Strategic Intellectual Property Protection Policy and North-South Technology Transfer

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Abstract

I analyze the welfare implications of protecting intellectual property rights (IPRs) in developing countries through its impact on innovation, market structure, and technology transfer. FDI, tariffs, and cooperation are introduced to the strategic IPR literature. In a North-South framework, the Southern government sets the IPR policy strategically by anticipating the Northern firm's decision on R&D expenditure and multinationalization in the presence of tariffs. A stringent IPR policy is always chosen in the South in order to motivate technology transfer, which in turn improves welfare. If cooperation is allowed for, joint ventures are very likely to occur for less R&D-intensive industries.

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1. Introduction

Protection of intellectual property rights (IPRs) has been an issue of rising interest in both industrialized and developing nations. The controversies tend to cluster on the relatively new Trade Related Aspects of Intellectual Property Rights (TRIPS) agreement of the Uruguay round of GATT which has called for a standardization of IPR protection among all members of the World Trade Organization (WTO) and potential new entrants. It requires developing countries to raise their intellectual property protection level to the standard in force in industrialized nations at the time of negotiation[1]. The agreement was a consequence of complaints and lobbying undertaken by technology intensive firms in the North claiming to have lost billions of dollars through infringement of their property rights due to loose IPR protection regimes in the South. These firms urged the WTO to bring this issue into the ambit of GATT, arguing that weak IPR protection lowers trade volume, distorts trading patterns, and deters firms from transferring technology abroad. Developing countries have however continuously resisted adopting stronger IPR legislation and its enforcement with the fear that foreign interests would be the only beneficiaries of such policies at the expense of domestic consumers. For instance, South Africa has refused to abide by the TRIPS agreement with regard to drugs for HIV/AIDS, claiming that the prices are too high given the present living standards in the country. Is such behavior rational when it has a direct effect on the behavior of multinational pharmaceutical companies and could it be justified in terms of welfare in the long run?[2]

In the last decade, the literature on IPR has gone through a remarkable evolution, shifting from views strongly against protecting IPRs to opinions solidly in its favor verifying that such policies are essential in a rapidly integrating world. In the early 1990s theoretical economists mostly highlighted the negative consequences of such policies for the South. They showed the static welfare effects of IPR protection by examining the trade-off between the incentives it creates to

[1] TRIPS does however offer flexibility for developing countries and economies in transition. This is exactly what different levels of IPR protection can be interpreted as. For example, they are granted a four-year transition period (10 years for least developed countries extendible upon request) to adapt to the required obligations with an additional five years for technology-oriented product patents not protected at the date of agreement (braga, et al., 2000).

[2] It can be argued that this particular case is of explicit nature as it involves human life concerns with sympathizing groups around the world demanding life before profits. Yet, South Africa was sued for the violation of IPRs by the world pharmaceutical industry. Leading pharmaceutical companies have however recently withdrawn from the case and agreed to cut the prices of HIV/AIDS drugs for South Africa by more than 70%. (http://www.cptech.org/ip/health/sa/)

innovate and the monopoly market power it yields to innovators.[3] A sharp rise in international investments in the last decade and a remarkable increase in the degree of IPR protection in the same period has nonetheless raised inquisitiveness about the link between technology transfer and IPR protection.[4] This has lead the IPR literature to take a turn in favor of IPR protection by analyzing firms' decision on the form and the amount of technology transfer to the South. Helpman (1993), Lai (1998), and Yang and Maskus (2001) were among these papers and used endogenous growth models to show that protecting IPRs *could* benefit the South by increasing the flow of technology to the South.[5] This branch of IPR literature has however only explored the consequences of IPR protection on the rate of innovation and the rate of multinationalization neglecting the implications they might have on Southern welfare.

This paper fills in this gap and presents a welfare analysis explicitly for the South that embodies the consequences of the Southern IPR policy on technology transfer as well as market structure and incentives to innovate. The results not only reinforce the optimistic views on IPR protection that suggest an increase in technology transfer, but also show that the latter brings about a welfare gain for the South.

The first paper written on IPRs in the context of strategic behavior by firms was Chin and Grossman (1990). It showed that enforcing full IPR protection always (except for a very high Southern share in global consumption) hurts the South while leading to a welfare gain for the North. Zigic (1998) extended this model to allow for different levels of IPR protection and found

[3] Chin and Grossman (1990) and Deardorff (1992) clearly displayed these trade-offs in a static welfare analysis. It was shown that the North always wins and that except when the South enjoys a very high share in the global consumption of the good, it always loses by adopting a patent policy from the North. Helpman (1993) extends the static welfare analysis to a dynamic general equilibrium model to find that stronger IPR protection hurts the South not only by diminishing its terms of trade and causing less efficient allocation of production, but also by slowing the rate of innovation in the long run.

[4] See Maskus (1998) for empirical evidence.

[5] The first basic model of this was introduced in the last section of Helpman (1993) to include FDI. It was shown that with exogenous innovation, FDI rises with a tightening of Southern IPR protection. Lai (1998) extended the model to show that when FDI is the channel of transfer, the rate of innovation also increases along with the rate of FDI as a result of a tighter IPR protection policy. Glass and Saggi (1995) however argued that imitation is a costly activity and came up with the exact opposite results with falling rates of innovation and FDI as a cause of wasted scarce resources in the South. Yang and Maskus (2001) showed that when the channel of diffusion is licensing, both rates of innovation and technology transfer increase for several reasons including less transfer costs and less rent sacrifice for the licensor to prevent possible imitation by the licensee.

that while this conflict holds when R&D efficiency is low, the interests could actually be in congruence for moderate and high R&D efficiency levels. The model presented in this paper takes a step further and endogenizes Southern *IPR protection policy*, Northern firm's *multinationalization decision*, and the *tariff regime* in the South. Shedding light on these three missing points in the strategic IPR literature, it overturns the results attained in the existing literature which have shown the South to generally lose from practicing adequate IPR protection. It will be shown rather that the South gains or at least never loses from enforcing a stringent IPR protection regime. Additionally, the possibility of cooperation is for the first time introduced to the IPR literature.

First, I apply an optimal IPR protection policy set *strategically* by the South. In both papers mentioned above, the firms compete in a two-stage game. The Northern firm chooses the optimal level of R&D in the first stage and the firms compete in the second stage. The level of IPR protection in both models is exogenous. The Southern government has no endogenous IPR policy that anticipates the Northern firm's decision on the channel used to serve the Southern market, i.e. whether to allow for technology transfer by going multinational or not. Such concerns over technology transfer cannot be neglected as they can be the only means of enhancing growth and prosperity in FDI-hungry developing countries. Exactly these countries appear to be those considered as the South in the above papers because they are assumed to be incapable of engaging in any R&D activity. Also, examples in the real world such as the South Africa case show that governments in the South do possess the authority to choose their IPR regime, although they may have to face the consequences of choosing a policy discordant with the WTO agenda. I add an extra stage to the game allowing the Southern government to choose the level of IPR protection strategically to maximize welfare.

