Innovation, protection, and retaliation

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Abstract[1]

This paper develops a model where firms engage in process-improving R&D and countries differ in their enforcement of intellectual property rights (IPR). We aim to study firm-level innovation under unilateral and bilateral trade protection allowing for country heterogeneity in IPR enforcement. We offer a general theory on the link between trade policy and innovation. Our results are consistent with historical and other stylized facts and offer an explanation for the broad pattern of trade protection empirically observed.

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1. Introduction

A recent worry amongst countries like the US and the EU is how the increased trade competition with countries like China is going to affect the incentives for firms to engage in R&D and other productivity improving investments. The worry is particularly relevant when R&D efforts and new innovations in the "North" are likely to spill over to developing countries in the "South" with poor intellectual property (IPR) enforcement, not allowing the North to appropriate the private benefits of the R&D investment incurred. Since, there does not exist a good international mechanism to enforce IPRs, increasingly countries like the EU and US turn to the use of trade protection such as Antidumping measures (AD) to protect R&D intensive sectors (Gao and Miyagiwa, 2005). Another recent phenomenon is that developing countries in the "South" have also started to apply contingent protection which has resulted in a recent increase of bilateral trade protection mostly in the form of antidumping duties (Vandenbussche and Zanardi, 2008).

With this in mind, this paper has two main purposes. The first is to explore the relationship between unilateral protection and R&D investment of protected firms. Our results show that the direction in which unilateral protection affects home R&D in the North depends on the extent to which the trade partner respects intellectual property rights. In an environment where the North trades with a partner that strictly enforces IPRs, the North has no incentive to take unilateral trade protection since free trade always yields a higher level of home R&D. But in an environment where foreign firms shamelessly "copy" home R&D, unilateral protection by the North turns out to be an instrument to counter IPR violation that can be used to spur home R&D.

The second purpose of this paper is to study the effects of bilateral protection on R&D investments of firms. We show that bilateral protection is unlikely to occur between countries that enforce IPRs since bilateral protection in this case would leave both countries with R&D levels below the free trade levels. But whenever a country in the “North” faces a trade partner in the “South” that does not respect IPRs, bilateral protection is likely to occur i.e. there exists a unilateral incentive for the North to protect which will be met with retaliatory tariffs by the trade partner in the South. The prospect of retaliation however, reduces the effectiveness of trade protection by the North as an instrument to spur R&D.

While the model of monopolistic competition, increasing returns and firm heterogeneity has become one of the workhorse models in international trade, it is less suited to study issues of trade policy. The main reason is that its analysis in this setting is complex for unilateral trade policy let alone for bilateral trade policy as shown by Demidova and Rodriguez-Clare (2007) that consider the unilateral case.

In order to study the effects of bilateral trade protection on innovation, we therefore turn to a very different type of model that does not consider firm heterogeneity within countries as in Melitz (2003), but that does allow for heterogeneity between countries in terms of intellectual property enforcement. The model’s focus is on the analysis of strategic interactions between firms when productivity is decided endogenously rather than drawn randomly. For this purpose we augment the reciprocal dumping model (Brander & Krugman, (1983); Schmitt, Anderson and Thisse (1995)) with a standard IO model on innovation (d’Aspremont & Jacquemin, 1988).[2] In the first period, firms can invest in process-improving R&D to reduce marginal costs and in the second

[2] Several other papers have used variants of this model to study issues dealing with optimal policy design. This is very different from the issues raised in this paper where policy is in the form of a legal antidumping procedure which allows countries to levy a duty whenever dumping occurs. In particular Spencer and Brander (1983), Neary and Leahy (2000), Bhagwell and Staiger (1994), Haaland and Kind (2008), Amir and Wooders (1998).

period firms produce and sell homogeneous products and compete in quantities.[3] All firms in this model sell both domestically and export abroad. The extent to which R&D investment can be appropriated or spills over to foreign rival firms, depends on the IPR enforcement of the trading country. First we consider how unilateral trade protection affects the incentives of a domestic firm and a foreign firm to innovate under different IPR regimes. Second we study innovation incentives when the foreign country follows suit and bilateral protection is in place.

In an earlier paper on innovation and trade protection, the maintained assumption was that firms and countries in the model were symmetric (Gao & Miyagiwa, 2005)[4] (G-M). Under those assumptions, G-M find that unilateral trade protection always lowers the incentive of the protected firm to innovate, and bilateral protection always spurs firm-level R&D of firms in both countries compared to free trade. The model developed in the current paper allows for country heterogeneity and derives a fuller set of results by showing that the effect of trade policy on R&D incentives largely depends on the extent of IPR enforcement of countries.

