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# Can a Lagging Country Benefit from Strengthening Intellectual Property Rights Protection to Gain Technology Spillovers from FDI?

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# Can a Lagging Country Benefit from Strengthening Intellectual Property Rights Protection to Gain Technology Spillovers from FDI?[·]

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**Abstract**

To analyse the policy effects of strengthening IPRs in a lagging country to attract FDI and expect technology spillovers, this paper introduces the double trade-offs, between 1) attracting FDI and deterring international technology diffusion and 2) encouraging domestic innovation and suppression of domestic technology spillovers. It is shown that lagging country can attract FDI by strengthening IPRs protection, but not necessarily benefit. This is because (a) the relationship between IPRs protection and host welfare is inverted-U-shaped, resulting that stringent IPRs protection above the optimal level induces welfare transfer from home to abroad; and (b) any gains from tightening IPRs protection to attract FDI in additional industries may be offset by losses in industries with existing FDI due to different industrial technological capability. Even ignoring the industrial differences, the combining policies of the optimal IPRs protection and financial incentives can be more beneficial means than solely IPRs protection to attract FDI under weak technological capability. Only the optimal industry-specific IPRs protection can maximize the overall welfare.

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*Keywords: IPRs Protection; technological capability; Domestic Innovation; Imitation; FDI*

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## 1. Introduction

Over the past decades, there has been a global trend toward stronger intellectual property rights (IPRs) protection in developing countries. A plausible reason for developing countries to strengthen IPRs protection is that adopting stronger IPRs protection can attract foreign direct investments (FDI) providing more technology spillovers (Glass, 2005). 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 more FDI (Gould and Gruben, 1996; Lai, 1998; Maskus, 1998; Gustafsson and Segerstrom, 2011; Branstetter and Saggi, 2011). It is true that strengthening intellectual property rights protection can attract FDI consisting of superior technology (Lee and Mansfield, 1996; Smith, 2001; Javorcik, 2004) and also encourage higher quality FDI (Nunnenkamp and Spatz, 2004). However, it has been shown that technology spillovers from FDI actually deter more FDI (Siotis, 1999; Javorcik, 2004; Petit and Sanna-Randaccio, 2000). IPRs protection is an important determinant of technology spillovers, and therefore presents a policy dilemma for strengthening intellectual property rights protection to gain technology spillovers from FDI. On the one hand, a lagging country should strengthen IPRs protection to attract FDI consisting of superior technology. On the other hand, stronger IPRs protection reduces the legal ability of firms in the host country to benefit from the technology spillovers. Aware of this impasse, Glass (2005) first examined this argument in his seminar work, and concluded that attracting FDI by strengthening IPRs protection is a second best option. In Glass's model, the trade-off between attracting FDI and deterring technology spillovers is the only consideration of IPRs protection, neglecting the impact of IPRs protection on domestic innovation and domestic technology diffusion. Also, following the North-South setups restricted to northern imitating northern inventions, Iwaisako et al., (2011) examined how strengthening patent protection in the South affects welfare in the South. They found that strengthening patent protection increases the South welfare by enhancing innovation and FDI, but also allows the firms with patents to charge higher prices for their goods, which decreases welfare. But the former positive welfare effect overcomes the latter negative one. International technology diffusion (i.e. technology spillover from FDI or trade), domestic technology innovation, and domestic technology diffusion are the most prominent channels to achieve a higher technology level. As these channels are interrelated, however, IPRs protection exerts effects on all three, and their promotion can require conflicting IPRs policies.

Under North–South setups, the dominant theoretical literature on IPRs typically divides the world into industrialized innovating countries (the North) and imitating developing countries (the South). The predominant point of view, derived from the framework of a North-South technology transfer, is that strengthening the protection of IPRs in the South would undermine overall welfare and inhibit technological progress in developing countries. It is argued that lowering IPRs protection in the South can increase the overall rates of innovation and IPRs strengthening causes welfare loss of the South (Helpman, 1993; Glass and Saggi, 2002). McCalman (2001) and Adams (2008), among others, have argued that the move toward stronger IPR in developing countries may work against national economic interests, transferring rents to multinational corporate patent holders headquartered in the world's most advanced countries, especially the United States. While, IPR advocates counter that strengthening IPR will induce more innovation in the global economy, thereby fostering more rapid economic growth. Furthermore, these advocates claim that even if the additional innovation is mostly concentrated in advanced countries, a strengthening of IPR will accelerate the transfer of technology through FDI, ensuring that all countries benefit (e.g.Mondal and Ranjan Gupta, 2009). Glass and Wu (2007) explored the impact of IPRs protection on FDI and technology diffusion. But the trade-off between promoting domestic innovation in a lagging country and the suppression of international technology diffusion was not taken into account. With the assumption that all innovative R&D is done in the North and all adaptive R&D is done in the South, Gustafsson and Segerstrom (2011) found that FDI is strictly promoted by better IPR protection as the risk of imitation decreases. Despite the fact domestic innovation in developing countries is crucial for assessing IPRs policy, predominant previous theoretical studies on intellectual property rights (IPR) protection in the North-South setups restricted to imitating northern inventions.

When southern innovation is taken into account in North-South setups, the effects of IPRs on R&D and welfare is non-monotonic. Chen and Puttitanun (2005) developed a model to illustrate the trade-off between imitating foreign technologies and 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 Primo Braga et al., (2000).Lorenczik and Newiak (2012) found the effects of IPRs on R&D and welfare to be non- monotonic and dependent on innovation efficiency and an innovation threshold in the South. Lorenczik (2012) found that stronger Intellectual Property Rights protection in developing countries leads to a transfer of R&D to emerging countries, but the extension of FDI potentially crowds out domestic innovations. Although the South can loose IPR protection, it will do so at a low and inefficient level of domestic R&D at the high welfare costs in terms of long-run utility. Glass (2010) also analyzed imitation and innovation in the South, but focuses on how imitation encourages R&D by providing the South with a sufficient knowledge base.