On the other side of the model, the Northern firm is given a choice of several channels to serve the Southern market. It could obstruct exposure of its production technology to the South and monopolize the market by producing in the North and exporting to the South. It can alternatively avoid trade costs by going multinational. This allows the production technology to be imitated by the Southern firm which can then compete to serve the local market if profitable. The level of cost reduction in production enjoyed by the Southern firm however depends on the degree to which the technology is being imitated which is in turn directly determined by the IPR protection level in the South. Once FDI has been undertaken, the Northern firm can still deter entry by choosing a level of R&D investment which makes it unprofitable for the South to produce.

The model also allows the South to impose tariffs on imports from the North. Although tariffs have been neglected in most of the IPR literature including Chin and Grossman (1990) and Zigic

(1998), they are essential in models that deal with developing countries who are likely to enforce a protectionist trade policy. I introduce an optimal tariff set after the IPR protection level as governments are unable to commit to tariffs, while obliged to set standards on IPRs, in advance. This separates the trade policy from the IPR policy and focuses the argument on the latter. The tariff is also set after the Northern firm has decided on the channel to serve the Southern market. This avoids tariffs being used as a form of compensation for low IPR protection levels to force the Northern firm into moving production to the South.

Firms in industrialized countries can also decide to form North-South JVs to bypass investment regulations in developing countries or to share risks involved in entering a new market. It could also be profitable to enter a JV agreement to avoid tariff and FDI fixed costs by taking advantage of the already existing resources in the South[6]. An extension is introduced by including this option as means of moving production to the South, giving the Northern firm the choice to cooperate by making a "take it or leave it" joint venture (JV) proposal. The offer is set to give the Southern partner the maximum share in profits which makes the Northern firm at least as well off (or in fact slightly better off) as under the best non-cooperative outcome. The South clearly only accepts the offer if its total welfare under cooperation is not lower than that under the non-cooperative equilibrium.

The game takes place in five stages. In the first stage, the Southern government strategically sets the optimal IPR protection level. In the second stage, the Northern firm decides its mode of supply, namely whether to export or to move production to the South. The South then sets the tariff policy in the third stage. The Northern firm then invests in R&D according to its decision made in the second stage and finally firms engage in production. The timing of the game is illustrated in figure 1. The extension on cooperation is then brought into the game by giving the Northern firm an extra option of forming a JV. The JV offer is made in the second stage and only goes through if the Southern government accepts the offer. Due to the full information aspect of the model, the cooperation game takes a simultaneous nature[7]. It can be seen in the enlarged circle to the right of the game tree in figure 1. Southern government's actions are shown in white boxes while those of the Northern firm are specified with shaded boxes.

The rest of this paper is structured as follows: section 2 presents the basics of the model following Chin and Grossman (1990) and Zigic (1998) and briefly examines the final stage of the game on

[6] See Miller, et al., (1996) for a complete explanation of incentives for the Northern firm to enter in a JV with a established firm in the South.

[7] As there is no uncertainty in the model, the Northern firm can calculate the Southern problem and is fully aware if its offer will be accepted or not.

production. Section 3 describes the scenarios facing the Northern firm regarding its decisions on R&D investment, which in turn depends on its decision on supply mode in the second stage. Section 4 demonstrates the Southern trade policy set in the third stage. Section 5 focuses on the welfare maximization problem faced by the Southern government in the first stage with IPR policy as its instrument. Section 6 introduces the possibility of cooperation and shows when it is the equilibrium outcome. Section 7 concludes the paper.

2. The Basics of the Model

There are two countries North and South: one firm resides in each country. The firms produce a single homogeneous good and compete in a Cournot duopoly setting. Only the Northern firm is capable of engaging in R&D aimed at improving the production technology. R&D reduces costs of production at a diminishing rate. Knowledge gained through R&D is assumed to have a public good character and can be imitated at zero cost.

A familiar linear inverse demand (market clearing price) in a single world market $P=A-Q$ is used where A represents the market size and Q the total quantity produced by the North and the South: $Q=q_n+q_s$. Consumers in the South are assumed to constitute a fraction $1/q$ of global demand implying that the South enjoys $1/q$ of total global consumer surplus. Southern consumer surplus is found by solving for the area under the demand curve:

$$S = \frac{(q_n + q_s)^2}{2q}. \qquad (1)$$

On the supply side, the costs of production for the Northern and the Southern firm are respectively

$$C = a - (gx)^{1/2}, \qquad (2)$$

$$c = a - b(gx)^{1/2}, \qquad (3)$$

where $x \leq a^2/g$, $A>a$, and $0 \leq b \leq 1$; parameter a reflects pre-innovative basic unit costs, b is the strength of IPR protection in the South which causes a North-South spillover of knowledge (with $b=0$ reflecting full protection/no spillover and $b=1$ no protection/full spillover), g is the efficiency of the R&D process, and x measures the level of R&D investment which reduces production costs.

Using backward induction, I start by briefly explaining the final stage of the game which is the more familiar part of the model. Firms maximize profits by choosing quantity in the fourth stage of the game. Under no cooperation, the Northern firm maximizes operating profits $q_n(P-C)$ less

research expenditure x and, in the case of exports, the total tariff costs tq_n. Its maximization problem is therefore

$$\underset{q_n}{Max}\, \pi_n(x) = [A-(q_n+q_s)]q_n - Cq_n - tq_n - x. \qquad (4)$$

The optimal quantity produced for exports is derived by solving for q_n from the first order conditions of (4) and setting q_s to zero[8] giving

$$q_{nm}^*(x) = \frac{A-\alpha+(gx)^{1/2}-t}{2}\ , \qquad (5)$$

where subscript m denotes monopoly exporting. If FDI is the outcome, the Northern firm solves (4) with $t=0$ and the Southern firm simply maximizes operating profits in the same stage with its problem being

$$\underset{q_s}{Max}\, \pi_s(x) = [A-(q_n+q_s)]q_s - cq_s. \qquad (6)$$

The optimal quantities produced by each firm in a duopoly outcome are

$$q_{nf}^*(x) = \frac{A-\alpha+(2-\beta)(gx)^{1/2}}{3} \quad \text{and} \quad q_{sf}^*(x) = \frac{A-\alpha-(1-2\beta)(gx)^{1/2}}{3} \qquad (7)$$

for the Northern and the Southern firm respectively where subscript f stands for FDI. The optimal R&D investment and profits are found for exports and FDI in the next section. The Northern firm then compares the profits under each scenario to decide which strategy to use to serve the Southern market.

3. Northern firm's Multinationalization Problem

3.1 Export

If the Northern firm has high concerns about the infringement of its technology, it could decide to keep production in the North and export the final goods to the South. It is assumed that if goods are imported, it is too costly and therefore impossible for the South, which is in possession of no R&D resources, to invent around the patent or to produce the homogenous good at all. Access to basic production technology can therefore only be gained after production has been moved to the South[9]. Exporting serves as an indirect punitive act by the Northern firm to avoid the imitation of

[8] Exporting gives the Northern firm a monopoly position as the Southern firm is assumed to be incapable of acquiring the production technology unless the Northern firm moves production to the South (see section 3.1).

[9] I am not considering the case of g=0 where no technology is needed to produce the good.

its technology. Such responses, i.e. exporting rather than moving production to the South, are reconfirmed by Smarzynska (1999) who provides empirical evidence indicating that weak IPR protection deters foreign investors from undertaking local production and shifts them towards distribution of imported products.