More specifically, our findings show that antidumping protection can be used as a second best instrument to spur R&D whenever the trading partner does not respect IPRs and engages in "copying" by which R&D investments partly or entirely spill over to foreign firms. This incentive does not disappear once we allow for bilateral protection, although the effectiveness of trade protection as an instrument to increase domestic R&D is lower once retaliation is likely to occur.

[3] While price competition is arguably the more natural way to think of since antidumping cases entail pricing issues, the analysis largely simplifies under homogeneous quantity competition. Allowing for price competition does not alter our results. Also introducing product differentiation does not alter our results.

[4] This is one of the few papers we are aware of that explicitly deals with trade policy and innovation.

Another way to interpret the theoretical results obtained in this paper is to think of IPR protection as a stage of a country's development. This allows us to label countries that respect intellectual property rights as developed countries in the North and countries with low IPR enforcement as developing countries in the South. The patterns of trade protection predicted by our theory are also the ones we tend to observe in real life. Our findings predict little trade protection amongst developed countries in the North, but substantial unilateral protection from the North against the South. This is confirmed by antidumping statistics (WTO website). Historically only a handful of countries in the North, usually referred to as "traditional" users, used antidumping. They did not so much use it against each other but primarily targeted developing countries in the South (document with some numbers in footnote). Our theory also suggests that the South has a distinct incentive to retaliate against the North. This offers a theoretical explanation for the antidumping proliferation that we observed recently. Empirical studies have shown that the recent proliferation wave of trade protection laws occurred mainly amongst developing countries including India, China and some Latin-American countries. Interestingly, new adopters of trade protection laws in the South use antidumping protection mainly against developed countries in the North (US, EU, Australia, Canada), that previously targeted them (Prusa, 2001; Vandenbussche and Zanardi, 2008). Theoretically, our model confirms that the South mainly wants to use antidumping protection in a defensive way i.e. they have an incentive to retaliate against the North.

This paper is by no means in favor of trade protection. In fact it shows that when a home country faces retaliation, its incentive to spur R&D through trade protection is lowered. Our model would predict that the prospect of retaliation reduces the incentive for the North to use protection to spur R&D in the first place. Recently a decrease in the number of antidumping cases initiated by the North can be observed which seems to correspond with what this model would predict.

In section 2 we set up the model. Section 3 deals with the analysis of unilateral protection while section 4 discusses bilateral protection. Results are discussed in section 5 and section 6 concludes.

2. The Model

2.1 Setup

Consider a world consisting of two countries, A and B. Each country hosts one firm, firm a and firm b, respectively. Assume firms are ex ante symmetric. This assumption lightens some notational burden and allows us to focus on the issue on hand; that is, the relationship between IPR law enforcement and R&D investment.

The firms engage in a two-stage game, first choosing a level of investment in cost-reducing R&D and then competing in output in both national markets. More specifically, in the fist stage, firms, initially facing the identical (constant) marginal costs of $\overline{c}$, simultaneously and independently decide on the level, g_i (i = a, b), of investment in R&D, which reduces marginal costs to

$$c_i = \overline{c} - g_i - \phi_i g_j .$$

The parameter $\phi_i \in [0, 1]$ captures spillovers from the rival's R&D as in d'Aspremont and Jacquemin (1988). Thus, an extent of a firm's cost reduction depends not only on its own but also on the rival's R&D investment. Unlike in d'Aspremont and Jacquemin (1988), however, the value of ϕ_i here reflects the stringency with which the country enforces its intellectual property rights law. The higher the value of ϕ_i, the more lax the country's law enforcement, so its national firm finds it easier to appropriate the rival's invention. At the extreme value of ϕ_i =1, the firm can fully appropriate the benefits of the rival's R&D investment. Only when ϕ_i =0, the returns to R&D are fully private to the firm. Notice that, although firms are ex ante symmetric, the difference in IPR law across countries can make marginal costs asymmetric ex post.