In closed economies setup, the studies on IPRs protection come to different conclusions mainly depend on whether domestic technological diffusion is allowed or not. The closed economy models without domestic technological diffusion conclude that strengthening IPR always enhances economic growth (Kwan and Lai, 2003, Iwaisako and Futagami (2003). However, allowing for technological sophistication that is driven by the cumulative experience in producing a final good, enhanced protection can have a negative effect on growth by increasing the share of monopolized sectors (Furukawa, 2007). Furukawa (2010) showed the inverted-U relationship between intellectual property rights protection and innovation emerges from an interaction between learning-driven and R&D-driven technological advances. Gangopadhyaya and Mondal (2012) incorporated the idea that the protection of intellectual property rights may hinder the free flow of scientific knowledge from innovations in a standard endogenous growth model and found that stronger protection of intellectual property rights may discourage innovation.

Aware of the effects of IPRs protection on international technology diffusion, domestic technology innovation, and domestic technology diffusion, this paper, following Glass's seminar work (2005), addresses whether a developing country seeking to attract FDI can in fact benefit from adopting stronger IPRs protection. A model is developed to study the effect of strengthening IPRs protection on FDI, technology spillovers from FDI, domestic innovation, and domestic technology diffusion. The crux of the model, which contrasts with that of Glass (2005), is the double trade-offs of IPRs protection. First, there is the trade-off between attracting FDI and deterring technology spillovers from FDI. Second, there is the trade-off between encouraging domestic innovation and deterring domestic technology diffusion. That is, stronger IPRs protection discourages further innovations building on other ideas. We find that IPRs protection can be used to attract FDI because stronger IPRs protection reduces the degree of technology spillovers that can be legally used by host firms. Further findings, however, cast doubt on whether IPRs protection should be used as a means of attracting FDI. The optimal level of IPRs protection to attract FDI depends on industrial technological capability in terms of domestic innovation efficiency and technology gap. While stringent IPRs protection above the optimal level can attract more FDI, it unfavorably induces welfare transfer from home to abroad. Because that FDI first occurs in industries with the least beneficial to host country, tighter IPRs protection can make more industries switch to FDI and benefit, but host firms in other industries are harmed by tighter IPRs protection. Only IPRs protection, which was optimized according to individual industry, can maximize overall welfare in lagging country. So the policy of IPRs can hardly serve well the purpose of welfare-maximizing due to the industrial heterogeneity in technological capability. Even ignoring the industrial heterogeneities, the combining policies of the optimal IPRs protection and financial incentives are a more efficient means of attracting FDI than solely IPRs when the technological capability is weak.

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 IPRs protection to attract FDI in the context of one industry. Section 5 verifies the effects of IPRs under multiple industries. Section 6 offers other policy option to attract FDI. Concluding remarks are contained in Section 7.

## 2. Basic Model

The world economy consists of two regions North and South of which the North is technologically advanced in its technological level. The firm of North engages only in innovation and is subject to imitation by firms in South. The firm in South imitates the North, engages in innovation and is also subject to imitated by other firms in South. The game takes place in two stages. In the first stage, the technologically lagging country's government sets the IPRs protection level, and the source firm with superior technology decides its mode of supply and whether to export or to move production to the lagging country. In the second stage, the source firm and host firms choose the optimal production and price to maximize profits.

A source (s) firm in the North and two host (h) firms in the South produce a homogeneous good and engage in Cournot oligopolistic competition. The scenarios of multiple host firms and multiple industries will be considered later. The two host firms have the same technology and average costs. Therefore, they are in a state of equilibrium because they are identical in production and price. Let the output of firm i be given by $q_i$, where $i \in \{1, 2, s\}$ represents two host firms and a source firm, and let total output be $Q = q_h + q_S = q_1 + q_2 + q_S$。The demand function is linear for computational ease： $p(Q) = a - Q$ 。Each firm $i$ chooses 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: $\partial \pi_i / \partial q_i = 0$. The outputs of the source and host firms are：

$$q_S = (a + 2C_h - 3C_S)/4, q_1 = q_2 = (a + C_S - 2C_h)/4 \quad (1)$$

This yields profits of:

$$\pi_S = (a + 2C_h - 3C_S)^2/16, \quad \pi_1 = \pi_2 = (a + C_S - 2C_h)^2/16 \quad (2)$$

Suppose the average cost depends on the level of technology, and the source firm holds technological advantage over two host firms. Let $A_S$ represent the technological level of the source firm. To produce one unit of output, the source firm needs one unit of labor. Thus, taking into account domestic technological level $A_i$ (i=1, 2), the host firms need $\Gamma$ ($\Gamma = A_S / A_i$) unit of labor to produce one unit of output. $\Gamma$ represents the technological gap between host firms and the source firm. The wage in the host country is normalized to one. The source firm has costs equal to one if it produces in the host country. If the source firm produces elsewhere, its marginal cost is $\lambda > 1$, 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 spillover opportunities to rivals.

In an open economy, host firms can achieve technological progress to reduce average costs in three ways: international technology diffusion, domestic technology innovation, and domestic technology diffusion. IPRs protection exerts effects on all three. According to classic endogenous growth literature (Romer, 1990; Helpman, 1993), the aggregate knowledge stock evolves according to $\dot{A} = \delta AL$, where $L$ represents human capital devoted into research, and $A$ is the stock of knowledge. The knowledge capital consists of the old technology, which has been imitated by other R&D enterprises and new technology that is not imitated. There is the implicit assumption that these two types of technology have the same function in technological progress. In fact, during the process of technological progress, the new technology always plays a more important role than the old technology, which is the essence of Schumpeter's theory on destructive creation. Mondal and Gupta (2006) redefined the knowledge capital by solely including the new technology. Following the Mondal and Gupta (2006) assumption about the knowledge capital, our model supposes that only new technology can make contributions to the development of new technologies, and the old imitated technology has no effect on R&D of new technologies.