While saving its technology from being imitated, exporting brings about extra trade costs for the Northern firm. The only other IPR-related literature to my knowledge that relates tariffs to IPRs is Zigic (2000). The paper introduces strategic trade policy into the IPR context; however, it only focuses on Northern welfare and leaves out the implications for the South. A punitive tariff is imposed on goods exported back to the North to deal with the violation of property rights in the South. Alternatively, I use tariffs as an extra cost for the Northern firm if it chooses to serve the Southern market through exports. Its problem could be thought of as a trade-off between trade costs and losses caused by imitation.

If exporting is the non-cooperative outcome, x can be found from the first order condition of (4) using q_{nm}^* as the quantity produced. In order to simplify the comparison between the upcoming equations, I normalize the unit tariff rate t by the size of the market and refer to it as τ where $0 \le \tau \le 1$ to get $t = \tau(A-a)$. Using this in (4) and (5), the optimal level of R&D investment turns out to be [10]

$$x_m^*(\tau) = \frac{g(1-\tau)^2}{(4-g)^2}. \qquad (8)$$

It can be seen in (8) that, given g, R&D expenditure x_m is always falling in τ. Substituting (5) and (8) into (4), optimal Northern profits can be derived for the case of exports:

$$p_{nm}^*(\tau) = \frac{(1-\tau)^2}{4-g}. \qquad (9)$$

Notice that Northern profits are independent of the IPR regime in the South β as there is no exposure to imitation. Profits obviously fall with higher tariff rates τ. In its multinationalization decision, the Northern firm compares export profits calculated by anticipating the optimal tariff with FDI profits given the optimal IPR policy set in the first stage.

3.2 FDI

[10] To further simplify the notation $A-\alpha$ which represents the market size at the point where no R&D takes place can be normalized to unity as $(A-\alpha)^2$ appears in all relevant equations.

The Northern firm can serve the South by building a subsidiary to avoid trade and transport costs, to work with the market locally to gain familiarity with the foreign market, or to take advantage of low labor costs. With this option however, it risks the imitation of its technology. I only examine trade-cost-savings as a motive for FDI as considering all the beneficial factors simultaneously is beyond the scope of this paper. Fixed FDI costs are left out while solving the model. Adding fixed costs only linearly affect the profits by decreasing the maximum b at which the Northern firm would undertake FDI.

In developing countries, FDI and other forms of technology transfer such as licensing and JVs are sometimes the only means of gaining access to the know-how invented in industrialized countries. Once production is moved to the South, know-how can be shared willingly in a JV or involuntarily by imitation. The latter is the case for FDI; however, when patents are binding, the cost-reducing part of technology caused by Northern R&D will not be fully exposed to the South. Looser levels of IPR protection allow more know-how to be disclosed to the Southern firm and lower the costs of production for the latter.

If production is profitable for both firms, the situation is an asymmetric duopoly (except when $b=1$). This is due to cost asymmetries resulting from the enforcement of IPRs which prevents the Southern firm from fully utilizing the cost reducing R&D. The optimal x is again found using the first order conditions of the firm's profit function using (7) for optimal quantities: [11]

$$x_f^* = \frac{g(2-b)^2}{\left[9-g(2-b)^2\right]^2}. \qquad (10)$$

It is easy to see that x_f^* is decreasing in b. The optimal profits for the Northern firm in an FDI duopoly situation are obtained by replacing (7) and (10) into the Northern firm's profits in (4):

$$\pi_{nf}^* = \frac{1}{9-g(2-b)^2}. \qquad (11)$$

The Southern firm's profits on the other hand turn out to be:

$$\pi_{sf}^* = \frac{\left[3-g(b-1)(b-2)\right]^2}{\left[9-g(2-b)^2\right]^2}. \qquad (12)$$

Equation (11) shows that that except for zero R&D efficiency where no R&D takes place, Northern profits always decrease in b. Expression (12) on the other hand helps us find the critical

[11] This is the same optimal R&D investment obtained in Zigic (1998) in the duopoly case.

value of b for each g under which the Southern firm's profits are negative and duopoly could no longer be an equilibrium:

$$\hat{b} = \frac{3 - \sqrt{1 + 12/g}}{2} \text{ for } g \geq 1.5. \qquad (13)$$

For $b < \hat{b}$, competition takes a constrained monopoly form[12] as it is optimal for the Northern firm to deter entry by choosing a predatory level of R&D expenditure which sets q_{sf} in (7) equal to zero:

$$x_p^* = \frac{1}{g(1-2b)^2}, \qquad (14)$$

where p stands for strategic predation. In contrast to the duopoly case, here R&D investment increases with increasing imitation, i.e. lower IPR protection levels. Zigic (1998) interpreted this perverse result as a need for higher R&D efforts to force the Southern firm out of the market when there are higher spillovers since the gap between the Northern and Southern unit costs is smaller. Northern profits under strategic predation are

$$\pi_{np}^* = \frac{g(1-b)^2 - 1}{g(1-2b)^2}. \qquad (15)$$

As a reminder from previous literature, strategic predation is only a possible outcome at $g \geq 1.5$ and b <0.5. Hence the problem of the firm for g<1.5 is to simply decide between securing a monopoly position by exporting or engaging in *duopoly* competition by undertaking FDI. For $g \geq 1.5$ however strategic predation also becomes a possible equilibrium market structure and the mode of competition under FDI is determined by the level of b.[13]

It is useful for the following sections to calculate the value of b which maximizes Northern profits under strategic predation. This level of IPR protection is referred to as $\tilde{b}$ and is derived using the first order conditions of (15):

$$\tilde{b} = 1 - 2/g \text{ where } g \geq 1.5 \text{ and } \tilde{b} \geq 0. \qquad (16)$$

[12] This is the same optimal R&D investment obtained in Zigic (1998) in the case of strategic predation.

[13] $\hat{b} = 0$ for $g=1.5$ and increases with g until it approaches 0.5 as g gets close to 4 (see figure 3). This threshold value is represented as curve g_d in figure 1 of Zigic (1998).

The value of $\tilde{b}$ is zero for $1.5 \leq g \leq 2$ (as $\tilde{b}$ must be non-negative similar to b) and increases with g for $g > 2$[14]. The intuition for this is that x bears costs for the Northern firm as it invests more in R&D to keep the Southern firm out of the market. However, when R&D efficiency is higher, the cost-reducing side of investing in R&D acquires more weight and dominates the costs up to a certain value of b. This critical level of IPR protection decreases ($\tilde{b}$ increases) with R&D efficiency as it becomes preferable to have a certain level of imitation to cause a higher x. $\tilde{b}$ reaches its maximum value at very high levels of g as the benefits from R&D are so high that profits always increase with x which in turn increases with b.

The next step is to find the optimal tariff, which the Northern firm anticipates in its multinationalization decision. To determine this, I turn to the trade policy setting problem of the Southern government in section 4.

