Intellectual Property Rights, FDI, and Technological Development*

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Abstract

This paper presents the double trade-off faced by a lagging country in strengthening its intellectual property rights (IPR) regime between (i) attracting FDI and deterring international technology spillovers, (ii) encouraging domestic innovation and suppressing technology diffusion. The optimal level of IPR protection depends on the technological capability of the host country. In less-developed countries IPRs should be just strong enough to induce FDI. Stronger protection is recommended for more advanced countries as IPRs encourage their domestic innovators. The results cast doubt on the adequacy of globally harmonized IPR standards that do not consider the level of development.

Keywords IPR Protection; Technological Capability; Domestic Innovation; FDI

JEL classification F23; O33; O32

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1 Introduction

The TRIPS (Trade Related Aspects of Intellectual Property Rights) agreement has led to a global trend toward stronger intellectual property rights (IPR) protection over the past decades. This initiative has been most drastic for developing countries (South), which were required to upgrade their IPR standards to those in force in the developed world (North). This was clearly seen as a severe and costly adjustment by the South, making the latter reluctant to comply with the guidelines (Ghio, 2011). The concerns led to the transitional arrangements in Article 65 of the TRIPS agreement that granted the least developed countries a longer time-frame to implement the TRIPS provisions. To avoid pushing the South towards technological isolation, the following Article 66 of TRIPS further obliged the North to promote and encourage technology transfer by its firms as a form of compensation in order to substitute imitation with more legitimate means of creating a viable technological base in the South. Foreign direct investment (FDI) has often been referred to as an important source of such technology transfer, due to its role as a catalyst for industrial development, see for instance Markusen and Venabales (1999). A plausible motive for the South to strengthen IPR protection is therefore to attract FDI and thereby facilitate technology spillovers. But is the attraction of FDI under a strong IPR environment necessarily accompanied with the envisioned technology transfer and development?

The aim of this paper is to determine circumstances under which FDI-inducing IPR protection also brings benefits to the South. In the spirit of Hall (2013) we split the problem and study (i) when IPR protection results in inward technology transfer by attracting FDI, and (ii) whether this hinders or spurs technological development through domestic imitation and/or innovation. Vast theoretical and empirical evidence points to the positive role of IPR in promoting technology transfer by inducing FDI.[1] Nevertheless, the response to the second question is not straight forward. In particular, our study is inspired by recent empirical findings of Kashcheeva (2013), who finds that regardless of the positive effects of FDI and IPRs, stronger IPRs weaken the growth effect of FDI for developing countries.

While IPR protection may attract new technology, it does not necessarily result in its diffusion in the domestic economy. IPR protection may for instance hamper the diffusion of FDI-driven technology made possible by imitation defeating the very purpose for its adoption. In addition, recent theoretical works such as Mathew and Mukherjee (2014), Mukherjee and Sinha (2013) and Poyago-Theotoky and Teerasuwannajak (2013) have established the growing importance of southern innovation when studying issues related to technology diffusion. It is therefore essential to also bear in mind the trade-off between suppressing international technology diffusion and promoting domestic innovation in a lagging country. Technology transfer through FDI, technology diffusion through imitation, and domestic innovation are three interrelated dimensions on which IPR protection exerts conflicting effects. It is therefore necessary to view the problem from a broader perspective. Namely, the technological gap, innovation efficiency and absorptive capacity in the South

[1] Gaining technology spillovers are a main reason why developing countries are interested in attracting FDI. Developing countries can benefit technologically from strengthening IPRs by attracting FDI, see for instance Lai (1998), Maskus (1998), Javorcik (2004), Branstetter et al. (2006), Iwaisako et al. (2011), Mondal and Ranjan Gupta (2009), Gustafsson and Segerstrom (2011) and Branstetter and Saggi (2011).

and the spillover propensity in the industry prove to be some of the key variables that determine the extent to which the intended benefits from IPRs can be fulfilled.

This paper provides a framework to examine the double impasse between (i) attracting FDI and deterring international technology spillovers and (ii) encouraging domestic innovation and suppressing domestic technology diffusion, to address conditions under which a developing country seeking to attract FDI can in fact benefit from adopting stronger IPR protection. The analysis starts by showing that IPR protection can be used to attract FDI by reducing the degree of technology spillovers that can be legally used by host firms. The findings cast doubt on the idea that IPRs always benefit the South in terms of technological attainment. Whether or not IPR protection can be welfare enhancing depends on the technological capability of the host country in terms of the distance to the technology frontier and domestic innovation efficiency. When the technological capability is weak reflecting inefficient innovation in the domestic industry, IPR protection should not exceed the minimum level that can attract FDI. The analysis also shows that although stricter levels of IPR protection can induce FDI in more industries, it unfavorably leads to a transfer of welfare from South to North in industries where FDI is already present. For more advanced countries in the South where the technology gap is small or a higher level of innovation efficiency has been reached, a optimal IPR regime is stronger than the level that induces FDI. IPRs here also play an important role in protecting domestic innovation and spur technological development. We can conclude that IPR protection in the South should be left to the minimum necessary to attract FDI in the first stages of development, and enhanced to a stronger level once the preconditions for technological development are met.

