technology spillovers are larger under FDI than exports Ψ . The larger the spillovers under FDI relative to exports, the more the cost falls for the host firm under FDI relative to exports, so the tighter IP protection needs to be in order to keep the source firm willing to engage in FDI.

$$\frac{\partial \mu_S}{\partial \Psi} = -\frac{2(\Omega - 1)}{\alpha\sigma(\Psi - 1)^2(\Gamma - 1)} < 0 \quad (9)$$

A decrease in relative spillovers from $\Psi = 3$ to $\Psi' = 2$ ($\sigma_F = \sigma'_F = 1$, $\sigma_X = 1/3$, $\sigma'_X = 1/2$) increases the source imitation threshold from $\mu_S = 1/2$ to $\mu'_S = 2/3$.

Third, consider the amount of absorption α . The larger spillovers under FDI are only put into practice if they can be absorbed. An increase in absorption lowers the cost for the host firm under FDI relative to exports, so IP protection needs to be tighter in order to keep the source firm willing to engage in FDI.

$$\frac{\partial \mu_S}{\partial \alpha} = -\frac{2(\Omega - 1)}{\alpha^2 \sigma \left(1 - \frac{1}{\Psi}\right) (\Gamma - 1)} < 0 \quad (10)$$

A decrease in absorption from $\alpha = 1$ to $\alpha' = 3/4$ increases the source imitation threshold from $\mu_S = 1/2$ to $\mu'_S = 2/3$.

Fourth, consider the cost savings from FDI Ω . Larger cost savings from FDI make the source firm more eager to engage in FDI, so IP protection can be weakened and still keep the source firm willing to engage in FDI.

$$\frac{\partial \mu_S}{\partial \Omega} = \frac{2}{\alpha \sigma \left(1 - \frac{1}{\Psi}\right) (\Gamma - 1)} > 0 \quad (11)$$

An increase in the cost savings of FDI from $\Omega = 1.5$ to $\Omega' = 1.67$ increases the source imitation threshold from $\mu_S = 1/2$ to $\mu'_S = 2/3$.

If allow for n identical host firms, the source imitation threshold becomes

$$\mu_S = \left(1 + \frac{1}{n}\right) \frac{\Omega - 1}{\alpha\sigma \left(1 - \frac{1}{\Psi}\right) (\Gamma - 1)} \quad (12)$$

which returns to the previous expression when $n = 1$. A larger number of host rivals amplifies the damage done to source profits by technology spillovers. So the larger the number of host rivals, the tighter IP protection needs to be in order to keep the source firm willing to engage in FDI.

$$\frac{\partial\mu_S}{\partial n} = -\frac{\Omega - 1}{\alpha\sigma n^2 \left(1 - \frac{1}{\Psi}\right) (\Gamma - 1)} \quad (13)$$

An increase in the number of host rivals from $n = 1$ to $n' = 2$ decreases the source imitation threshold from $\mu_S = 1/2$ to $\mu'_S = 3/8$.

Proposition 2 *The level of IP protection required to attract FDI is stronger (imitation needs to be smaller): the larger the technology gap Γ , the larger the degree of technology spillovers under FDI relative to*

exports Ψ , the larger the absorption ability of host firms α , the larger the number of host firms n , and the smaller the cost reduction with FDI Ω .

4. Effects on Host Country

So the host country can attract FDI by offering sufficiently tight IP protection. But would it want to – what level of IP protection is best for the host country?

Host profits under exports and host profits under FDI increase with μ due to lower costs for the host firm. At the lower bound $\mu = 0$, host profits under exports exceed host profits under FDI $\pi_H^X(\Omega, \Gamma) > \pi_H^F(1, \Gamma)$ because the host firm's costs are the same but the source firm has higher costs under exports. Host profits under FDI rise faster with μ than host profits under exports due to the larger spillovers under FDI than exports.

Definition (Host Imitation Threshold) *The host imitation threshold μ_H is the level of μ such that host profits under FDI equal host*

profits under exports: $\pi_H^F(\mu_H) = \pi_H^X(\mu_H)$.

Figure 2 illustrates that the host firm prefers FDI when μ is high (IP protection weak) and prefers exports when μ is low (IP protection strong). H^F depicts π_H^F and H^X depicts π_H^X . If IP protection is too tight, FDI may harm the host firm by allowing a cost reduction for the source firm but little cost reduction for the host firm. At $\mu = \mu_H$, the host firm is able to use just enough of the source firm's superior technology to be indifferent to FDI. When IP protection is sufficiently weak $\mu \geq \mu_H$, the host firm benefits when the source firm chooses FDI.