4. Trade Policy in the South

In the third stage, which is only relevant if the Northern firm decides to export, the Southern government chooses an optimal tariff which maximizes Southern welfare under exports W_m. This value consists of Southern consumer surplus under exports, S_m , and tariff revenue, which comes from the unit tax levied on every imported good (tq_n). The problem for the South is

$$\underset{t}{Max}\, W_m = S_m + T, \qquad (17)$$

where S_m is found by replacing the anticipated monopoly quantity produced by the North[15] in (1) giving

$$S_m = \frac{2(1-t)^2}{(4-g)^2 q}. \qquad (18)$$

[14] For lower values of g profits fall with b. As g gets larger the profits first increase with b and then fall after b exceeds $\tilde{b}$. This peak value of b increases with g. Eventually, at very high R&D efficiency $\tilde{b}$ reaches its maximum value at the upper limit of b where strategic predation is still a possible outcome; in other words, profits will always be increasing with b.

[15] In order to avoid redundancy, only the final forms of S_m, T, and t are shown. Instead of first writing these terms in terms of x, they are directly expressed in terms of g by using the optimal R&D investment x^* from equation (8) for x in the Northern firm's optimal export quantity q_{nm} (see section 3.1).

Consumers always lose when the tariff rate t increases as both the quantity produced and the R&D expenditure fall with increasing t. Yet, the South has tariff revenue T as another source of income which is solved for using q_{nm}^* as the quantity imported:

$$T = tq_{nm}^* = \frac{2t(1-t)}{(4-g)q}. \qquad (19)$$

Tariff revenue increases directly with increasing t and falls indirectly due to the reduction in production caused by higher t. T reaches its maximum level at $t = 0.5$. The first order condition of W_m with respect to t gives the optimal tariff t^* in terms of g:

$$t^* = \frac{2-g}{2(3-g)}. \qquad (20)$$

Using the optimal tariff in (9) we can now determine the optimal profits of the Northern firm in case of exports:

$$p_{nm}^* = \frac{4-g}{4(3-g)^2}. \qquad (21)$$

It is important to notice that t^* is set after the Northern firm has already chosen to export; it is set to maximize welfare particularly under exports and can not be used to make the Northern firm deviate from its multinationalization decision in the second stage. Tariff rates above this level are not credible as they only reduce Southern welfare under exports and are therefore never chosen. As g approaches 0, the optimal tariff is at its highest value of $1/3$ as the tariff revenue portion of welfare dominates consumer surplus when R&D is inefficient. The optimal tariff decreases as g increases until it reaches zero at $g=2$. Free trade is the optimal trade policy for high R&D efficiency levels of $g \geq 2$.

The Northern firm now has all the tools to compare the its optimal profits under every mode of supply in the second stage. Northern firm's decision now only depends on R&D efficiency which is predetermined exogenously, and the IPR policy set by the Southern government in the first stage. Section 5 shows how the Southern government can act strategically to bias the decision of the Northern firm in its favor.

5. IPR Policy in the South

In the first stage of the game, the Southern government chooses an optimal level of IPR protection strategically. The policy chosen is endogenous unlike previous literature in the sense that the government takes the reaction of the Northern firm to the level of IPR protection into

consideration when choosing the welfare maximizing b. Unlike Chin and Grossman (1990) and Zigic (1998), the Northern firm is not the sole force that determines the market structure as the Southern government is here able to influence the latter. This results in interesting new equilibrium outcomes.

When the Northern firm undertakes FDI, Southern welfare consists of consumer surplus and profits of the Southern firm with the latter being zero under strategic predation (W_f equals $S_f + p_{sf}$ or S_p). Consumer surplus can be calculated for each scenario under FDI by substituting the corresponding quantities produced into (1)[16]. This is shown in equations (22) and (23) for duopoly and strategic predation respectively:

$$S_f = \frac{[6 - g(2-b)(1-b)]^2}{2[9 - g(2-b)^2]^2 q}, \qquad (22)$$

$$S_p = \frac{(1-b)^2}{2(1-2b)^2 q}, \qquad (23)$$

As duopoly was shown to be the only possible form of competition under FDI for $g<1.5$, (12) and (22) are the relevant equations for this range of g. It is clear from (12) that $dp_{sf}/db > 0$ as stricter IPR protection means less imitation, which in turn indicates higher production costs for the Southern firm. On the other hand, $dS_f/db < 0$ suggests that consumer surplus in the South falls with looser IPR protection in the case of FDI duopoly. This is directly related to the Northern firm investing less in R&D as b increases. The magnitude of the loss in consumer surplus caused by higher b increases as R&D efficiency increases.

Things are different for $g>1.5$ as strategic predation is a feasible solution for the Northern firm. Since $dS_p/db > 0$ consumer surplus always increases with looser IPR protection as the latter raises R&D expenditure x. Total welfare also increases with b as in a strategic predation FDI situation its only component is consumer surplus. The threshold value of b where the Southern consumers are indifferent between duopoly and strategic predation is exactly the point where the R&D investment and consumer surplus are at their maximum level. It is the highest possible b that gives strategic predation (highest consumer surplus under strategic predation) and at the same time the lowest possible b which gives duopoly (highest consumer surplus under duopoly); this

[16] Note again that once the decision is made to serve the South through exports, the IPR protection level in the South is irrelevant as the production technology remains safe in the North.

value, which just drives Southern firm's profits to zero, was found as $\hat{\beta}$ in section 3.2. It can be seen here that the same $\hat{\beta}$ makes S_f and S_p and therefore W_f and W_p equal.

We are now in a position to solve the model for different values of R&D efficiency. Following Chin and Grossman (1990), I categorize R&D efficiency into the three regions of $0 < \gamma < 1.5$, $1.5 \leq \gamma < 2$, and $\gamma \geq 2$ [17].

Low R&D Efficiency

Looking at (12) and (22), it can be seen that the highest Southern welfare for $\gamma \leq 1.5$ is attained at zero IPR protection. This is because the Southern firm's profits dominate the consumer surplus component of welfare at low γ's causing total Southern welfare to rise with increasing β. The Southern government is however forced to play strategically to bring FDI into the country. As the Northern firm makes a credible threat of exporting rather than undertaking FDI depending on the IPR protection level in the South, the Southern government foregoes its first-best welfare maximizing IPR protection level under FDI (zero protection) to motivate technology transfer. It chooses the lowest possible level of protection in which the North is still persuaded to engage in FDI instead of exporting to the South (hereafter β^*)[18]. So in this range, the optimal β is derived by equalizing Northern export profits in (18) and FDI profits in (20) giving

$$\beta^* = 2 - \sqrt{\frac{15 - 4\gamma}{4 - \gamma}} \quad \text{for } \gamma < 1.5. \qquad (24)$$

Any higher β brings FDI profits below export profits and hence provokes the Northern firm to keep production in the North. This holds for all levels of the Southern share in global consumption as the latter does not play a role in Northern profits. In addition, comparing W_m and W_f given β^* and τ^* reveals that welfare is strictly higher under FDI for all levels of the Southern share in global consumption. As the South always prefers FDI, it gains from this strategic move

[17] At $\gamma = 0$ FDI profits are always identical to export profits with $\tau^* = 1/3$. As no R&D takes place at this initial level of γ, the value of β plays no role in the decisions and the outcome of the game.