A series of previous works confirm that strengthening IPR enforcement can attract superior technology in R&D intensive industries (Lee and Mansfield, 1996) or more technology-intensive sectors (Javorcik, 2004) through higher quality FDI (Nunnenkamp and Spatz, 2004) to countries with stronger imitative capacity (Smith, 2001). Yet, it is also true that the role of IPR protection as safeguard against technology spillovers creates a policy dilemma when it comes to exploiting the technology brought in by FDI.[2] On the one hand, a lagging country should strengthen its IPR regime to attract FDI consisting of superior technology. On the other hand, stronger IPR protection reduces the legal ability of firms in the host country to benefit from technology spillovers. Assessing this trade-off, Glass (2005) and Naghavi (2007) showed that the IPR protection in a lagging country should be just strong enough to attract FDI.

The dominant theoretical literature on IPRs and FDI typically divides the world into an industrialized innovating North and a less developed imitating South, neglecting the impact of IPRs on potential domestic innovation. While the role of imitation at the lower stages of development is indispensable, countries at a relatively more advance position tend to be more willing to adopt IPRs to protect their own inventors. Chen and Puttitanun (2005) developed a model to illustrate the trade-off between imitating foreign technologies and

[2] The predominant point of view derived from the North-South technology transfer framework states that strengthening the protection of IPRs in the South would undermine overall welfare and inhibit technological progress (Helpman, 1993； Glass and Saggi, 2002), block the free flow of scientific knowledge from innovations (Gangopadhyaya and Mondal, 2012), or work against national economic interests by transferring rents to multinational corporate patent holders headquartered in the North (McCalman, 2001; Adams, 2008).

encouraging domestic innovation in a developing country's choice of IPRs, and found that a country's optimal level of IPRs depends on its level of development non-monotonically, first decreasing and then increasing. The existence of an empirical U-shaped curve between IPRs and per capita GNP has also been noticed empirically by Maskus (2000) and by Braga et al., (2000). Glass (2010) and Lorenczik and Newiak (2012) specifically consider the imitation of Southern innovation to investigate whether stronger IPR protection promote or discourage further innovations that build on existing ideas. Glass (2010) emphasizes the importance of imitation in providing the South a sufficient knowledge base as a stepping stone to innovation, whereas Lorenczik and Newiak (2012) highlights the role of IPRs in generating a shift from an imitating to an innovating South.[3] The model presented in this paper essentially incorporates the idea of domestic innovation and imitation introduced in Glass (2010) and Lorenczik and Newiak (2012) into the basic trade-off between FDI and technology spillovers assessed in Glass (2005) and Naghavi (2007).

The rest of the paper is organized as follows. The next section presents a basic framework. Section 3 illustrates the inflow of FDI, and section 4 investigates the optimal level of IPR protection to attract FDI in the context of one industry. Section 5 verifies the effects of IPRs under multiple industries. Concluding remarks are contained in section 6.

2 Basic Models

Consider a world economy that consists of two regions: a technologically advanced North and a lagging South. A northern source firm (*s*) engages in innovation and enjoys full IPR protection at home. Host firms in the South (*h*) also engage in innovation, but an imperfect IPR regime allows them to imitate the northern firms and other southern firms. Suppose a simple game that takes place in two stages. In the first stage the government in the South sets the IPR protection level and the source firm with superior technology decides whether to export or to move production to the South. In the second stage, the source firm and the host firms produce a homogeneous good and engage in Cournot competition. In line with Leahy and Naghavi (2010), in our basic framework we consider two host firms that are symmetric in terms of technology and average cost.[4]

Let the output of firm *i* be given by q_i, where $i \in \{1, 2, s\}$ represents the two host firms and the source firm respectively. Total output is given by $Q = q_h + q_s = q_1 + q_2 + q_s$. The demand function is linear for computational ease: $p(Q) = a - Q$. Firm *i* chooses its quantity q_i to maximize profits, $\pi_i = [p(Q) - C_i]q_i$, where C_i represents the average cost of each firm. The equilibrium output of each firm is derived from the standard first-order condition, $\partial\pi_i / \partial q_i = 0$ and solves:

$$q_s = \frac{a + 2C_h - 3C_s}{4} \quad \text{and} \quad q_1 = q_2 = \frac{a + C_s - 2C_h}{4} \tag{1}$$

This yields profits of:

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[3] Leahy and Naghavi (2010) and Lorenczik (2012) extend the argument in another dimension and instead look at the interaction between the IPRs and the FDI policies on technology transfer and Southern welfare in the presence of joint ventures and domestic innovation respectively.

[4] The scenarios of multiple host firms and multiple industries will be addressed in the upcoming sections.

$$\pi_s = \frac{(a + 2C_h - 3C_s)^2}{16} \quad \text{and} \quad \pi_1 = \pi_2 = \frac{(a + C_s - 2C_h)^2}{16} \tag{2}$$

Suppose the average cost depends on the level of technology, and that the source firm holds technological advantage over the two host firms. Let A_S represent the technological level of the source firm and A_i *(i=1, 2)* that of domestic firms. To produce one unit of output, the source firm needs one unit of labor, whereas the host firms need Γ ($\Gamma = \frac{A_S}{A_i} > 1$) units of labor. Parameter Γ in other words represents the technological gap between the two regions. The wage in the host country is normalized to one. The average cost of production for the source firm is equal to one if it produces in the host country, but $\lambda > 1$ if it chooses to produce at home and export, due to higher wages or trade costs. Accordingly, the host country offers potential cost savings to the source firm, but at the expense of risking technology spillovers to rival firms.