Let the degree of IPRs protection be $\mu$, $0 \le \mu \le 1$. When $\mu = 0$, all new technologies can be leaked due to a lack of sufficient IPR protection. When $\mu = 1$, new technologies cannot be leaked due to very stringent IPR protection. Thus, $1 - \mu$ represents the fraction of new technology, which has the potential to leak based on the host country's IPRs protection. Let the degree of practical technology spillovers be $\sigma$, and only the fraction $\beta$ is absorbed by host firms. Absorption capability $\beta$ 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. $\beta\sigma(1 - \mu)$ is the fraction of new technology that may be imitated. Stronger IPRs protection decreases the imitated fraction for imitator to "imitate around the patent". According to the definition of the knowledge capital given above, the knowledge capital of host firms can be derived by $A_i - \beta\sigma(1-\mu)A_i$. Let the average innovation input per unit of product be $L_1$ .With the average research input per unit of product ($L$), domestic innovation of host firms revolves as follows:

$$\dot{A}_i^{in} = \delta\left[A_i - \beta\sigma(1-\mu)A_i\right], \forall i = 1,2 \tag{3}$$

$$A_1 = A_2, \beta < 1, 0 \le \mu \le 1$$

Where $\delta$ denotes the efficiency of domestic innovation, One host firm only imitates new technology of the other domestic firm because the old technology imitated has no effect on R&D of new technologies. With the average imitation input per unit of product ($L_2$), technology available to one domestic firm through the imitation of another domestic firm is:

$$\dot{A}_i^{imh} = \beta\sigma(1-\mu)\,\dot{A}_i^{in} = \delta\beta\sigma(1-\mu)\left[A_i - \beta\sigma(1-\mu)A_i\right], \forall i = 1,2 \tag{4}$$

Eqs. (4) captures the feature that ideas build on other ideas, as pointed out in Boldrin and Levine (2004).The third channel for domestic firms to achieve technological progress is to imitate the new technology from the source firm. The fraction of technology that domestic firms can imitate from the source firm is $A_S - A_i$. Thus, with the average imitation input per unit of product ($L_3$), technology available to each domestic firm through the imitation of the source firm is:

$$\dot{A}_i^{ims} = \beta\sigma(1-\mu)(A_S - A_i), \forall i = 1,2 \tag{5}$$

Technology spillovers are assumed to be larger under FDI than under export: $\sigma_F > \sigma_X$. Let $\sigma = \sigma_F = \psi\sigma_X$, where $\psi > 1$. The total new technology of each host firm is：

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

Suppose new technology resulting from domestic innovation and imitation is indifferent in production. That is, one unit of labor is required to produce one unit of output either by innovative technology or by imitated technology. The proportion of the new and old technologies are $(\dot{A}_i^{in} + \dot{A}_i^{imh} + \dot{A}_i^{ims})/A_i$ and $1-(A' + A'' + A''')/A_i$ respectively. The average cost to each host firm is：

$$C_h = (\dot{A}_i^{in} + \dot{A}_i^{imh} + \dot{A}_i^{ims})/A_i \times 1 + \left[1-(\dot{A}_i^{in} + \dot{A}_i^{imh} + \dot{A}_i^{ims})/A_i\right] \times \Gamma + L_1 + L_2 + L_3 \tag{7}$$

Substituting Eqs.（3）、（4）、（5）into Eq.（7）, the average costs of each host firm under FDI (F) and export(X) are obtained.

$$C_h^F = \left[\delta(1-K^2) + K(\Gamma-1)\right](1-\Gamma) + \Gamma + L_1 + L_2 + L_3 \tag{8}$$

$$C_h^{\ X} = \left[\delta(1-K^2) + K(\Gamma-1)/\psi\right](1-\Gamma) + \Gamma + L_1 + L_2 + L_3 \tag{9}$$

Where $K = \beta\sigma(1-\mu)$. Combining Eqs.（2）and（9）, the profits under export ($X$) are obtained：

$$\pi_S^{\ X} = (a + 2C_h^{\ X} - 3\lambda)^2/16, \pi_1^{\ X} = \pi_2^{\ X} = (a + \lambda - 2C_h^{\ X})^2/16 \tag{10}$$

Combining Eqs.（2） and（8）, the profits under FDI ($F$) are obtained：

$$\pi_S^{\ F} = (a + 2C_h^{\ F} - 3)^2/16, \pi_1^{\ F} = \pi_2^{\ F} = (a + 1 - 2C_h^{\ F})^2/16 \tag{11}$$

**3. Adverse selection of FDI and IPRs protection**

The source firm makes a choice between FDI and export together with a host country's choice of IPRs protection. A source firm may ship his production to a host country, knowing that some of its superior technology will leak to host rivals. Alternatively, the source firm may instead choose to keep production in the source country, which is a more expensive location with higher marginal cost（$\lambda>1$）. The physical distance in this arrangement will reduce its technology spillovers to rivals.

When $\pi_S^F(1, C_h^{\ F}) = \pi_S^X(\lambda, C_h^{\ X})$, the profits of the source firm under FDI and export are indifferent. The minimum level of IPRs protection required for the source firm to choose FDI can be determined by the following equation.

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

Substituting Eqs.（8）、（9）into Eq.（12）, the threshold of IPRs protection required for the source firm to choose FDI is:

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

This expression, which indicates the required threshold of IPRs protection for the source firm to choose FDI, reveals how the threshold is affected by the various parameters of the model.

$$\frac{\partial\mu_S}{\partial\Gamma} > 0, \quad \frac{\partial\mu_S}{\partial\sigma} > 0, \quad \frac{\partial\mu_S}{\partial\beta} > 0$$

The large technology gap ($\Gamma$) means the more technology spillovers the host firms can gain from the source firm. Accordingly, IPRs protection will need to be tighter to keep imitation at a minimum such that the source firm will be willing to engage in FDI. The source firm prefers to initiate FDI in industries with smaller technology gaps such that technology spillovers can be reduced. The degree of Technology spillovers ($\sigma$) are larger under FDI than export. The larger the spillovers under FDI relative to exports, the more the cost falls for the host firm under FDI relative to exports. For that reason, IPRs protection needs to be tighter to keep the source firm participating in FDI. An increase in absorption capacity ( $\beta$ ) lowers the cost for the host firm under FDI relative to exports. Thus, IPRs protection needs to be tighter to keep the source firm willing to engage in FDI.

Allowing for n identical host firms, the source imitation 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 performed to source profits by technology spillovers. $\partial\mu_s/\partial n > 0$, The larger the number of host rivals, the tighter IPRs protection needs to be to keep the source firm willing to engage in FDI. Given IPRs protection, the source firm prefers to initiate FDI in less competitive industries to reduce technology spillovers.

By the above analysis, we come to the same conclusion as Glass (2005) that FDI occurs first in industries that confer the smallest gains to the host country. The policy of strengthening intellectual property rights to attract FDI and benefit from technology spillovers is ineffective due to the adverse selection of FDI.