[18] For high levels of the Southern share in global consumption and the high side of g in the low R&D efficiency range, *full protection* can be chosen voluntarily by the South as welfare at $\beta = 0$ may surpass that with $\hat{\beta}$. These results occur at $1.36 < \gamma < 1.5$ for $1/\theta = 1$. This range shrinks (the minimum γ at which this condition happens increases) as $1/\theta$ and therefore the importance of Southern consumer surplus falls relative to the Southern firm's profits (it does not happen for values of $1/\theta$ under 0.4). This atypical result is left out of the investigation to avoid complexity as it only strengthens the results obtained in the paper.

even if the IPR protection level required to achieve it is very high. This can be seen in figure 2 where Southern welfare is illustrated for both cases[19]. The results for low R&D efficiencies are the opposite to those in previous strategic IPR models in which the lack of legitimate means of technology transfer causes the South to always lose from IPR protection. It can be seen in figure 3 that this optimal IPR protection level b^* starts at approximately *0.06* for g just above zero and increases very slowly to around *0.1* as g gets close to *1.5*.[20]

Result 1: *At low levels of R&D efficiency ($0<g<1.5$) the South always chooses a stringent IPR protection regime to motivate technology transfer. This level of optimal protection is derived from a strategy $p_{nm}^*=p_{nf}^*$ at each g.*

Moderate R&D Efficiency

For moderate R&D efficiency levels of $1.5 \leq g<2$ it is optimal for the Northern firm to deter entry if $b \leq \hat{b}$. As the Southern welfare is at its maximum at $\hat{b}$, the Southern government would never set a high enough level of protection ($b > \hat{b}$) for duopoly to be viable. Strategic predation is therefore the equilibrium market structure for this range of g. This also alters the level of b which induces FDI at this range of g. Predatory profits in (15) rather than (20) must now be used to set FDI profits equal to exports profits (18). This yields the FDI inducing level of b:

$$b^{**} = \frac{(4-g) - 2(3-g)^2 + (3-g)\sqrt{\frac{4(3-g)^2 - (4-g)^2}{g}}}{\left[(4-g) - (3-g)^2\right]}. \qquad (25)$$

The Southern government can however enforce its first-best IPR protection level $\hat{b}$ as long as Northern FDI profits at $\hat{b}$ are in excess of its profits under the export option. This necessary condition is only satisfied for g up to 1.81. After this point, FDI profits at $\hat{b}$ fall short and the South can only motivate FDI by lowering b to the point where Northern FDI profits *under*

[19] To make the figure legible, only a particular case is shown where half of the goods produced are consumed in the South. However, the relationship between the two curves holds for all values of the Southern share in global consumption, with welfare higher under FDI than under exports.

[20] The magnitude of the effect of higher efficiency in the R&D in Northern profits is much higher in lower bs. This is due to the Northern firm taking full advantage of its own R&D when IPR protection is being strictly enforced in the South. This accounts for the small increment in b^* as higher g's give extra space to the South to play with. Yet, the rise in b^* is limited to minimal amounts as export profits become more attractive at higher g due to the decreasing optimal tariff rate.

strategic predation and its profits under exports are equal (b^{**}). Comparing W_m and W_p given the optimal tariff and the optimal IPR protection level shows that Southern welfare under FDI well exceeds that under exports also when strategic predation is the FDI outcome. This can clearly be seen on the right-hand segment of figure 2 which shows Southern welfare for both cases at moderate R&D efficiency levels under an optimal IPR protection and tariff regime. Exactly this is the source of the motivation for the South to choose a level of b that triggers FDI.

As shown in figure 3 the optimal IPR protection is $\hat{b}$ and starts at *0* with $g=1.5$ and rises to about 0.11 where it reaches its peak at $g=1.81$ (see section 3.2). At this point the optimal policy switches to b^{**} and falls as g further increases to match export profits which get more attractive as t^* gets closer to zero. Ultimately b^{**} reaches zero at $g=2$ where full protection is the only alternative to make the Northern firm content with FDI.

Result 2: *At a moderate range of R&D efficiency (*$1.5 \geq g > 2$*) if* $p_{np}\big|_{b=\hat{b}} > p_{nm}\big|_{t=t^*}$ *then* $\hat{b}$ *is the optimal IPR protection policy. After this critical g where choosing* $\hat{b}$ *makes* p_{np} *drop under* p_{nm}*, a lower level of b than desired is required to induce technology transfer through the next best strategy* $p_{nm}^*=p_{np}^*$.

High R&D Efficiency

For high R&D efficiency levels of $g>2$, the optimal IPR protection level is somewhat similar to Zigic (1998). Even though the outcome can still be strategic predation, Northern profits with FDI strategic predation never exceed exporting profits at the now optimal free trade policy. The optimal IPR protection policy is $\tilde{b}$ (see section 3.2) as this is the only point where profits under FDI strategic predation match export profits. The South can not enforce the slightly larger $\hat{b}$ illustrated by the thinner curve in figure 3, where Southern consumer surplus and welfare are higher. The South itself is indifferent between FDI strategic predation and imports $at\,\tilde{b}$ as welfare is equal under both market structures.[21]

[21] If the South prefers strategic predation over imports for technology transfer reasons not discussed in the model, they have to first choose b^{**} as their protection regime for a given g to make the North indifferent and take subsequent actions to convince the North to engage in FDI. It is important to note that at this range of g, the smallest amount of tie-breaking tariff imposed would make strategic predation a preferable option for the North. As a result of such tariffs b^{**} increases as export profits are lower and both sides the strictly prefer a situation of FDI strategic predation. On the other hand, smallest fixed costs of establishing a

Result 3: *At high R&D efficiency (g>2), the South can only make the North indifferent between FDI and export through a moderate IPR protection regime* $\tilde{b}$*, which makes* $p_{nm}^*=p_{np}^*$*. Nevertheless, the North and the South are both indifferent between exports and FDI at* $\tilde{b}$*.*

Looking at figures 1 and 2 simultaneously, setting a b above the b^* curve in figure 3 makes the Southern welfare curve in figure 2 jump from the FDI curve to the export curve. Choosing a b below b^* on the other hand slightly shifts the FDI welfare curve downward. Yet, it remains above the export curve. For a direct comparison of the model with Chin and Grossman (1990), the range of policy set by the North can be restricted to the two choices of $b=0$ and $b=1$. It can easily be seen that, in contrast to their results, the South would never strictly prefer to choose no protection over full protection in the presence of technology transfer.

6. The Cooperation Game

The cooperation game extension can now be added to the second stage as an extra alternative for the Northern firm while it chooses its mode of supply. Although previously ignored in the IPR literature, forming a JV with a local firm in the South could be another alternative to serve a foreign market. In this model I adopt an introductory approach by having a JV indicate joint profit maximization with a fixed share of profits for each partner[22]. This could also be thought of as licensing with the Northern share of profits resembling a royalty cost paid by the Southern firm. Agency problems such as moral hazard and adverse selection have been taken out of the argument as the Northern firm willingly shares *all* its technology with its partner in a two-firm framework[23].

In the case of cooperation, joint profit maximization gives firms a joint problem of

$$\underset{Q}{Max}\, p_c(x) = (A-Q)Q - cQ - x \qquad (26)$$

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subsidiary in the South makes exporting the optimal solution. Therefore, these factors can be measured against each other at outcomes with multiple solutions to determine the tie-breaking single solution.