Technological progress in terms of reducing the costs of production takes place according to $\theta = \delta A$, where A is the stock of knowledge capital, and δ represents the efficiency of domestic innovation. Knowledge capital (A) consists of the old technology, which has been imitated by other R&D enterprises, and new technology not yet replicated. There is the implicit assumption that these two types of technology have the same function in technological progress. It is however more plausible to think of newer technologies being more relevant than vintage knowledge in the evolution of technological capabilities, which is also the essence of Schumpeter's theory of creative destruction. Mondal and Gupta (2006) for instance develop a framework where knowledge capital solely includes the novel technologies. Following this approach, our model assumes that old imitated technology is ineffective for R&D, whereas new technologies are the key contributors to innovation.

Define the degree of IPR protection as μ, where $0 \le \mu \le 1$. If $\mu = 0$, all new technologies can be imitated due to the lack of an adequate IPR regime. Alternatively if $\mu = 1$, new technologies cannot leak due to the perfect enforcement of IPRs. Thus, $1 - \mu$ represents the fraction of new technologies, which are subject to imitation based on the host country's IPR protection level. Let the degree of practical technology spillovers in the industry be σ, whereas only a fraction β can be absorbed by host country firms. Absorption capability β 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. $K = \beta\sigma(1 - \mu)$ is therefore the total fraction of new technology that can be imitated.

According to the definition above, the knowledge capital of host firms is derived from the expression $A_i - KA_i$. Domestic innovation of host firms evolves as:

$$\theta_i^{in} = \delta[A_i - KA_i], \forall i = 1,2 \tag{3}$$

Note that a host firm only imitates the new technology of the other domestic firm because the vintage technologies have no effect on the development of new inventions. Technology available to one host firm through the imitation of another domestic firm is:

$$\theta_i^{imh} = K\theta_i^{in} = \delta K[A_i - KA_i], \forall i = 1,2 \tag{4}$$

Equation (4) simply captures the feature that ideas build on other ideas, as pointed out in Boldrin and Levine (2004). The third channel of technological progress for domestic firms is to imitate the superior technology of the source firm. The fraction of imitable technology is $A_s - A_i$. Thus, the technology available to each domestic firm through the imitation of the source firm is:

$$\theta_i^{ims} = K(A_s - A_i), \forall i = 1,2 \tag{5}$$

Technology spillovers are assumed to be larger under FDI than exports: $\sigma_F > \sigma_X$. Hereafter we distinguish spillovers under the two modes by referring to it as $\sigma = \sigma_F = \psi\sigma_X$, where $\psi > 1$.

Aggregating the three sources of progress, the total new technology of each host firm can be written as：

$$\theta_i = \theta_i^{in} + \theta_i^{imh} + \theta_i^{ims}, \forall i = 1,2 \tag{6}$$

Suppose the new cost-reducing technology influences production in the same way regardless of whether it is obtained from domestic innovation or imitation. That is, one unit of labor is required to produce one unit of output either by innovating the technology or imitating it. The proportion of new and old technologies are θ_i / A_i and $1-(\theta_i / A_i)$, respectively. Hence, the average cost to each host firm is：

$$C_h = (\theta_i / A_i) \times 1 + (1 - \theta_i / A_i) \times \Gamma \tag{7}$$

Substituting Equations (3), (4), and (5) into (7), the average costs of each host firm under FDI (*F*) and exports (*X*) are:

$$C_h^F = [\delta(1-K^2) + K(\Gamma - 1)](1-\Gamma) + \Gamma \tag{8}$$

$$C_h^X = [\delta(1-K^2) + K(\Gamma - 1)/\psi](1-\Gamma) + \Gamma \tag{9}$$

Combining Equations (2) and (9) we obtain profits under exports：

$$\pi_s{}^X = \frac{(a + 2C_h{}^X - 3\lambda)^2}{16} \quad \text{and} \quad \pi_1{}^X = \pi_2{}^X = \frac{(a + \lambda - 2C_h{}^X)^2}{16} \tag{10}$$

Equations (2) and (8) in turn derive the profits under FDI:

$$\pi_s^F = \frac{\left(a + 2C_h^F - 3\right)^2}{16} \quad \text{and} \quad \pi_1{}^F = \pi_2{}^F = \frac{(a + 1 - 2C_h{}^F)^2}{16} \tag{11}$$

3 IPR protection and FDI

In line with Ferrantino (1993), the source firm chooses between FDI and export as its mode of serving the South given the host country's level of IPR protection, acknowledging that FDI makes it more likely for its superior technology to be disclosed to host rivals. Keeping production in the North helps safeguard its technology due to physical distance and the lack of a demonstration effect, but entails higher marginal costs of production (λ>1).