In stage 2, firms use the technologies determined in stage 1 to produce homogeneous goods and compete in quantities in both markets. When exporting to market j, firm i also incurs trade costs of $\overline{t}_j$ per unit, which equal pure transport costs τ in the absence of tariffs by country j.[5]

Let (*) denote the variables pertaining to a firm's export market. For example, x_a^* and p_a^* respectively denote firm a's export demand and price prevailing in foreign market, while x_a and p_a respectively denote the corresponding variables for its domestic market. Assume that demands are linear and symmetric in the two national markets. Then, firm a's domestic demand and export demand are respectively given by

$$p_a(x_a, x_b^*) = \alpha - x_a - x_b^* \tag{1}$$

$$p_a^*(x_b, x_a^*) = p_b(x_b, x_a^*) = \alpha - x_a^* - x_b \,. \tag{2}$$

In the analysis to follow we set the demand intercept, α, to unity without loss of generality.

2.2 The second-stage (product market) game

[5] Our results are robust to alternative setups such as assuming price competition and allowing for differentiated products. Results can be obtained from the authors.

We now solve the model, beginning with the second-stage game. In the second stage firm *a* faces ex post marginal cost of $c_a = \overline{c} - g_a - \phi_a g_b$, and the additional trade cost of $\overline{t}_B$ for its exports. Thus, firm *a*'s second-stage profits is given by:

$$\pi_a(x_a, x_a^*; c_a) \equiv (p_a - c_a)x_a + (p_b - c_a - \overline{t}_B)x_a^*, \tag{3}$$

where the inverse demands are as in (1) and (2). The first term on the right is the profit from domestic sales and the second from exports. Due to the trade cost and linear marginal costs, the national markets are effectively segmented. Firm *a* chooses quantities for each national market independently to maximize the total profit in (3), taking as given its rival's output in the two markets. The first-order conditions are

$$1 - c_a - 2x_a - x_b^* = 0 \tag{4}$$

for the domestic market (country A) and

$$1 - c_a - 2x_a^* - x_b - \overline{t}_B = 0 \tag{5}$$

for the export market (country B). (4) and (5) define firm a's best-response function in the domestic and the foreign market, written $x_a = r_a(x_b^*, c_a)$, and $x_a^* = r_a^*(x_b, c_a, \overline{t}_B)$, respectively.

Firm b solves a similar problem. Its best response functions readily obtain by interchanging the subscripts a and b in (4) and (5). Straightforward calculations yield the following equilibrium outputs for firm a:

$$\widehat{x_a} = \frac{1 - 2c_a + c_b + \overline{t}_A}{3} \tag{6}$$

$$\widehat{x_a^*} = \frac{1 - 2c_a + c_b - 2\overline{t}_B}{3} \tag{7}$$

Substituting these equilibrium quantities into the profit function, we obtain firm a's second-stage equilibrium profit:

$$\widehat{\pi_a}(c_a, c_b) = (\widehat{x_a})^2 + (\widehat{x_a^*})^2 .$$

The profit for firm b obtains analogously.

2.3. The first-stage (R&D) game

Following d'Aspremont and Jacquemin (1988), assume a quadratic R&D cost function of the form $(\gamma/2)g_i^{\,2}$. Firm a chooses g_a to maximize the net profit

$$\Pi_a(g_a, g_b) = \widehat{\pi_a}(g_a, g_b) - (\gamma/2)g_a^{\,2}.$$

The first-order condition is

$$\frac{\partial \Pi_a}{\partial g_a} = 2(2-\phi_b)\{A + 2(2-\phi_b)g_a + 2(2\phi_a - 1)g_b\}/9 - \gamma g_a = 0$$

where

$$A \equiv 2 - 2\overline{c} + \overline{t}_A - 2\overline{t}_B$$

which is assumed positive for relevant parameter values. The second-order condition requires that

$$4(\phi_b - 2)^2 - 9\gamma < 0.$$[6]

The first-order condition can be arranged to yield the best-response function:

$$g_a = \frac{2(2-\phi_b)[A + 2(2\phi_a - 1)g_b]}{9\gamma - 4(2-\phi_b)^2}. \qquad (10)$$

The best-response function for firm b is found analogously. The Nash equilibrium $\{\widehat{g_a}, \widehat{g_b}\}$ satisfy those two best response functions simultaneously.