[22] There is however a vast literature on JVs. Much interesting work such as d'Aspremont and Jacquemin (1988), Suzumara (1992), and Neary and O'Sullivan (1999) has particularly been done on research JVs in the presence of spillovers.

[23] Vishwasrao (1994) considers a different framework of incomplete information, namely a screening game, where the innovating firm decides on different licensing contracts or exporting. Some outcomes intuitively reflect the results in this paper. For instance, in both models, the benefits to the South from loose IPR protection regimes are offset by the choice of the Northern firm on the mode of technology transfer.

with subscript *c* representing cooperation. An agreed profit share of f (*1-f*) goes to the Northern (Southern) partner where $0 \le f \le 1$. As this model aims to highlight the technology transfer aspect of JVs, it is assumed that in the case of a JV all production takes place in the South, i.e. *c* is the cost of production. This gives an optimal joint output of

$$Q(x) = \frac{A - a + b(gx)^{1/2}}{2}. \qquad (27)$$

The Northern firm now invests in R&D in the fourth stage of the game according to the outcome of the cooperation game in the second stage (recall figure 1). If the JV offer is accepted, the optimal R&D investment is found using (27) in (4) and differentiating the latter with respect to *x* to get

$$x_c^* = \frac{b^2 g}{(4 - b^2 g)^2}. \qquad (28)$$

The optimal profits for each JV partner are found by substituting (27) and (28) into the profit function and multiplying the expression by f and *1-f* respectively:

$$p_{nc}^* = \frac{f^*}{4 - b^2 g}, \qquad p_{sc}^* = \frac{1 - f^*}{4 - b^2 g}. \qquad (29)$$

As both dp_{nc}^*/db and dp_{sc}^*/db are positive, it is in the interest of both firms to have full *internal* spillovers as any lower level is inefficient for both firms[24]. Thus, full spillovers *(b=1)* in a JV make Southern IPR protection irrelevant in a two-firm framework. Equations (28) and (29) reduce to

$$x_c^* = \frac{g}{(4 - g)^2}, \qquad (28b)$$

$$p_{nc}^* = \frac{f^*}{4 - g}, \qquad p_{sc}^* = \frac{1 - f^*}{4 - g}. \qquad (29b)$$

The profits of the two firms change linearly with f and are negatively related to each other. It can also be seen from (17) and (28b) that R&D investment is similar to that under the exporting option when the optimal trade policy in the South is free trade ($t^*=0$).

[24] An example of this is the recent agreement by UK's Pilkington Glass and Iran's Qazvin Glass Company to form a JV. The agreement involves building a new glass plant in Iran to replace two of the existing sheet glass furnaces, which use older technology (http://www.payvand.com/news/01/mar/1120.html).

The Northern firm initiates the JV agreement and makes an offer to the Southern partner over the share that goes to the latter from their joint profits. The Northern firm makes the most generous offer it can afford that would leave itself at least as well off as under the best non-cooperative outcome.[25] It can be summarized as choosing a profit share f^* such that

$$p_{nc}(f^*) = \{p_{nm}|_{t=t^*} \text{ for } g < 1.5 \text{ and } g > 1.81, p_{np}|_{b=\hat{b}} \text{ for } 1.5 \le g \le 1.81\}. \quad (30)$$

Notice that as b is set to make Northern FDI profits equal to export profits given t^*, it makes no difference whether FDI or export profits are set equal to (29b) to find f^* (with the exception of $1.5 \le g \le 1.81$ where FDI strategic predation profits under $\hat{b}$ must be used).[26] Using p_{np} with the definition of $\hat{b}$ for $1.5 \le g \le 1.81$ and p_{nm} from (18) for all other g's as means of comparison we get

$$f^* = \begin{cases} (1-t^*)^2 = \left[\dfrac{(4-g)}{2(3-g)}\right]^2 & \text{for } g < 1.5 \text{ or } 1.81 > g > 2 \\ \dfrac{\left[g\left(\dfrac{\sqrt{1+12/g}-1}{2}\right)^2 - 1\right](4-g)}{g(\sqrt{1+12/g}-2)^2} & \text{for } 1.5 \le g \le 1.81. \end{cases} \quad (31)$$

The share offered to the Southern partner $(1-f^*)$ is *0.55* at g's just above *0* and falls as g increases due to higher profits caused by a lower t^*. There is a discontinuous fall in $(1-f^*)$ at g=1.5 as the FDI market structure now implies strategic predation and p_{np} is now used to find the FDI inducing b. To be more precise, $\hat{b}$ rather than b^{**} represents the optimal IPR protection level at $1.5 \le g \le 1.81$ (see section 3.2). For $g \ge 2$, only a zero share of profits is offered to the Southern firm as that is the only value which makes Northern profits in a JV *similar* to the best non-

[25] The results are exactly the same when the sides change in the bargaining game. The Southern government would then offer the Northern firm a share which would make the South as well off under cooperation as under the non-cooperative outcome. Then the Northern firm accepts the offer if its profits in a JV with that share (which since welfare under two situations are being compared now also depends on the share of global consumption in the South) exceed that under the non-cooperative outcome. The threshold value of $1/q$ under which JV occurs remains exactly the same.

[26] As $\hat{b}$ is smaller than the b^{**} that makes FDI and export profits equivalent, the offer to the South is smaller than it would be under b^{**}. This explains the discontinuity of the JV welfare curve and the threshold value curve in figures 1 and 3 at $g=1.5$ which are both caused by this discontinuity in f^*.

cooperative outcome. This also makes JV welfare similar to welfare under exports and under FDI strategic predation given optimal IPR protection $\tilde{b}$ for g≥2.

The Southern government then compares its welfare under cooperation and non-cooperation to accept or reject the JV offer. Southern welfare under cooperation consists of consumer surplus and the Southern firm's share of profits in the JV (W_c equals $S_c + p_{sc}$) where consumer surplus turns out to be

$$S_c = \frac{2}{(4-g)^2 q} \ . \qquad (32)$$

A JV is only accepted if Southern welfare is higher with the offer than under FDI ($W_c \geq W_f$). W_c can only exceed W_f at $g<2$, below a threshold value of the Southern share in global consumption[27]. An accepted JV offer symbolizes a case where cooperation can make both the Northern firm and the South better off. JVs are very likely to occur for the low R&D efficiency range except for high levels of Southern share in consumption and low values of g. At moderate R&D efficiency levels of $1.5 \leq g < 2$ JVs could, but are less likely to, occur as they require a much lower level of Southern share in consumption. The intuition behind this is that the South has little to gain when R&D efficiency is very low and is offered too small of a share in the JV when R&D efficiency is relatively high. A lower $1/q$ is needed in the latter case as Southern profits carry a heavier weight in Southern welfare under a JV than under FDI while the opposite holds for consumer surplus. Since $1/q$ only affects the consumer surplus portion of welfare, lower $1/q$ makes a JV more attractive. In addition, Southern profits under a JV increase with g only until they reach a peak around $g \approx 0.9$ and fall thereafter. The range of g in which welfare with a JV given f^* is higher than FDI welfare can be seen in figure 2 for $1/q = 0.5$.