The minimum level of IPR protection required by the source firm to select FDI is determined by setting profits under the two modes equal, $\pi_s^F(1, C_h^{\;F}) = \pi_s^X(\lambda, C_h^{\;X})$, to obtain

$$\frac{(a + 2C_h^{\;F} - 3)^2}{16} = \frac{(a + 2C_h^{\;X} - 3\lambda)^2}{16} \tag{12}$$

Substituting Equations (8) and (9) into (12), the minimum IPR level necessary to attract FDI is:

$$\mu_s = 1 - \frac{3(\lambda - 1)}{2\beta\sigma(1 - 1/\psi)(\Gamma - 1)^2} \tag{13}$$

We can also examine how various parameters of the model affect this threshold. Simple comparative statics reveal $\frac{\partial \mu_s}{\partial \Gamma} > 0$, $\frac{\partial \mu_s}{\partial \beta} > 0$, $\frac{\partial \mu_s}{\partial \sigma} > 0$. A larger technology gap (*Γ*) implies that the source firm incurs larger losses upon the imitation of its technology therefore requires tighter IPR protection to undertake FDI.[5] At the same time, a higher absorptive capacity in the host country (β) also deters FDI in the absence of a sufficiently strong IPR regime. The degree to which an industry is predisposed to technology spillovers (σ) also affects the critical level of IPRs that induces FDI positively as losses from spillovers larger under FDI than exports.

Allowing for *n* identical host firms, the IPR threshold becomes

$$\mu_s = 1 - \frac{n(\lambda - 1)}{\beta\sigma(n-1)(1 - 1/\psi)(\Gamma - 1)^2} \tag{14}$$

A larger number of host rivals will amplify the damage to source firm's profits from technology spillovers: $\partial \mu_s / \partial n > 0$. Therefore, the larger the number of host rivals, the tighter IPR protection is required for FDI to occur. Seen the other way around, given the IPR level the source firm tends to choose FDI over exports in less competitive industries to prevent severe technology spillovers.

The analysis so far shows that IPR enforcement can succeed in attracting FDI. We now turn to the welfare implications of IPRs to see whether they can prove beneficial to the developing world. Observing first the consumer surplus, $CS_h^{\;j} = (a - P^j)Q^j / 2$, it is easy to see that consumers are always better off with FDI than under exports: $CS_h^{\;F} = \frac{(3a - 2C_h^{\;F} - 1)^2}{32} > CS_h^{\;X} = \frac{(3a - 2C_h^{\;X} - \lambda)^2}{32}$. This arises due to lower production costs, and hence higher output and lower prices in equilibrium under FDI. We next evaluate total welfare in the lagging country to determine the optimal level of IPR protection under each mode. Define welfare in the lagging country as the sum of profits and consumer surplus. The optimal level of IPR protection is obtained by:

$$\max_{\mu} W_h^{\;J} = \pi_h^{\;J} + CS_h^{\;J}, J \in (X, F).$$

As per $\partial W_h^{\;F} / \partial \mu = 0$ and $\partial^2 W_h^{\;F} / \partial^2 \mu < 0$, the optimal IPR protection of the lagging country under FDI is

[5] It will be shown in section 5 that if the technology gap is viewed from an industry (instead of country) perspective as suggested by Glass (2005), FDI occurs first in industries with the smallest technology gap that confer the smallest gains to the host country. The policy of strengthening IPRs to attract FDI and benefit from technology spillovers may therefore prove ineffective.

$$\mu^{F*} = 1 - \frac{\Gamma - 1}{2\beta\sigma\delta} \tag{15}$$

Equation (15) suggests an inverted U-shaped relationship between IPRs and welfare in the South under FDI as $\partial W_h^F / \partial\mu > 0$ for $\mu < \mu^{F*}$, whereas $\partial W_h^F / \partial\mu < 0$ for $\mu > \mu^{F*}$. The optimal IPR regime under exports can be obtained in a similar manner and is