We now examine (10) more closely. First, differentiating (10) yields

$$\frac{\partial g_a}{\partial g_b} = \frac{2(4\phi_a - 2)(2-\phi_b)}{9\gamma - 4(\phi_b - 2)^2}$$

Since the denominator is positive by the second-order condition, and since $\phi_i < 1$,

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[6] The second order condition holds if γ is large enough. Its value must be sufficiently large to keep the ex post marginal costs positive.

$$\frac{\partial g_a}{\partial g_b} < 0 \text{ if and only if } \phi_a < \frac{1}{2}.$$ [7]

Similar results hold for firm b. Thus,

Lemma 1: A *firm's R&D investment is a strategic substitute if its country enforces its intellectual property rights strictly in the sense that ϕ_i < 1/2. Otherwise, it is a strategic complement.*

Intuitively, with $\phi_i = 0$ R&D investment is a strategic substitute because when the rival increases its investment and reduce cost the firm's profit from both markets fall, thereby diminishing the firm's inventive to invest in R&D. With $\phi_i > 0$, the rival's R&D also reduces the firm's cost through copying, thereby mitigating the negative effect on the firm's profit. If $\phi_i = 1/2$, the rival's R&D, which reduces the firm's output, reduces the firm's cost by the same magnitude. Thus, the firm' output is unchanged; see (6) and (7). Since the profits are the sum of output squared in each market, the firm's profit is unaffected by the rival's R&D. If $\phi_i > 1/2$, the rival's R&D increases the firm's output. With higher profit, the firm now has an incentive to increase its own R&D. Thus, R&D investment is a strategic complement for $\phi_i > 1/2$.

Next, differentiating (10) with respect to the $\bar{t}_i$ yields

$$\frac{\partial g_a}{\partial \bar{t}_A} = 2K > 0 \tag{11}$$

$$\frac{\partial g_a}{\partial \bar{t}_B} = -4K < 0, \tag{12}$$

where

[7] This threshold value is not related to the innovation efficiency parameter of its competitor. This property is robust with *ad valorem* and *Iceberg* trade cost function.

$$K \equiv \frac{(2-\phi_b)}{9\gamma - 4(\phi_b - 2)^2} > 0. \tag{13}$$

We have (11) because protection by the home government increases its profitability in its home market, generating more of an incentive to innovate for the firm, and (11) because protection by the rival country makes export less profitable, thereby diminishing the incentive for R&D. Thus,

Lemma 2: A firm's best-response function shifts out when its domestic country raises the tariff and shifts in when the foreign country raises its tariff.

Notice also that

$$\left|\frac{\partial g_a}{\partial \bar{t}_B}\right| > \left|\frac{\partial g_a}{\partial \bar{t}_A}\right|.$$

The reason is that for the model considerincreases thenit increase in the tariff in country B decreases firm a's export by 2/3, while a unit increase in the tariff in country A raises firm A's home sale by 1/3. Thus, the own tariff has less effect on the firm's incentive to invest in R&D than the foreign tariff. In the light of Lemma 3, this discussion implies the next result.

Lemma 3: An increase in the foreign tariff shifts the firm's best-response function inward (or downward) by a greater magnitude than the equal-rate increase in the home country tariff shifts it outward (or upward).

Finally, notice that K is decreasing in ϕ_b (proved by straightforward differentiation). As ϕ_b increases, K falls, so that country B becomes more lax in protecting IPRs, the tariff, regardless of which country imposes, loses its effect on firm A's incentive to invest in R&D, whether the effect is positive as in (11) or negative as in (12). More generally, as the foreign country becomes more lax in IPR protection, the home firm's best-response function shifts less in magnitude as a result of tariffs, regardless of which country imposes the tariff. The next lemma says this more succinctly.

Lemma 4: $\partial \left| \frac{\partial g_i}{\partial \bar{t}_j} \right| / \partial \phi_k < 0$ (i $\neq$ k).

The intuition is based on the general notion in oligopoly that, the higher the firm's output, the greater impact changes in marginal costs have on its profit. This is a standard assumption in general oligopoly models investigating similar issues, but holds exactly for the Cournot model.[8] Back in our model, as IPR protection in the foreign country becomes more lax, the home firm's R&D investment decreases the foreign firm's cost by a greater magnitude through increased copying. As the foreign firm's cost falls, the home firm's equilibrium output decreases in both markets. Then, by the above argument, since output is lower, changes in unit costs, resulting from tariff changes, have less impact on the firm's profit. When profit is less sensitive to tariff changes, the incentive to invest in R&D is also less sensitive to tariff changes, which is what Lemma 4 says.

3. Protection and retaliation

[8] See, e.g., Besley and Suzumura 1992, McAfee and Schwartz 1994 and Miyagiwa and Ohno 1995).