The Northern firm and the South are both indifferent between cooperation and non-cooperation at $g \geq 2$ as the outcome is a mirror of the monopoly situation under exports. JVs therefore never occur in R&D intensive industries as the profit share offered to the South is zero, welfare is not improved, and the Northern firm can achieve the same profits at a monopoly position by exporting.

The results are parallel to Smarzynska (2000) in which a developing country government tends to favor JVs over other forms of FDI believing that local participation made possible by the former is a better way to facilitate absorption of new technologies. The zero JV share offer to the South for g≥2 also complies with this empirical paper, which shows that JVs in high R&D sectors

[27] See the appendix for the derivation of the critical value of $1/q$ below which the offer ($1-f^*$) is accepted.

present a lower potential for transfer of technology as Northern firms would be more likely to engage in wholly owned projects than to share ownership.

Result 4: *JVs are very likely to occur at low R&D efficiencies except for very low g's, where there is little to gain from cooperation, and high levels of Southern share in global consumption (1/q). A much lower (1/q) is needed for a JV to be accepted at moderate R&D efficiency levels as the share offered to the South is very small at this range. The non-cooperative results of the last section hold for* $g \geq 2$ *as the Northern firm is reluctant to share ownership with the Southern firm and wholly owned subsidiaries do not make either side better off than the non-cooperative outcome.*

Figure 4 summarizes the equilibrium market structure in the space of the Southern share in global consumption and R&D efficiency. It can be seen that for $g<1.5$, a JV is preferred to FDI by the Southern government in a significant portion of the figure. The threshold value *of* $1/q$ below which cooperation is accepted jumps to a much lower level for higher values of g, making JVs less likely to be the equilibrium outcome for $1.5 \leq g < 2$.

7. Conclusion

This paper uses the welfare implications of protecting IPRs in developing countries to show that when technology transfer considerations are accounted for, it is not rational for governments in these countries to oppose IPR protection. As the Southern government gets to choose the IPR protection level first before the Northern firm makes its multinational decision, it can induce technology transfer. The level of IPR protection is chosen such that exporting is never strictly preferred to technology transfer by the North. Even when the South desires a lower level of IPR protection to reach its first-best welfare, the Northern firm's credible threat of exporting rather than undertaking FDI and the strategic interaction between the firm and the government restrict the latter to lower levels of b. Therefore the rational South who moves first never strictly prefers to violate international IPR protection and sets an optimal level of IPR protection which is in most cases very strict and in extreme cases (very high R&D efficiency) moderate. Endogenizing the decisions of both sides confirms the necessity of IPR protection for FDI in developing countries.

Another purpose of the paper is to attempt a more complete model that includes other factors involved in IPR protection such as tariffs and the possibility of a JV. As exporting could be used as an alternative to avoid imitation of technology, tariffs were shown to play an important role in determining the optimal level of IPR protection and in turn the market structure. It was seen however that tariffs only effect the outcome at low and moderate efficiency levels as the South

sees it optimal to have a free trade policy on technology intensive goods. Furthermore, when cooperation is allowed for, a JV is preferred to FDI by both sides and is therefore the equilibrium in a significant range of the Southern share in global consumption at low R&D efficiency levels. At moderate R&D efficiency levels JVs are less likely to occur, due to the lower share offered to the Southern firm. Firms from industrialized countries do not however choose to share ownership in technology intensive industries.

A possible extension of the model could be to follow the argument in Glass and Saggi (1995) and make imitation costly. This requires the Southern firm to engage in imitation R&D to be able to utilize Northern innovation R&D. The Southern firm then undertakes own R&D activity even when there is no IPR protection to be able to take advantage of cost-reducing technology of the competing firm in the case of FDI or a JV. This setting could describe emerging markets with limited R&D capacity as opposed to less developed countries incapable of engaging in any R&D activity. Another interesting line of research would be to extend the model to allow for entry by a second Southern firm into the market once the Northern firm has transferred its know-how. In a three-firm framework, the two firms in the JV may want to conceal their technology from a second outsider Southern firm which enters the market after the Northern firm moves its production to the South.

It is worth mentioning that this paper only considers the *indirect* trade impact of IPR protection for the South. Direct trade impacts are not considered as in this model the Northern firm always serves the Southern market as long as there is demand and has only to choose the channel of transfer[28]. It also ignores other important criteria that may reinforce or rule out the suitability for inclusion of IPRs in the WTO such as international externalities, policy coordination failures, and meaningful dispute resolution. Analyzing these criteria shows that IPRs may indeed have a stronger case for standardization than other fields such as competition policy, environmental protection, and labor standards (Maskus, 2000). Though, this paper by no means supports a general harmonization of regulatory standards, including IPRs, through the WTO. It rather tries to make obvious the important role that policies in the South play in its welfare when a developing country confronts a profit-maximizing firm from an industrialized nation whose profits and therefore actions are directly based on these policies. It shows that the innovator can avoid global dissemination of technology and that nations that want to gain access to the knowledge or simply enjoy a larger quantity of the goods containing it must pay a cost and forego policies, which truly maximize their welfare.

[28] Maskus and Penubarti (1995) uses empirical evidence to demonstrate that IPRs are strongly trade-related and that the net impact on imports depends on a variety of factors in each country and each product.

Appendix. Determining the critical share of Southern consumption below which JV occurs

The threshold value of $1/q$ below which JV is desirable for the South given $(1-f^*)$ is derived by solving the equation $W_f=W_c$ for $1/q$. This takes the form $S_f + p_{sf} = S_c + p_s$ for $g<1.5$ giving

$$\frac{1}{q}^{crit} = \frac{2(4-g)\left[9-g(2-b^*)^2\right]^2\left[1-\left(\frac{4-g}{2(3-g)}\right)\right] - 2(4-g)^2\left[3-g(b^*-1)(b^*-2)\right]^2}{(4-g)^2\left[6-g(2-b^*)(1-b^*)\right]^2 - 4\left[9-g(2-b^*)^2\right]^2}. \qquad \text{(A.1)}$$

For g≥1.5, FDI welfare under strategic predation is used making the equation $S_p = S_c + p_s$ to give

$$\frac{1}{q}^{crit} = \begin{cases} \dfrac{2(1-2\hat{b})^2(4-g)\left[1-\left(\dfrac{\left[g(1-\hat{b})^2-1\right](4-g)}{g(1-2\hat{b})^2}\right)\right]}{(1-\hat{b})^2(4-g)^2 - 4(1-2\hat{b})^2} & \text{for } 1.5 \le g \le 1.81 \\ \dfrac{2(1-2b^{**})^2(4-g)\left[1-\left(\dfrac{4-g}{2(3-g)}\right)\right]}{(1-b^{**})^2(4-g)^2 - 4(1-2b^{**})^2} & \text{for } g > 1.81. \end{cases} \qquad \text{(A.2)}$$

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Figure 1: The Stages of the Game