$$\mu^{X*} = 1 - \frac{(\Gamma - 1)/\psi}{2\beta\sigma\delta} \tag{16}$$

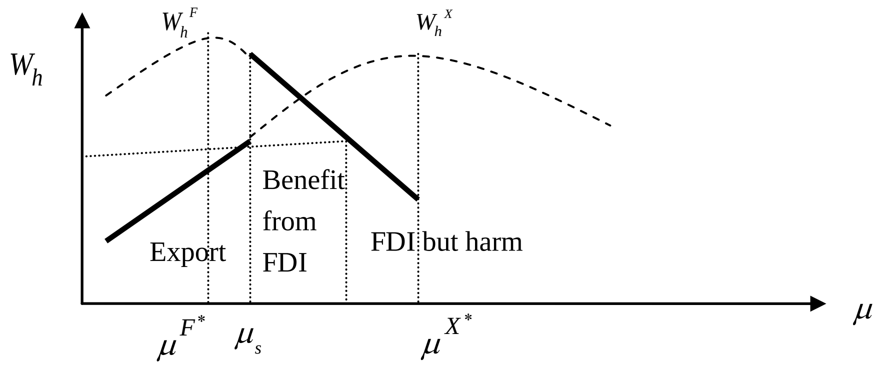

Fig. 1 IPRs and Welfare under FDI versus Export

Comparing Equations (15) and (16) yields $\mu^{X*} > \mu^{F*}$. That is, the optimal level of IPR protection is stronger under exports than FDI. This is because lower spillovers under exports reinforce the importance of domestic inventions and the need for their protection to foster technological progress. In fact, the inverted U-shaped relationship between IPRs and welfare comes from the double-edge effect of strengthening IPR protection on technological progress, thereby on the cost and eventually on the profits of host firms and consumer surplus in equilibrium. We show in Appendix 1 that the profits, consumer surplus and therefore welfare in the lagging country all move in the same direction with IPR enforcement. Strengthening IPR protection can encourage FDI and domestic innovation, but deters international and domestic technology diffusion. Strengthening IPR protection has a non-monotonic effect on welfare, implying that FDI does not always lead to a higher welfare than exports. In particular, when IPR protection is strong, southern welfare under FDI can be inferior to that under exports. Figure 1 depicts welfare for each equilibrium supply mode under different levels of IPR protection.

Proposition 1. *The relationship between IPR protection and welfare in the lagging country takes an inverted-U shape. Stronger IPR protection can enhance welfare by attracting FDI and encouraging domestic innovation, but also causes a deterioration of welfare by blocking international and domestic technology diffusion.*

4 Technological Capability and the Optimal IPR Regime

This section investigates the main factors determining the optimal level of IPR protection for the South in the context of one single industry and whether it induces FDI. Equation (15) in the previous section illustrates how the optimal level of IPR protection in the South under FDI depends on technological capability. Stronger technological capability, that is a narrower technology gap Γ or higher southern innovation efficiency δ, brings the need for a stricter IPR regime as $\partial \mu^{F*} / \partial \Gamma < 0$, and $\partial \mu^{F*} / \partial \delta > 0$. According to $\partial \pi_s^{\ F} / \partial \mu = 0$ and $\partial^2 \pi_s^{\ F} / \partial^2 \mu > 0$, the level of IPR protection that maximizes the host's welfare with FDI is identical to the level that generates the minimum profits for the source firm under FDI (μ_s^{F*}):

$$\mu_s^{F*} = \mu^{F*} = 1 - \frac{\Gamma - 1}{2\beta\sigma\delta} \tag{17}$$

Equation (17) suggests a U-shaped relationship between IPRs and the profits of the source firm under FDI as $\partial \pi_s^{\ F} / \partial \mu < 0$ for $\mu < \mu_s^{\ F*}$, whereas $\partial \pi_s^{\ F} / \partial \mu > 0$ for $\mu > \mu_s^{\ F*}$.

When $\mu < \mu^{F*}$, strengthening IPRs will increase the welfare in the host country ($\partial W_h^{\ F} / \partial \mu > 0$) and decrease the profits of the source firm ($\partial \pi_s^{\ F} / \partial \mu < 0$) because the full capacity of domestic innovation is not realized under a weak IPR regime. In addition, the positive effect of stronger IPRs on domestic innovation outweighs its negative impact on imitation. Thus, strengthening IPRs reduces costs of host firms, making them more competitive against the source firm, and increases the host consumer surplus through lower prices and higher output in equilibrium. We show in Appendix 2 how the price and total output in equilibrium change in IPR enforcement. When $\mu > \mu^{F*}$ instead, strengthening IPRs will decrease the host welfare and increase the profits of the source firm as the capacity of domestic innovation is already exhausted with strict IPRs and the positive effect of stronger IPRs on domestic innovation falls short of its negative impact on imitation. Thus, strengthening IPRs further increases costs of host firms and decreases the host consumer surplus in equilibrium, and leads to a transfer of welfare from the host firms and consumers to the source rival in equilibrium.

Likewise, when the source firm opts for exports the optimal IPR protection for the South is equal to the level that minimizes the profits of the source firm (μ_s^{X*}):

$$\mu_s^{X*} = \mu^{X*} = 1 - \frac{(\Gamma - 1)/\psi}{2\beta\sigma\delta} \tag{18}$$