In this section, we examine the effect of protection on equilibrium levels of R&D investment. To economize on algebra and obtain sharper results, we limit our attention to the extreme cases in which ϕ_i takes either zero or unity. If $\phi_i = 0$, the country is called an (IPR law) enforcer. If $\phi_i = 1$, the country is called a non-enforcer. We assume that an enforcer belongs in the North, since intellectual property rights are generally well respected in developed countries. On the other hand, a non-enforcer is likely to belong in the South, since some well-known flagrant IPRs violators are among developing countries.

With these parameter values, for firm a, Lemma 4 implies

$$\frac{\partial g_a}{\partial t_A}(\phi_b = 0) > \frac{\partial g_a}{\partial t_A}(\phi_b = 1) > 0$$

$$\frac{\partial g_a}{\partial t_B}(\phi_b = 0) < \frac{\partial g_a}{\partial t_B}(\phi_b = 1) < 0.$$

Thus, firm a's best-response function shifts by a lesser magnitude when country B violates firm a's IPRs (ϕ_b =1) than when it respects it (ϕ_b = 0). More generally,

Lemma 5: A tariff by either country causes the best-response function of firm i = a, b to shift by a greater magnitude when the rival firm's country j ($\neq$ i) enforces its IPR law, i.e.,

$$\left|\frac{\partial g_i}{\partial t_k}(\phi_j = 1)\right| < \left|\frac{\partial g_i}{\partial t_k}(\phi_j = 0)\right|$$

We can also derive the equilibrium levels of R&D $\{\widehat{g_a}, \widehat{g_b}\}$. When both countries are enforcers, it can be shown that

$$\widehat{g_a}(0,0) = \frac{A - 8B/Z}{Z/4 - 16/Z},$$

$$\widehat{g_b}(0,0) = \frac{B - 8A/Z}{Z/4 - 16/Z}$$

where

$$Z \equiv 9\gamma - 16 > 0$$

by the second order condition, and

$$B \equiv 2 - 2\overline{c} + \overline{t_B} - 2\overline{t_A}.$$

is firm b's counterpart to the term A. The values of $(\phi_a, \phi_b) =$ (0, 0) are denoted in parentheses. When country A is an enforcer while country B is not, we have

$$\widehat{g_a}(0,1) = \frac{A - 8B/Z}{z/2 + 8/Z}$$

$$\widehat{g_b}(0,1) = \frac{B + 4A/z}{Z/4 + 8/z},$$

where the second-order condition gives

$$z \equiv 9\gamma - 4 > Z > 0.$$

Finally, when both are non-enforcers, we have

$$\widehat{g_a}(1,1) = \frac{A + 8B/z}{z/2 + 8/z}$$

$$\widehat{g_b}(1,1) = \frac{B + 8A/z}{z/2 + 8/z}.$$

When there are no tariffs (the benchmark case) A = B, so

$$\widehat{g_i}(0,0) = \frac{4A_0}{Z + 8}$$

$$\widehat{g_i}(1,1) = \frac{2A_0}{z - 4}.$$

where

$$A_0 \equiv 2 - 2\overline{c} - \tau > 0.$$

In the benchmark,

$$\widehat{g}_i(0,0)-\widehat{g}_i(1,1)=\frac{(2A_0)(2z-Z)}{(z-4)(Z+8)}>0$$

because the denominator on the right is positive and

$$2z - Z = 9\gamma + 8 > 0.$$

Proposition 1: World total investment in R&D is smaller when both countries ignore each other's IPRs than when both respect IPRs.

However, there is an incentive not to enforce IPRs on the other country's IPRs, since

$$\widehat{g}_b(0,1)-\widehat{g}_b(0,0)=\frac{A_0(3Zz+32z+16Z+108)}{(zZ+32)(Z+8)}>0\,.$$

Of course this gain in country B comes at the expense of country A:

$$\widehat{g}_a(0,1)-\widehat{g}_a(0,0)<0\,.$$

Proposition 2: In the benchmark case, a country can induce its firm to invest more in R&D by disregarding the rival firm's IPRs, which causes the rival to invest less in R&D.