Indeed, IPRs protection can succeed in attracting FDI. As IPRs protection is strengthened, FDI will occur in industries with more technology spillover. In addition, consumer surplus $CS^j = (a - P^j)Q^j / 2$ is higher under FDI than export. Three 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 attract FDI.

$$CS^F = \frac{(3a - 2C_h^F - 1)^2}{32} > CS^X = \frac{(3a - 2C_h^X - \lambda)^2}{32}$$

The optimal IPRs protection should base on the maximizing of overall welfare in the lagging country. Define welfare in the lagging country as the sum of profit and consumer's surplus. To maximize the welfare under FDI, the optimal IPRs protection under FDI can be obtained.

$$\max_{\mu} W^J = 2\pi_h^J + CS^J, J \in (X, F)$$

According to $\partial W^F / \partial\mu = 0$ and $\partial^2 W^F / \partial^2\mu < 0$, the optimal IPRs protection of the lagging country under FDI can be obtained.

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

When $\mu < \mu^{F*}$, $\partial W^F / \partial\mu > 0$; and When $\mu > \mu^{F*}$, $\partial W^F / \partial\mu < 0$.That means the relationship between IPRs protection and home welfare is inverted-U-shaped under FDI. Similarly, the optimal IPRs protection of the lagging country under export can be obtained.

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

$\mu^{X*} > \mu^{F*}$ means that the optimal IPRs protection of the lagging country under export is stronger than that under FDI. The economic implication is obvious. When international technology spillover is minor, the technology progress in the lagging country mainly depends on the domestic innovation, which requires stronger IPRs protection.

An inverted-U-shaped relationship between IPRs protection and home welfare comes from the double-edge effects of strengthening IPRs protection on the technological progress, thereby on the cost and profits of host firms. Strengthening IPRs protection can encourage domestic innovation, but deter international and domestic technology diffusion. The host welfare does not monotonically change with strengthening IPRs protection. That means the host welfare under export do not necessarily smaller than that under FDI. When IPRs protection is strong enough, the host welfare under FDI will be smaller than that under export, but not necessarily benefits.

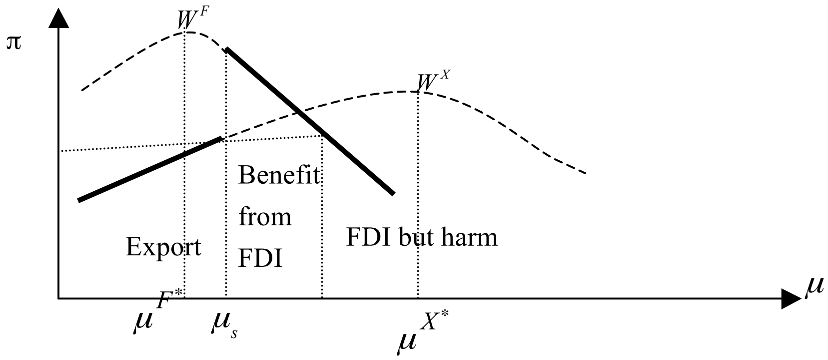


**Fig. 1 Relation between *W* and $\mu$ under FDI versus export**

**Proposition 1.** *The relationship between IPRs protection and home welfare in the lagging country is inverted-U-shaped. FDI arises first in industries that confer the smallest benefits to the host country. Stronger IPRs protection can attract FDI into industries with better gains for the lagging country, but could worsen the welfare of the lagging country by deterring international and domestic technology diffusion.*

## 4. Technological capability and the optimal IPRs Protection

This section investigates the main factors determining the optimal level of IPRs protection to attract FDI in the context of one industry. Eqs. (15) illustrates the optimal level of IPRs protection of the lagging country depend on the technological capability in terms of domestic innovation efficiency $\delta$ and technology gap $\Gamma$, $\partial\mu^{F*}/\partial\delta > 0$, $\partial\mu^{F*}/\partial\Gamma < 0$. The stronger technological capability is, i.e. smaller technology gap and stronger innovation efficiency, the higher level of optimal IPRs protection is required to maximize the welfare in the lagging country. The problem arises here is whether the optimal IPRs protection is able to attract FDI.

According to $\partial \pi_S{}^F / \partial \mu = 0$ and $\partial^2 \pi_S{}^F / \partial^2 \mu > 0$, the level of IPRs protection can be determined when the source firm has the minimum profits under FDI.

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

Under FDI, when $\mu < \mu_h^{F*}$, strengthening the IPRs protection will increase the profits of host firms ($\partial \pi_h{}^F / \partial \mu > 0$) and decrease the source firms' profits ($\partial \pi_s{}^F / \partial \mu < 0$) because, in the context of weak IPRs protection ($\mu < \mu_h^{F*}$), the potentiality of domestic innovation is not fully realized. In addition, the positive effect that strengthening IPRs protection has on domestic innovation is much larger than the negative effect IPRs protection has on technology imitation. Thus, strengthening IPRs protection will reduce the costs and increase the profits of host firms. Therefore, host firms will capture the profits of the source firm in market competition. When $\mu > \mu_h^{F*}$, strengthening the IPRs protection will decrease the profits of host firms and increase the source firms' profits because, under the context of stronger IPRs protection ($\mu > \mu_h^{F*}$), the potentiality of domestic innovation has been almost completely realized, and the positive effect that strengthening IPRs protection has on domestic innovation is less than the negative effect that IPRs protection has on technology imitation. Thus, strengthening IPRs protection will increase the costs and reduce the profits of host firms. Therefore, the source firm will capture the profits of host firms in market competition.

When the source firm opts to export, the optimal IPRs protection for the lagging countries is the level where the profit of the source firm is minimal.