Equation (18) also suggests a U-shaped relationship between IPRs and the profits of the source firm under export. Recalling $\mu^{X*} > \mu^{F*}$, the curves $W_h^{\ F}$ and $\pi_s^{\ F}$ lie to the left of $W_h^{\ X}$ and $\pi_s^{\ X}$. Technology gap and domestic innovation efficiency turn out to play an important role in determining the optimal IPR level and the supply mode. For relatively low technological capability, i.e. when $\Gamma > \sqrt[3]{3(\lambda - 1)\delta / (1 - 1/\psi)} + 1$ or (and) $\delta < (\Gamma - 1)^3 (1 - 1/\psi) / 3(\lambda - 1)$, inequality $\mu_s > \mu^{F*}$ holds. In this case, the first-best IPR regime is not sufficiently strong to attract FDI. Figure 2 illustrates this relationship between $W_h^{\ X}$, $\pi_s^{\ X}$, $W_h^{\ F}$ and $\pi_s^{\ F}$ .Figure 2 shows that when IPR protection in the lagging country is weak ($\mu < \mu_s$), $\pi_s^{\ X} > \pi_s^{\ F}$ holds indicating that the source firm chooses to export to reduce technology spillovers. Under exports, strengthening IPRs lowers profits of the source firm ($\partial \pi_s^{\ X} / \partial \mu < 0$), while increasing that of the host firms ($\partial \pi_h^{\ X} / \partial \mu > 0$) by encouraging domestic innovation. Moreover, minor spillovers with exports gives more weight to the impact of IPRs on domestic innovation relative to its adverse effects of inhibiting the diffusion of domestic and foreign technologies. In addition, consumers' surplus under exports is also an increasing function of IPRs, that is $\partial CS_h^X / \partial\mu > 0$, as shown in Appendix 1. All in all, when $\mu < \mu_s$ so that the source firm prefers to export, strengthening IPR protection shifts profits from the source firm to southern consumers and firms, resulting in the increment of the welfare in the lagging country(W_h^X). When IPR protection level reaches μ_S and the source firm switches mode to FDI, there is a jump in southern welfare. However once FDI is the established supply mode due to sufficient IPRs ($\mu > \mu_S$ → $\pi_s^F > \pi_s^X$), further tightening of the IPR regime has the opposite consequences: $\partial\pi_s^F / \partial\mu > 0$, $\partial\pi_h^F / \partial\mu < 0$ and $\partial CS_h^F / \partial\mu < 0$. Strengthening IPR protection decreases the welfare in the lagging country (W_h^F) in terms of consumer surplus and the profits of the host firms, while increasing the profits of the source firm. This is equivalent to an international transfer of welfare from the host country to the foreign firm. This conclusion is consistent with McCalman's (2002) empirical results, which argue that increasing IPR protection in the South to the level in force in the North results in a large volume of income transfers from developing to advanced nations. The results under low technological capability support Glass (2005) and Naghavi (2007) in that IPR protection should only be strong enough to bring in FDI.

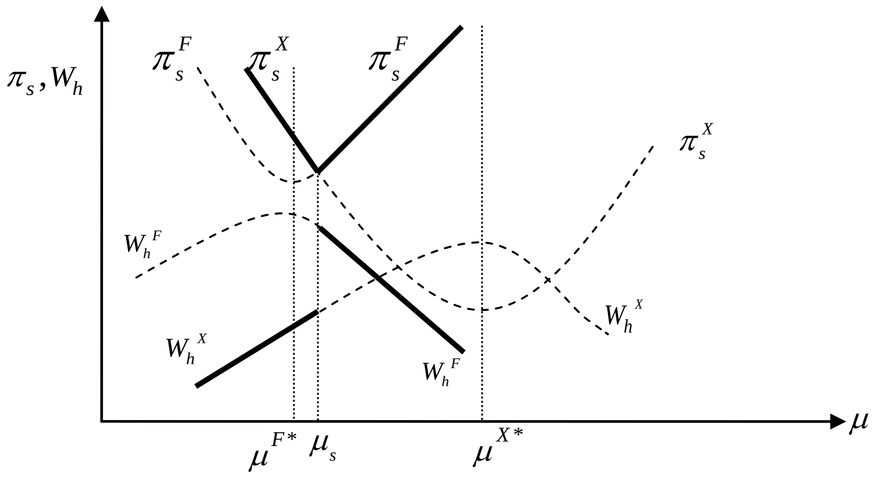

Fig. 2 The optimal IPRs Protection when $\mu_s > \mu^{F*}$

Proposition 2. *The optimal IPR protection to attract FDI depends on domestic technological capability in terms of technology gap and innovation efficiency. When* $\Gamma > \sqrt[3]{3(\lambda-1)\delta/(1-1/\psi)}+1$ *or (and)* $\delta < (\Gamma-1)^3(1-1/\psi)/3(\lambda-1)$, $\mu_s > \mu^{F*}$ holds. Since $W_h^F\big|_{\mu=\mu_s} > W_h^X\big|_{\mu=\mu_s}$ *, the optimal IPR protection for the lagging country is the level just sufficient to attract FDI (* μ_S *).*

When the South enjoys a relatively high level of technological capability so that $\Gamma < \sqrt[3]{3(\lambda-1)\delta/(1-1/\psi)}+1$ or (and) $\delta > (\Gamma-1)^3(1-1/\psi)/3(\lambda-1)$, inequality $\mu_s < \mu_s^{F*}$ holds implying that the optimal IPR protection in view of the South is enough to attract FDI. Figure 3 shows the relationship between W_h^X, π_s^X, W_h^F and π_s^F. Starting from weak IPR protection ($\mu < \mu_S$), $\pi_s^X > \pi_s^F$ indicates that the source firm chooses export over FDI. Moreover, $\partial\pi_h^X / \partial\mu > 0, \partial\pi_s^X / \partial\mu < 0$, and $\partial CS_h^X / \partial\mu > 0$ specify that welfare in the lagging country (W_h^X) is increasing, while the profits of the source firm is decreasing in IPR enforcement. When $\mu_S < \mu < \mu^{F*}$, the source firm opts for FDI as $\pi_s^F > \pi_s^X$, where $\partial\pi_h^F / \partial\mu > 0, \partial\pi_s^F / \partial\mu < 0$, and $\partial CS_h^F / \partial\mu > 0$ point towards the role of IPRs in transferring income from source to host firms and domestic consumers. A stricter IPR regime than the FDI-inducing level is here beneficial to the South. Finally, very high levels of IPR protection ($\mu > \mu^{F*}$) results in a transfer of welfare from the host country to the foreign firm. This allows us to conclude that in countries that have reached higher levels of technological capability, welfare in the lagging country is at its maximum level when $\mu = \mu^{F*}$. This is contrast with Glass (2005) and Naghavi (2007), highlighting the positive role of IPR protection for technological progress in countries at a higher stage of development. The significance of IPR protection here goes beyond the attraction of FDI due to an existing domestic innovation sector.