Proposition 3 *The host country can benefit from using IP protection to attract FDI. The host firm benefits from FDI by the source firm provided IP protection is sufficiently weak $\mu \geq \mu_H$, where*

$$\mu_H = \frac{(\Omega - 1)}{2\alpha\sigma \left(1 - \frac{1}{\Psi}\right) (\Gamma - 1)}. \quad (14)$$

Corollary 4 *As $\mu_H = \mu_S/4$, the host imitation threshold is always less than the source imitation threshold. Thus, at the source imitation*

threshold μ_S , FDI benefits the host firm $\pi_H^F(\mu_S) > \pi_H^X(\mu_S)$.

The analysis of host country effects thus far has ignored consumer surplus. Consumer surplus $CS_j = (A - P_j)Q_j/2$ is higher under FDI than exports. Both firms have lower costs, so the market equilibrium yields higher quantities and lower prices under FDI than exports. Thus, consumer surplus gains provide an additional reason to desire FDI.

5. Intellectual Property Policy

Setting a policy of μ_S , by making the source firm indifferent to FDI, benefits the host firm. Any strengthening of IP protection beyond μ_S merely raises the cost of the host firm. *The host country benefits the most from FDI by providing the minimum level of IP protection required to attract FDI.*

However, offering even IP protection of the source imitation threshold, the lowest level that attracts FDI, is dominated by a pure subsidy scheme. Any IP protection raises the cost of the host firm, an ineffi-

ciency. If FDI can be attracted by subsidies, then using IP protection to affect FDI decisions is not the best choice of policy instrument due to the resulting inefficiencies. *Using financial incentives may be more efficient than using IP protection to attract FDI because the latter raises the cost of the host firm.* Subsidies are feasible provided the host firm gains from FDI more than the source firm loses, which occurs when industry profits are higher under FDI – see Glass and Saggi (2002).

For example, for the standard parameters used in Figure 1, at $\mu = 1$, source firm losses from FDI

$$\pi_S^F(\mu = 1) - \pi_S^X(\mu = 1) = 21.8 - 25 = -3.2 \quad (15)$$

are smaller than the host firm's gains.

$$\pi_H^F(\mu = 1) - \pi_H^X(\mu = 1) = 21.8 - 12.3 = 9.5 \quad (16)$$

Offering a subsidy of 3.2 to the source firm conditional on FDI still leaves the host country with a net gain of 6.5. If instead IP protection were used to attract FDI, at $\mu_S = 1/2$, gains to the host firm are only.

$$\pi_H^F(\mu = 1/2) - \pi_H^X(\mu = 1/2) = 13.4 - 10 = 3.4 \quad (17)$$

If start from $\mu = 1$ and tighten IP protection to $\mu_S = 1/2$, gains for the host firm are even smaller.

$$\pi_H^F(\mu = 1/2) - \pi_H^X(\mu = 1) = 13.4 - 12.3 = 1.1 \quad (18)$$

If the technology gap increases to $\Gamma' = 6$, the subsidy needed to induce FDI increases, but the benefit of FDI to the host firm also increases, leaving a net gain of 7.2. Using financial incentives to attract FDI generates larger gains for the host country than using IP protection.

Spillovers from exports with $\mu = 1$ may be better for the host firm than spillovers from FDI with $\mu = \mu_S$ (the level of IP protection required to induce FDI). For example, consider Figure 3, where use the parameters from Figure 2 but with the larger technology gap of $\Gamma' = 6$. The source imitation threshold falls to $\mu'_S = 0.3$ (and the host imitation threshold is $\mu'_H = 0.075$). Host profits are higher under FDI than exports at $\mu'_S = 0.3$.

$$5.4 = \pi_H^F(\mu = 0.3) > \pi_H^X(\mu = 0.3) = 3.4 \quad (19)$$

However, host profits under FDI at $\mu'_S = 3/10$ are lower than host

profits under exports at $\mu = 1$.