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

According to $\pi_h^F = \pi_h^X$, the IPRs protection, under which the profits of the host firms are undifferentiated between FDI and export, can be obtained.

$$\mu_h = 1 - (\lambda - 1)/2\beta\sigma(1 - 1/\psi)(\Gamma - 1) \tag{19}$$

According to $\mu^{X*} > \mu^{F*}$, the curves of $\pi_h{}^F$ and $\pi_s{}^F$ are all on the left of $\pi_h{}^X$ and $\pi_s{}^X$. Technology gap and domestic innovation efficiency are sensitive factors, which could determine the optimal IPRs protection. When industrial technological capability is inefficient enough, that is when $\Gamma > \sqrt[3]{3(\lambda - 1)\delta/(1 - 1/\psi)} + 1$ or (and) $\delta < (\Gamma - 1)^3 (1 - 1/\psi)/3(\lambda - 1)$, $\mu_s > \mu^{F*}$.When $\mu_s > \mu^{F*}$, the optimal IPRs protection is not able to attract FDI. Figure 2 shows the relationship between $\pi_h{}^X$ 、$\pi_s{}^X$ 、$\pi_h{}^F$ 、 $\pi_s{}^F$[1]:

[1] The source firm holds the technological advantage over host firms, and thus, $\pi_h{}^F < \pi_s{}^F$ under any level of IPRs protection. Moreover, the maximum and minimum values of $\pi_h{}^X, \pi_s{}^X$ $\pi_h{}^F, \pi_s{}^F$ do not affect the analysis below.

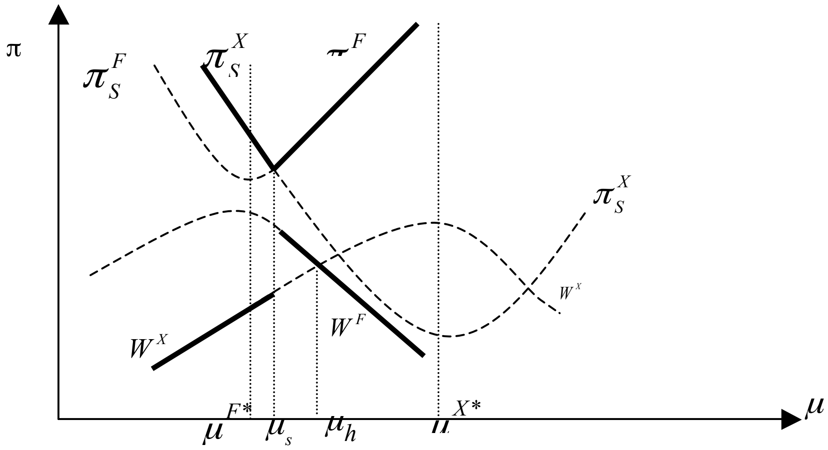


**Fig. 2 The optimal IPRs Protection when** $\mu_s > \mu^{F*}$

Figure 1 illustrates that when $\mu < \mu_S$, IPRs protection in the lagging country is sufficiently weak. Then, $\pi_s^X > \pi_s^F$, indicating that the source firm chooses export rather than FDI because export with a smaller technology spillover can protect its technology in the context of weak IPRs protection. Under export conditions, strengthening IPRs protection will decrease the profit of the source firm ($\partial \pi_s^X / \partial \mu < 0$) and increase the profits of the host firms ($\partial \pi_h^X / \partial \mu > 0$) because reinforcing IPRs protection encourages domestic innovation. Moreover, the negative effects of strengthening IPRs protection on imitation (domestic and foreign technology imitation) are outweighed by the positive effects of strengthening IPRs protection on domestic innovation when technology spillovers from export in minor. Furthermore, the consumer's surplus $CS = (3a - 2C_h^X - \lambda)^2 / 32$ under export will increases with strengthening IPRs protection, that is $\partial CS / \partial \mu > 0$. Therefore, when $\mu < \mu_S$, the source firm prefers to export, strengthening IPRs protection source decreases the profit of the source firm and increases the consumer's surplus and firms' profits in the lagging country. In other words, international income is transferred from source firms to host firms and domestic consumers.

When $\mu > \mu_S$, $\pi_s^F > \pi_s^X$ indicates that the source firm opts for FDI. In the context of FDI, $\partial \pi_s^F / \partial \mu > 0$, $\partial \pi_h^F / \partial \mu < 0$ and $\partial CS / \partial \mu < 0$. Strengthening IPRs protection source decreases the profit of the host firms and consumer's surplus and increases the profit of the source firm, i.e., international income transfers from host firms and domestic consumers to the source firm. This conclusion is consistent with McCalman's (2002) empirical results. McCalman argued that developing countries have been pressured to harmonize their IPRs protection to that of developed countries, resulting in a large volume of income transfers from developing countries to the United States.

**Proposition 2.** *The optimal IPRs protection to attract FDI depends on domestic technological capability in terms of innovation efficiency and technology gap. When*

$\Gamma > \sqrt[3]{3(\lambda-1)\delta/(1-1/\psi)}+1$ *or (and)* $\delta < (\Gamma-1)^3(1-1/\psi)/3(\lambda-1)$, *the optimal IPRs protection for lagging country should be only sufficient to attract FDI (* $\mu_S$ *).*

When industrial technological capability is high enough, that is when $\Gamma < \sqrt[3]{3(\lambda-1)\delta/(1-1/\psi)}+1$ or (and) $\delta > (\Gamma-1)^3(1-1/\psi)/3(\lambda-1)$, $\mu_S < \mu_S^{F*}$, the optimal IPRs protection is not able to attract FDI. Figure 3 shows the relationship between $\pi_h^X$、$\pi_s^X$、$\pi_h^F$、$\pi_s^F$:

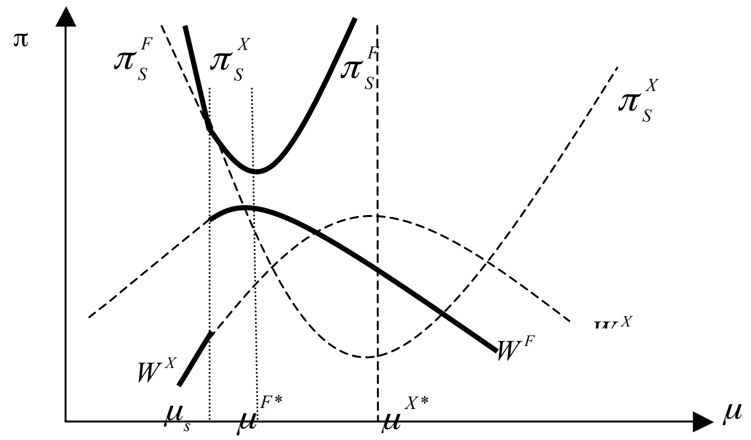


**Fig. 3 The optimal IPRs Protection when** $\mu_s < \mu^{F*}$

Figure 2 illustrates, when $\mu < \mu_S$, then $\pi_s^X > \pi_s^F$, indicating that the source firm chooses export rather than FDI. In the context of $\mu < \mu_S, \partial\pi_h^X/\partial\mu > 0, \partial\pi_s^X/\partial\mu < 0$, $\partial CS/\partial\mu > 0$, indicating the welfare in the lagging country increase in its IPRs protection . When $\mu_S < \mu < \mu^{F*}$, $\pi_s^X < \pi_s^F$ indicates that the source firm opts for FDI, $\partial\pi_h^F/\partial\mu > 0, \partial\pi_s^F/\partial\mu < 0$, $\partial CS/\partial\mu > 0$. Strengthening IPRs protection results in the income transfer from source firms to host firms and domestic consumers. When $\mu > \mu^{F*}$, then $\pi_s^F > \pi_s^X$, $\partial\pi_s^F/\partial\mu > 0$, $\partial\pi_h^F/\partial\mu < 0$ and $\partial CS/\partial\mu < 0$, indicating that that welfare is transferred from host firms and domestic consumers to the source firm. All comes to the conclusion that when industrial technological capability is high enough, the profits and consumer surplus in the lagging country could be at their maximum when $\mu = \mu^{F*}$. This is contrast with Glass (2005), in with Glass's oligopoly game model, the profits of host firms monotonically decrease with strengthening property rights protection. So the main point is that the host country should strengthen IPRs protection only to the degree necessary for attracting FDI. This is actually only apply to the situation in our model when innovation efficiency is so low and technology gap is so large that $\mu_s > \mu^{F*}$.

**Proposition 3.** *When industrial technological capability is strong enough, i.e.* $\Gamma < \sqrt[3]{3(\lambda-1)\delta/(1-1/\psi)}+1$ *or (and)* $\delta > (\Gamma-1)^3(1-1/\psi)/3(\lambda-1)$, *the optimal IPRs protection of the lagging country should be* $\mu^{F*}$. *Below the optimal IPRs protection of* $\mu^{F*}$, *strengthening IPRs protection will result in foreign welfare transfer to the lagging country. Above the optimal IPRs protection of* $\mu^{F*}$, *strengthening IPRs protection results in welfare transfer from the lagging countries to abroad.*

## 5. **The policy effects of IPRs with multiple industries**

The lagging country seems be able to choose the level of optimal IPRs protection to attract FDI according to industrial technological capability. However, the further analysis in the context of multiple industries casts doubt on that.

The lagging country has multiple heterogeneous industries, and the level of optimal IPRs protection varies by industries. Technology gap and innovative efficiency are different in each industry, and thus, the optimal IPRs protection in each industry is different. The industries with smaller technology gaps and stronger innovative efficiency require stronger IPRs protection. But the uniform IPRs protection is usually implemented equally across all industries. Initial strengthening of IPRs protection will attract FDI in industries with minimal gains for the host country. Strengthening IPRs protection to attract FDI in certain industries comes at the expense of over-tightening IPRs protection in industries with existing FDI. At some point, further strengthening of IPRs protection is harmful. For example, there are *n* domestic industries with increased $\mu^{F*}$ values over industries. Let the total profits of firms in each industry be $\pi_i$. The initial IPRs protection is the optimal value for the first industry to attract FDI ($\mu_1^{F*}$). When the IPRs protection is strengthened to $\mu_2^{F*}$, the profits of the second industry reach a maximum, while the profits in the first industry are reduced. Similarly, Strengthening IPRs protection to $\mu_3^{F*}$ will raise host profits in the third industry and reduce profits in the first two industries, and so forth, causing overall host profits in the host country to decrease. When IPRs protection is strengthened from $\mu_{n-1}^{F*}$ to $\mu_n^{F*}$, the profit in the n[th] industry is optimal but fall short in the n-1 industries, causing a decrease in total host profits. A large amount of welfare is transferred from host firms and consumers to source firms in the other n-1 industries. Thus, by strengthening the IPRs protection, the following condition will be satisfied.

$$\sum_{i=1}^{n-1}\left[\pi_i^F(\mu_{n-1}^{F*})-\pi_i^F(\mu_n^{F*})\right] > \pi_n^F(\mu_n^{F*})-\pi_n^X(\mu_{n-1}^{F*}) \tag{20}$$

Equation (20) illustrates that by strengthening the IPRs protection in the lagging country, the decreased profit is more than the increased profits. This outcome results from the adverse selection of FDI and the different optimal level of IPRs protection for individual industries. 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. IPRs protection is a blunt instrument for attracting FDI. IPRs protection is applied equally across all industries, but the optimal level of IPRs protection needed to attract FDI varies by industries.

If policymakers are constrained to implement uniform IPR protection, then they should set the uniform IPR protection to a weighted average of sector-specific optimal IPR protection (Chu, 2011). But even a moderate degree of asymmetry across sectors can generate a significant welfare cost of uniform IPRs protection, which can be obviously showed by figure.2 and Figure.3. Take two industries for example, $\mu_1^{F*}$ and $\mu_2^{F*}$ are the optimal levels IPRs protection for industry 1 and industry 2 respectively. Let $\mu_2^{F*} > \mu_1^{F*}$, and the weighted average of sector-specific optimal IPR protection be $\mu_a^{F*}$. $\mu_2^{F*} > \mu_a^{F*} > \mu_1^{F*}$ means the uniform IPRs protection( $\mu_a^{F*}$ ) does not maximize the welfare in both industries. Only the optimal level of IPRs protection for each industry individually will maximize the overall welfare in the host country.

**Proposition 4.** *The levels of optimal IPRs protection vary by industry. When IPRs protection is applied equally across all industries, further strengthening IPRs protection to attract FDI in additional industries comes at the expense of over-tightening IPRs protection in industries with existing FDI. Even the uniform IPRs protection to a weighted average of sector-specific optimal IPR protection generates a significant welfare cost. Instead, the industry-specific optimal IPRs protection for each industry individually will maximize the overall welfare in the host country.*

## 6. Policy Choices under inefficient technological capability

The traditional macro-analysis of IPRs on national level used to consider industrial technological capability as the one of the nation. In this case, the lagging country should choose the optimal level of IPRs protection according to technological capability of the state to attract FDI. That is, when state technological capability is weak, the optimal IPRs protection for the lagging country should be sufficient enough to attract FDI ( $\mu_S$ ). When state technological capability is strong, the optimal IPRs protection of the lagging country should be $\mu_1^{F*}$. However, further analyses cast doubt on this assumption. When state technological capability is low，the optimal IPRs protection for the lagging country should be sufficient enough to attract FDI ( $\mu_S$ ), although the profits of host firms [$\pi_h^F(\mu_S)$] are not at their peak.