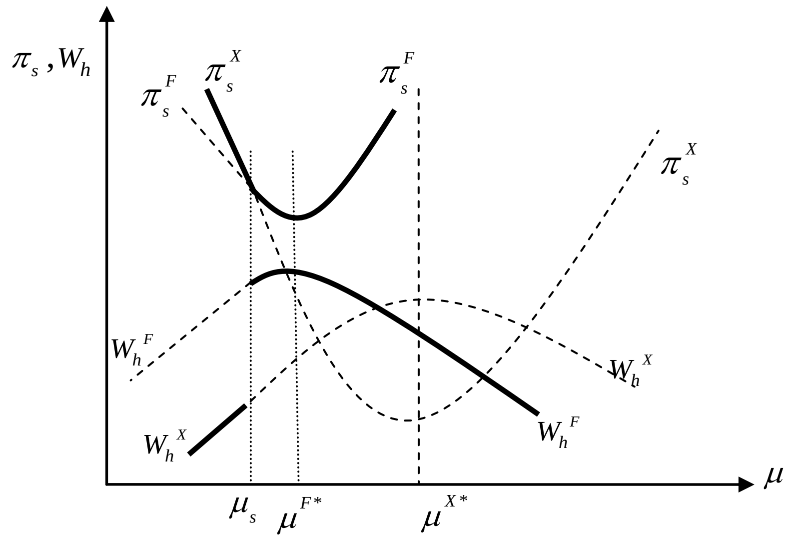

Fig. 3 The optimal IPRs Protection when $\mu_s < \mu^{F*}$

Proposition 3. *When domestic technological capability is strong enough, i.e.* $\Gamma < \sqrt[3]{3(\lambda-1)\delta/(1-1/\psi)}+1$ *or (and)* $\delta > (\Gamma-1)^3(1-1/\psi)/3(\lambda-1)$, $\mu_s < \mu_s^{F*}$ holds. *The optimal IPR protection of the lagging country is therefore* μ^{F*} *and lies above the FDI-inducing level to support domestic innovation in countries that have reached a sufficiently advanced stage of development.*

5 Heterogeneous Industries

In this section we view the main determinants of the optimal IPR regime in the South, namely technology gap and innovation efficiency, from a heterogeneous industries perspective. This changes the argument in the sense that the optimal level of IPR protection and/or the level required to attract FDI differs according to the technological capability in the industry (as opposed to the whole country).

Putting the results obtained in the previous section in the context of heterogeneous industries, industries with smaller technology gaps and stronger innovative efficiency require stronger IPR protection. This implies that tighter IPR enforcement initially attracts FDI in industries with minimal gains for the host country. Strengthening IPRs further attracts FDI in more industries, but at the expense of excessive IPR protection in industries with existing FDI. Recalling the uniform character of IPR across all industries, IPR protection can after a certain point become harmful to the South.

Suppose for example *n* industries with increased technological capability over industries, where $\mu_S = \mu^{F*}$ for simplicity as the argument holds for both first-best optimal IPRs and the FDI-inducing level. We know from the previous section that μ^{F*} increasing in the technological capability, now of an industry. Let the total profits of firms in each industry be π_i. The optimal level of IPR protection for the least efficient industry is μ_1^{F*}. When IPRs are strengthened to μ_2^{F*}, the profits of the second (more efficient) industry reach a maximum, while the profits in the first industry are reduced. Similarly, Strengthening IPRs protection to μ_3^{F*} will raise host profits in the third industry and reduce profits in the first two industries, and so forth. More generally, when IPR protection is strengthened from μ_{n-1}^{F*} to μ_n^{F*}, profits in the n^{th} industry reach their maximum level but reduced in the *n-1* industries. This causes a reduction of overall host profits if the following condition is satisfied:

$$\sum_{i=1}^{n-1}\left[\pi_i^F(\mu_{n-1}^{F*}) - \pi_i^F(\mu_n^{F*})\right] > \pi_n^F(\mu_n^{F*}) - \pi_n^X(\mu_{n-1}^{F*}) \tag{19}$$

The greater the number of industries, the more likely it is that the increased costs for host firms in other industries outweighs the benefits from lower costs in the industry that switched to FDI.[6] It is therefore important to remember that although policymakers are constrained to implement a uniform IPR regime across all industries, the optimal protection level needed to attract FDI varies by industries. Chu (2011) suggests that in this case the level of IPR protection should be set as a weighted average of its sector-specific optimal values.