$$5.4 = \pi_H^F(\mu = 0.3) < \pi_H^X(\mu = 1) = 6.8 \quad (20)$$

The level of IP protection that leaves host profits under FDI equal to host profits under exports with $\mu = 1$ is

$$\tilde{\mu}_H = \frac{1}{\Psi} + \frac{\Omega - 1}{2\alpha\sigma(\Gamma - 1)} \quad (21)$$

and (unlike μ_H) not always less than μ_S . *For industries requiring strong IP protection to attract FDI, the host firm need not benefit compared to no IP protection. However, zero IP protection may not be an option for the host country as it may want to provide some minimum level of IP protection for other reasons than FDI.*

The fundamental idea here is that there is a trade-off between a greater degree of spillovers from FDI (relative to exports), and that IP protection reduces the ability of host firms to make use of technology spillovers. Improving IP protection to attract FDI need not benefit host firms if the degree that IP protection must be strengthened is great relative to the degree that FDI increases spillovers.

Furthermore, suppose there are multiple heterogeneous industries and initially μ is high enough that none engage in FDI. As the host country strengthens its IP protection to reduce μ , FDI will occur first in the industries that confer the smallest gains to the host country. *Strengthening IP protection adversely selects FDI* in industries with: smaller technology gaps Γ , smaller degree of technology spillovers under FDI relative to exports Ψ , smaller absorption ability of host firms α , and smaller number of host firm n .

Initial strengthening of IP protection will attract FDI in industries with smaller gains for the host country. Strengthening IP protection further to attract FDI in additional industries comes at the expense of overtightening IP protection in industries with existing FDI. At some point, further strengthening of IP protection is harmful.

For example, suppose there are four industries with technology gaps Γ of 3.5, 4, 4.75, and 6. The corresponding source imitation thresholds μ_S are 0.6, 0.5, 0.4, and 0.3 (using the same values for the other parameters as before). At $\mu = 0.6$, the first industry (with

Γ of 3.5) has FDI and the other three industries have exports. The total host profits for all four industries are $\sum \pi_H(\mu = 0.6) = 39.2$. Strengthening IP protection to $\mu = 0.5$ achieves FDI in the second industry, and total host profits rise to $\sum \pi_H(\mu = 0.5) = 39.9$. However, strengthening IP protection further to $\mu = 0.4$ achieves FDI in the third industry, but total host profits fall to $\sum \pi_H(\mu = 0.4) = 39.3$. While host profits rise in the third industry, they fall sufficiently in the other three industries for total host profits to fall. Similarly, strengthening IP protection to $\mu = 0.3$ achieves FDI in the last industry, but total host profits drop to $\sum \pi_H(\mu = 0.3) = 36.9$.

This outcome results from the adverse selection of FDI and that IP protection raises costs for the host firm. The greater the number of industries, the more likely that the increased costs for host firms in other industries outweighs the benefits from lower costs in whatever industry switched to FDI. *IP protection is a blunt instrument for attracting FDI.* IP protection is applied equally across all industries, but the level of IP protection needed to attract FDI varies by industries.

6. Conclusion

A source firm's superior technology may leak out to host firms to a greater degree if the source firm opts for FDI. The extent that host firms may benefit from technology spillovers is restricted by IP protection. We examine whether the host country can benefit from strengthening IP protection to attract FDI. The host country should strengthen IP protection only to the degree required to attract FDI – any further strengthening raises costs for host firms and reduces consumer surplus. Additionally, using IP protection to attract FDI leads to adverse selection of FDI. FDI arises first in industries that confer the smallest gains to the host country. IP protection is a blunt instrument for attracting FDI. Since IP protection is applied equally across industries, any gains from tightening IP protection to attract FDI in the better industries may be offset by losses from tightening IP protection in other industries. Since IP protection raises costs of host firms, using other means to attract FDI may be better from the viewpoint of both host welfare and global efficiency.