One option is lowering IPRs protection $\mu^{F*}$, while the lagging country attracts FDI through subsidy. The amount of subsidy is $\pi_S^X(\mu^{F*}) - \pi_S^F(\mu^{F*})$. The source firm would still like to choose FDI, and a part of its profits would transfer into domestic consumer surplus. Domestic consumer surplus increases from

$$CS(\mu_S) = Q(\mu_S)^2/2 = (3A - 1 - 2c_h^{F(\mu_S)})/32 \tag{21}$$

to

$$CS(\mu^{F*}) = Q(\mu^{F*})^2/2 = (3A - 1 - 2c_h^{F(\mu^{F*})})/32 \tag{22}$$

A part of the source firms' profit transfers to host firms. The profits of host firms will increase if the following condition is satisfied.

$$4[\pi_h^F(\mu^{F*}) - \pi_h^F(\mu_S)] + Q(\mu^{F^*})^2 - Q(\mu_S)^2 > 2\pi_S^X(\mu^{F*}) - 2\pi_S^F(\mu^{F*}) \tag{23}$$

Therefore, the policy of using subsidies to attract FDI is more beneficial than strengthening IPR protection. We use a numerical simulation method to confirm the above conclusion. Suppose $A = 15, \psi = 2, \delta = 1, \lambda = 4/3$, then $\mu^{F*} = 1 - (\Gamma - 1)/2\beta\sigma$ and $\mu_S = 1 - 1/(\Gamma - 1)^2 \beta\sigma$. When $\Gamma > \sqrt[3]{(3\lambda - 1)\delta L/(1 - 1/\psi)} + 1 = \sqrt[3]{2} + 1$, $\mu_s > \mu_S{}^{F*}$. The government of the lagging country can decrease the level of IPRs protection from $\mu_S$ to $\mu^{F*}$, at the meantime; the government subsidizes the source firm to initiate FDI. The net profit transferred to the lagging country through the source firm is：

$$\pi_{net} = 2[\pi_h{}^F(\mu^{F*}) - \pi_h{}^F(\mu_S)] + \frac{Q(\mu^{F^*})^2}{2} - \frac{Q(\mu_S)^2}{2} - [\pi_S{}^X(\mu^{F*}) - \pi_S{}^F(\mu^{F*})] \tag{24}$$

Simplifying the equation (27) with figures:

$$\pi_{net} = \frac{7(\Gamma - 1)^6}{2} - \frac{10}{(\Gamma - 1)^6} + 28(\Gamma - 1)^3 + \frac{196}{(\Gamma - 1)^3} - 155 \tag{25}$$

According to equation (25), when the technology gap is at a minimum $\Gamma = \sqrt[3]{2} + 1$, the minimum of $\pi_{net}$ is 10.5. Thus, when there is a large technology gap ($\Gamma > \sqrt[3]{3(\lambda - 1)\delta/(1 - 1/\psi)} + 1$), choosing $\mu^{F*}$ as the optimal IPRs protection and providing subsidies for FDI encourage the source firm to initiate FDI and transfer its income to the lagging country.

Another alternative measure can be taken without choosing the optimal IPRs protection $\mu_S$ when technological capability is weak. Improving domestic innovation efficiency ($\delta$) to make $\mu^{F*} \geq \mu_s$ and then choosing $\mu^{F*}$ may be more effective than choosing $\mu_s$. Innovation efficiency can be improved by adding in additional job training and education to increase the right human capital, or government can make the general technology needed to innovation easy to access. Improving domestic innovation efficiency can make $\mu^{F*} \geq \mu_s$. Choosing the optimal IPRs protection $\mu^{F*}$, the firms' profits and consumer surplus in the lagging country can reach a maximum value. Therefore, even if neglecting difference of industries, in the context of inefficient industrial technology capability, increasing the optimal IPRs to attract FDI by subsidizing FDI and improving domestic innovation efficiency, and then choosing $\mu^{F*}$ is more beneficial than choosing $\mu_s$. Strengthening the IPRs protection to attract FDI and expect to benefit from technology spillovers is the second best option.

**Proposition 5.** *Even if neglecting the difference of industries, the combining policy , which is to subsidize FDI or improving domestic innovation efficiency to make* $\mu^{F*} \geq \mu_s$ *and choosing* $\mu^{F*}$*, can maximize the overall welfare in lagging countries in the context of weak technology capability.*

## 7. Concluding remarks

One argument generally used to support the strengthening of IPRs protection in lagging countries is that doing so will attract FDI and result in technology spillovers. Glass (2005) first examines this argument without allowing for domestic innovation and technology diffusion. In this paper, we re-examine the argument in a two-stage dynamic game model. I have focused on double trade-offs: the need to facilitate domestic technology diffusion and the need to provide incentives for domestic innovation, and the need to facilitate international technology diffusion and the need to attract FDI. I found that the optimal IPRs protection varies according to different industrial technological capability in terms of technology gap, and research efficiency of domestic innovation. Stringent IPRs protection above the optimal level induces welfare transfer from home to abroad; and any gains from tightening IPRs protection to attract FDI in better industries may be offset by losses in other industries when IPRs protection is applied equally across all industries. Only the optimal levels of IPRs protection according to the individual industrial technological capability can maximize overall welfare. The uniform IPRs protection to a weighted average of sector-specific optimal IPR protection also generates a significant welfare cost. Even ignoring the industrial difference as what the traditional macro-analysis of IPRs on national level usually does, the combining policies of the optimal IPRs protection and financial incentives are more beneficial means for lagging countries to attract FDI than solely IPRs protection in the context of weak technological capability. It is a blunt instrument to attracting FDI and expects more technology spillovers by strengthening IPRs protection. This conclusion is contrasted with some latest welfare analyses on IPRs like Iwaisako et al., (2011), who concluded that the strictest form of IPRs protection in the South maximizes welfare in the South as well as in the North.