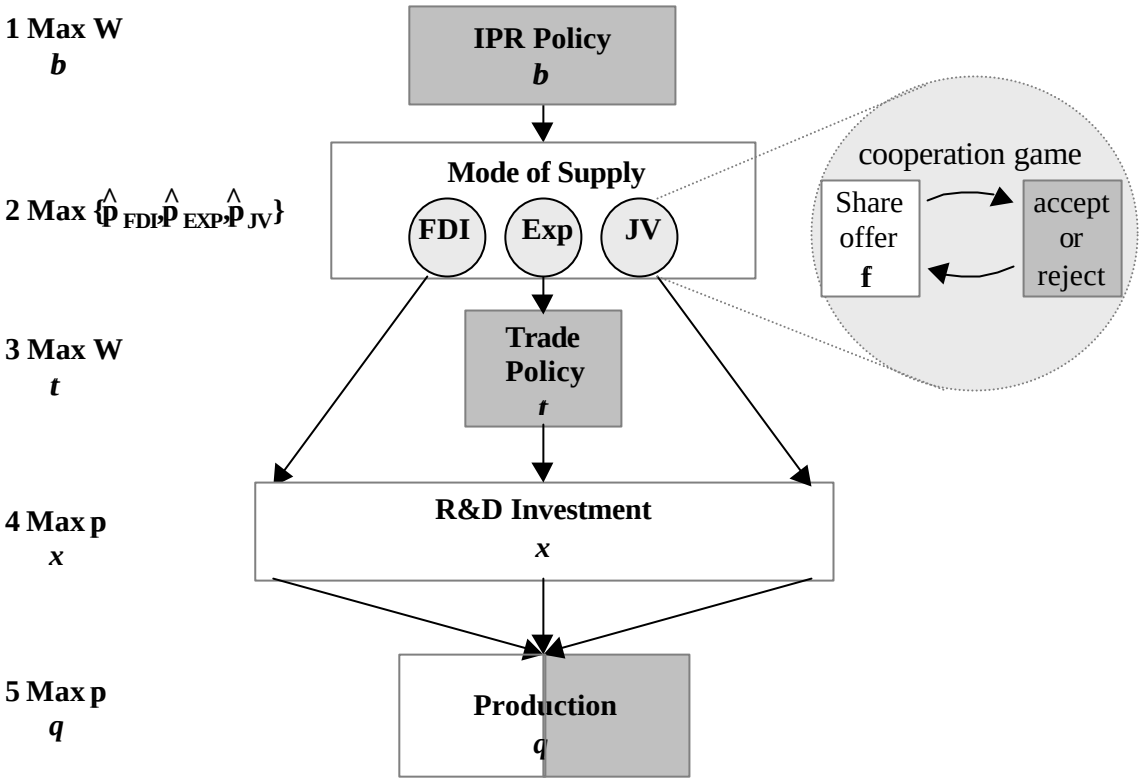

Figure 2: Southern Welfare for $1/q = 0.5$

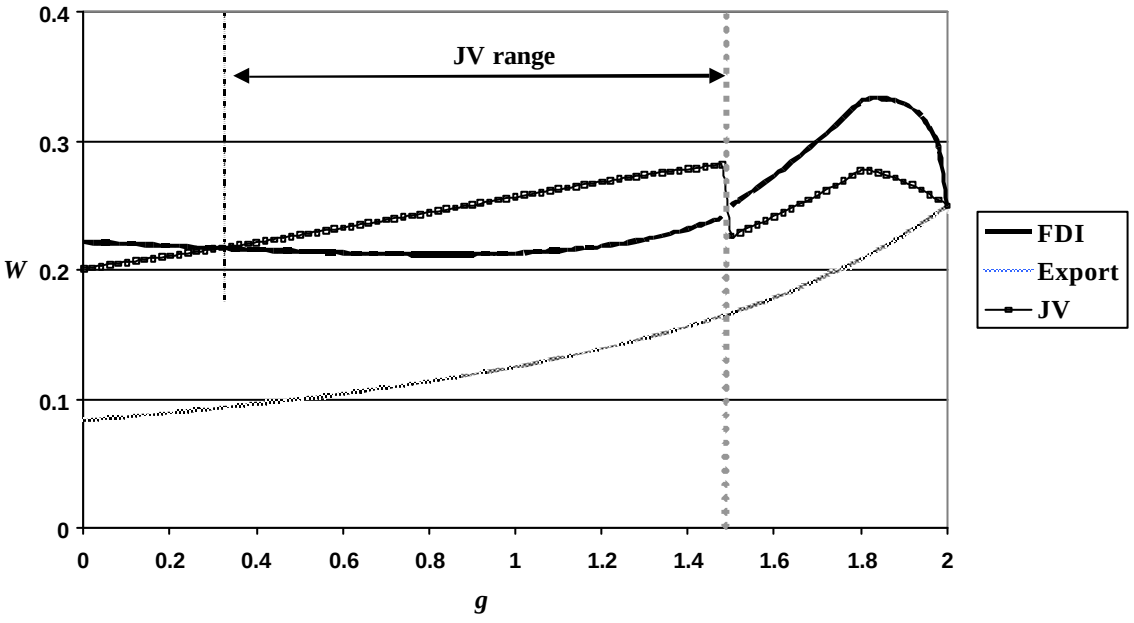

Figure 3: Optimal IPR Protection Level

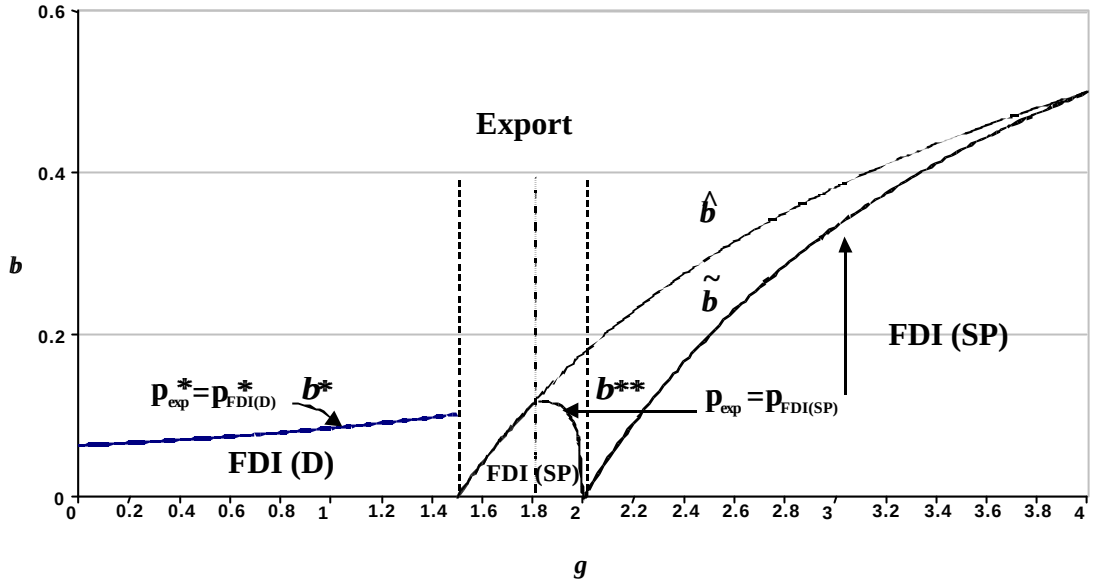

Figure 4: Market Structure