6. Concluding remarks

An argument generally used to support the strengthening of IPRs protection in lagging countries is that doing so will attract FDI and result in a welfare gain through technology spillovers. In this paper, we re-examine the argument in a two-stage game by focusing on its double trade-offs: the simultaneous need for attracting FDI, facilitating international technology spillovers, providing incentives for domestic innovation, and stimulating domestic technology diffusion. Our study finds that optimal IPR protection varies according to technological capability in terms of technology gap, and research efficiency of

[6] As shows in Appendix 1 that consumer surplus moves the same direction as the profits in the lagging country, so the idea can be extended to welfare.

domestic innovation. Stringent IPR protection above an optimal level induces a welfare transfer from home to abroad. More precisely, for less technologically developed countries, IPR enforcement should just be enough to attract FDI, whereas a stronger protection level is optimal for more advanced countries with an active and efficient domestic innovation sector.

Our analysis suggests that attracting FDI can indeed be beneficial to lagging countries and that IPRs can be an instrument to encourage it. We show however that IPR protection is a delicate policy, and that the global harmonization of IPRs can hardly serve well the purpose of welfare maximization. This conclusion is in contrast with some recent welfare analyses of IPRs like Iwaisako et al., (2011), who conclude that stricter forms of IPR protection in the South are always welfare maximizing for both the North and the South. The crucial dilemma for the practice of IPRs is that the optimal level of IPR protection varies across countries (and even by industry) according to technology gap and innovation efficiency. The results are in line with Schumpeterian growth model of Chu, et al. (2014) in showing that the optimal degree of IPR protection depends on the stage of development. This implication provides another reason as to why the harmonization of global IPR protection may not be beneficiary to developing countries given that the industrial technological capability differs significantly across some countries. Also, the dilemma of the double trade-off presented is especially relevant for some large emerging economies with massive industries like China, Russia and India, where some industries have achieved a remarkable catching-up while others still overly depend on technological adoption. Therefore, our analysis suggests special attention should be given to the heterogeneity across countries and industries in the practice of IPR protection. In the long-run, aiding lagging countries directly to increase their innovative capabilities and close the technology gap is perhaps the best initial step in promote the harmonization of global IPR protection.

Appendix 1

Take example of welfare analysis under FDI. Let the price and overall output in equilibrium under FDI are p^F and Q^F respectively.

$$W_h^{\ F} = 2\pi_h^F + CS_h^{\ F} = 2\pi_h^F + \frac{p^F Q^F}{2} = \frac{2\left(a+1-2C_h^{\ F}\right)^2}{16} + \frac{\left(3a-2C_h^F-1\right)^2}{32}$$

$$\frac{\partial W_h^{\ F}}{\partial u} = 2\frac{\partial \pi_h^F}{\partial u} + \frac{\partial CS_h^{\ F}}{\partial u} = -\frac{1}{2}\left(a+1-2C_h^{\ F}\right)\frac{\partial C_h^{\ F}}{\partial u} - \frac{1}{8}\left(3a-2C_h^{\ F}-1\right)\frac{\partial C_h^{\ F}}{\partial u}$$

And $\frac{\partial^2 W_h^{\ F}}{\partial^2 u} = -\frac{1}{2}\left(a+1-2C_h^{\ F}\right) - \frac{1}{8}\left(3a-2C_h^{\ F}-1\right) < 0$

Where $a+1-2C_h^{\ F} = q^F{}_h > 0$ and $3a-2C_h^{\ F}-1 = Q^F > 0$

So $sign(\frac{\partial W_h^{\ F}}{\partial u}) = sign(\frac{\partial \pi_h^F}{\partial u}) = sign(\frac{\partial CS_h^{\ F}}{\partial u}) = -sign(\frac{\partial C_h^{\ F}}{\partial u})$

When $\mu < \mu^{F*} = 1 - \frac{\Gamma - 1}{2\beta\sigma\delta}$, $\frac{\partial C_h^{\ F}}{\partial u} < 0$ and $\frac{\partial \pi_h^F}{\partial u} > 0, \frac{\partial CS_h^{\ F}}{\partial u} > 0, \frac{\partial W_h^{\ F}}{\partial u} > 0$,

while $\mu > \mu^{F*}$, $\frac{\partial C_h^{\ F}}{\partial u} > 0$ and $\frac{\partial \pi_h^F}{\partial u} < 0, \frac{\partial CS_h^{\ F}}{\partial u} < 0, \frac{\partial W_h^{\ F}}{\partial u} < 0$

Welfare analysis under export can be obtained in a similar way.

Appendix 2

The overall output in equilibrium under FDI $Q^F = 3a - 2C_h^{\ F} - 1$, and the price in equilibrium under FDI $p^F = -2a + 2C_h^{\ F} + 1$. So $-sign(\frac{\partial Q^F}{\partial u}) = sign(\frac{\partial p^F}{\partial u}) = sign(\frac{\partial C_h^{\ F}}{\partial u})$.

When $\mu < \mu^{F*}$, $\frac{\partial C_h^{\ F}}{\partial u} < 0$ and $\frac{\partial Q^F}{\partial u} > 0, \frac{\partial p^F}{\partial u} < 0$, while $\mu > \mu^{F*}$, $\frac{\partial C_h^{\ F}}{\partial u} > 0$ and

$\frac{\partial Q^F}{\partial u} < 0, \frac{\partial p^F}{\partial u} > 0$.

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