Our analysis suggests IPRs is a delicate policy, and can hardly serve well the purpose of welfare-maximizing. The crucial dilemma for the practice of IPRs is that the optimal level of IPRs protection varies by industries, but IPRs protection is usually applied equally across all industries. This dilemma leaves lagging countries a tough decision to make, especially for some large emerging economies with massive industries like China, Russia and India, where some industries have achieved a remarkable catching-up, whereas others overly depended on technological adoption. Therefore, our analysis suggests a special attention should be given to the heterogeneity across industries in the practice of IPRs protection. Also, this implication provides another reason as to why the harmonization of global IPRs protection may not be beneficiary to developing countries given that the industrial technological capability differs significantly across some countries. In the long-run, helping developing countries increase their innovative capabilities and close technology gap perhaps is the best what developed countries should do to promote the harmonization of global IPRs protection.

## References


Adams, Samuel. Globalization and income inequality: implications for intellectual property rights, *Journal of Policy Modeling*, 2008, 30(5):725～735.

Awokuse, Titus O. and Yin, Hong. Intellectual property rights protection and the surge in FDI in China, *Journal of Comparative Economics*, 2010, 38(2): 217～224.

Branstetter, Lee & Fisman, Ray & Foley, C. Fritz & Saggi, Kamal. Does intellectual property rights reform spur industrial development? *Journal of International Economics*, 2011, 83(1): 27～36.

Branstetter, Lee and Saggi, Kamal. Intellectual property rights, foreign direct investment and industrial development, *the Economic Journal*, 2011, 121(555): 1161～1191.

Boldrin, M. and D. K. Levine. IER Lawrence Klein Lecture: The Case Against Intellectual Monopoly, *International Economic Review*, 2004,45: 327～350.

Chen, Y., Puttitanun, T. Intellectual property rights and innovation in developing countries. *Journal of Development Economics,* 2005,78 (2), 474～493.

Chu, Angus C. The welfare cost of one-Size-fits-all patent protection, *Journal of Economic Dynamics and Control*, 2011, 35: 876～890.

Furukawa, Y. Intellectual property protection and innovation: an inverted-U relationship. *Economics Letters*, 2010,109 (2):99～101.

Furukawa, Yuichi.The protection of intellectual property rights and endogenous growth: Is stronger always better? *Journal of Economic Dynamics and Control*, 2007,31(11): 3644～3670.

Gangopadhyay, Kausik and Mondal, Debasis. Does stronger protection of intellectual property stimulate innovation? *Economics Letters*, 2012, 116:80～82.

Glass Amy Jocelyn, Saggi Kamal. Intellectual property right and foreign direct investment. *Journal of International Economics* .2002, (56):387~410.

Glass Amy Jocelyn. Intellectual property policy and international technology diffusion. www. econweb.tamu.edu/aglass/ippitd,2005.

Glass Amy Jocelyn and Wu Xiaodong. Intellectual property rights and quality improvement. *Journal of Development Economics*,2007,82(2):393～415.

Gustafsson, P., Segerstrom, P. North-South trade with multinational firms and increasing product variety. *International Economic Review*, 2011, 52 (4), 1123～1155.

Gould, D.M., Gruben, W.C. The role of intellectual property rights in economic growth. *Journal of Development Economics*, 1996, 48(2): 323～350.

Helpman, E. Innovation, Imitation, and intellectual property rights. *Econometric*, 1993, 61(6):1247～1280.

Iwaisako, T., and Futagami, K. Patent policy in an endogenous growth model. *Journal of Economics,* 2003, 78(3):239～258.

Iwaisako, Tatsuro & Tanaka, Hitoshi & Futagami, Koichi. A welfare analysis of global patent protection in a model with endogenous innovation and foreign direct investment, *European Economic Review*, 2011, 55(8):1137～1151.

Javorcik, B.S. The composition of foreign direct investment and protection of intellectual property rights: Evidence from transition economies. *European Economic Review*, 2004, 48(1):39～62.

Kausik Gangopadhyay, Debasis Mondal. Does stronger protection of intellectual property stimulate innovation? *Economics Letters*, 2012, 116(1):80～82.

Kwan, Y.K., Lai, E.L.-C. Intellectual property rights protection and endogenous economic growth. *Journal of Economic Dynamics and Control*, 2003, 27(5): 853～873.

Lai, Edwin L.-C. International intellectual property protection and the rate of production innovation. *Journal of Development Economics* , 1998,(55):133～153.

Lorenczik, Christian and Newiak, Monique. Imitation and innovation driven development under imperfect intellectual property rights, *European Economic Review*, 56 (2012) 1361～1375.

Lorenczik ,Christian. Intellectual Property Rights as determinants of FDI, technology spillovers and R&D in developing economies, working paper, 2012.

Maskus, Keith E. The role of intellectual property rights in encouraging foreign direct investment and technology transfer. *Duke Journal of Comparative and International Law*, 1998, (32): 471～506.

McCalman, P. Reaping what you sow: an empirical analysis of international patent harmonization. *Journal of International Economics*, 2001, 55 (1): 161～186.

Mondal Debasis and Gupta Manash Ranjan. Innovation, imitation and intellectual property rights: a note on Helpman's Model. *Journal of Economic*, 2006, 87 (1): 29～53.

Mondal, Debasis & Ranjan Gupta, Manash. Endogenous imitation and endogenous growth in a North-South model: A theoretical analysis, *Journal of Macroeconomics*, 2009, 31(4): 668-684.

Naghavi, Alireza. Strategic intellectual property rights policy and North-South technology transfer. FEEM Working Paper No. 1805. 2005.

Park, Walter G. and Lippoldt, Douglas. The impact of trade-related intellectual property rights on trade and foreign direct investment in developing countries. OECD Papers: Special Issue on Trade Policy, 2003, Vol. 4, No. 11, Issue 294.

Petit, Maria-Luisa and Sanna-Randaccio, Francesca. Endogenous R&D and foreign direct investment in international oligopolies. *International Journal of Industrial Organization*, 2000, 18(2):339～367.

Smith, P.J. How do foreign patent rights affect U.S. exports, affiliate sales, and licenses? *Journal of International Economics*, 2001, 55 (2):411～439.