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Fig. 1. Source profits under exports versus FDI

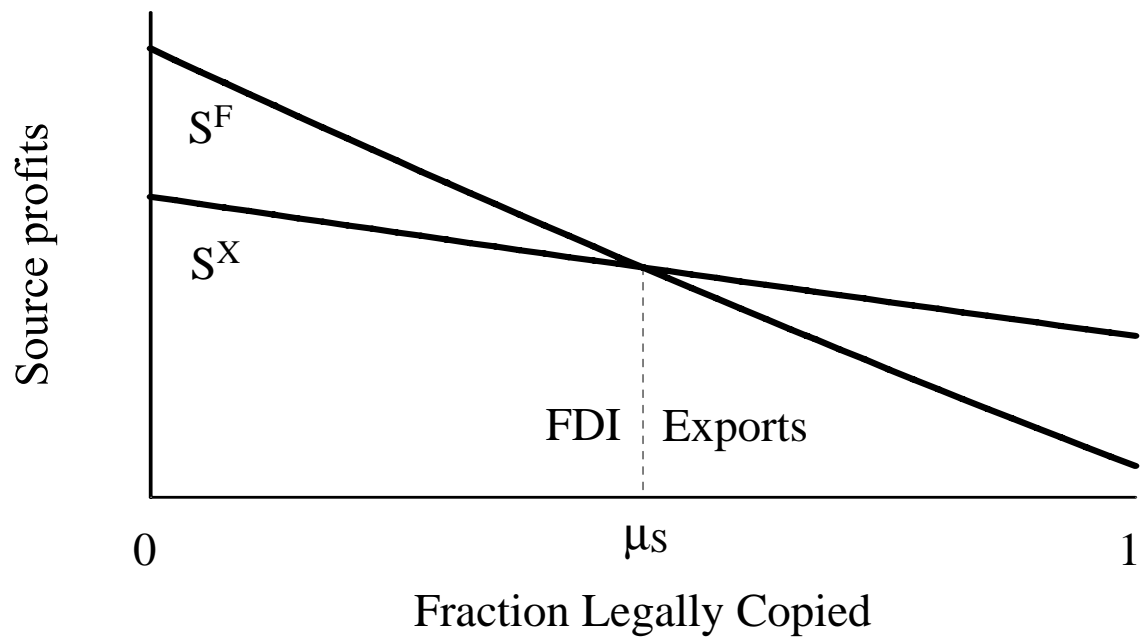


Fig. 2. Host profits under exports versus FDI

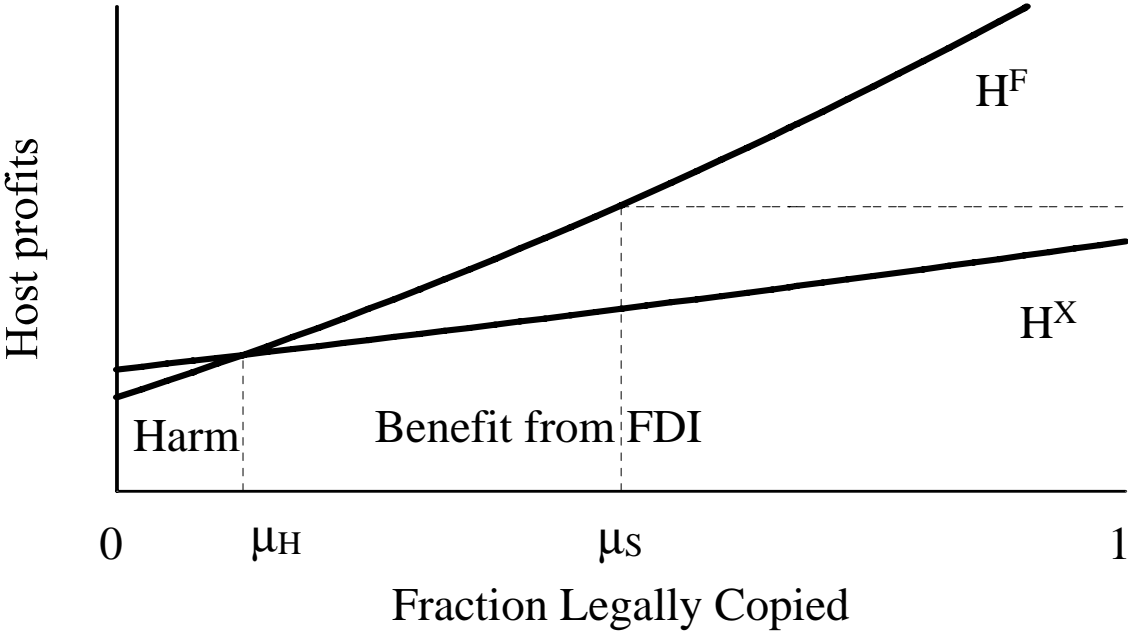


Fig. 3. Host profits under exports versus FDI, $\Gamma=6$