We first examine the effect of a tariff by country A on firm A's equilibrium net profit, which can be written, in terms of the notation from the preceding section, as

$$\Pi_a(\widehat{g}_a,\widehat{g}_b)=\widehat{\pi}_a(\widehat{g}_a,\widehat{g}_b)-(\gamma/2)\widehat{g}_a^{\,2}\,,$$

where, { $\widehat{g}_a,\widehat{g}_b$ }, it is recalled, is the subgame-perfect Nash equilibrium investment levels, whose values depend on both countries tariff rates. Differentiating and using the envelope theorem, we obtain

$$d\Pi_a(\widehat{g_a},\widehat{g_b})/dt_A = \partial\widehat{\pi_a}(\widehat{g_a},\widehat{g_b})/\partial t_A + (\partial\Pi_a(\widehat{g_a},\widehat{g_b})/\partial\widehat{g_b})(\partial\widehat{g_b}/\partial t_A).$$

Thus, the own country tariff affects firm A's profit through the direct protection effect and also indirectly by influencing the rival firm's R&D decision. The direct protection effect is just the effect of the protective tariff by the home country on firm A's home market profit and is positive as shown below:

$$\partial(\widehat{x_a}^{\,2}/9)/\partial t_A = 2(1-2c_a+c_b+\overline{t_A})/9.$$

The indirect effect is a composite effect. An increase in country A's tariff decreases firm B's investment in R&D. A decrease in B's R&D investment raises firm B's cost It may also decrease firm A's cost if country A is a non-enforcer but this is dominated as seen in the following

$$\partial\Pi_a(\widehat{g_a},\widehat{g_b})/\partial\widehat{g_b}$$

$$= -(2/9)\{(2\phi_A+1)(1-2c_a+c_b+\overline{t_A}) + (1-2c_a+c_b-2\overline{t_B})\} < 0.$$

Summing up the two effects we obtain

$$d\Pi_a(\widehat{g_a},\widehat{g_b})/dt_A > 0.$$

While this is positive, when $\phi_A = 1$ the first term vanishes. Thus, we conclude that the home country tariff raises the firm's profit but by less if the home is a non-enforcer.

The effect of a tariff by country B also decomposes into the similar two effects:

$$d\Pi_a(\widehat{g_a},\widehat{g_b})/dt_B = \partial\widehat{\pi_a}(\widehat{g_a},\widehat{g_b})/\partial t_B + (\partial\Pi_a(\widehat{g_a},\widehat{g_b})/\partial\widehat{g_b})(\partial\widehat{g_b}/\partial t_B).$$

The direct effect is the effect on firm A's profit from exports and is given by

$$-4(1-2c_a+c_b-2\overline{t_B})/9$$

In the indirect effect, we know that firm B increases the level of investment in R&D when country B increases a tariff. So firm A is harmed by country B's tariff.

Incomplete:

We thus consider an extended game in which prior to play by firms two governments choose whether to adopt AD law and enforce it. We assume that the governments' objective is to

Given the governments' penchant for R&D investment, adoption of AD law is the dominant strategy by Lemma 2, so this game has a unique equilibrium in which both countries adopt AD law. However, the interpretations of the equilibrium differ depending on which countries are involved.

In the North-North case, $\phi_a = \phi_b = 0$. By Lemma 2, the foreign country tariff hurts the home country. By Lemma 3, further, the foreign tariff dominates. Thus, while both countries adopt AD measures, the equilibrium is a prisoners' dilemma outcome. We show this in Figure.

Thus, if these countries interact repeatedly, we expect that they try to maintain a cooperative outcome, in which neither country uses AD measures against each other.

The situation is different in the North-South case. Suppose that country A is in the North and country B in the South ($\phi_a = 0$ and $\phi_b = 1$). Again, in a one-shot game, both countries impose AD measures. However, by Lemma 4 AD actions by country B has a muted impact on the best-response functions of firm a, because country A is not an IPR law enforcer. In contrast, country A's AD actions have a more significant effect on firm b's reaction function because IPR law is respected in country A. Therefore, although both firms' best-response functions move inward as a result of both countries' AD actions, the displacement effect is more magnified for country B.

Therefore, firm b's best-response function shifts in more relative to firm a's. Furthermore, by Lemma 1 firm b's reaction function is upward-sloping while firm a's is downward-sloping. Therefore, firm a's equilibrium investment increases and firm b's decreases.

Since country A is a winner there is little room for a cooperative outcome even in a repeated-game setting. Historically, countries in the North have used AD actions extensively on imports from countries in the South, prompting the South to retaliate against the North with similar AD measures.

Finally, consider the South-South case ($\phi_a = 1$ and $\phi_b = 1$). In this case both firms' best-response functions are upward-sloping. Although bout countries have the unilateral incentive to impose AD duties, the one-shot game again has the unique equilibrium in a prisoners' dilemma situation. We therefore expect that both countries will work out a cooperative agreement not to slip into a prisoners' dilemma trap. In fact, AD actions by countries in the South against each other are small in number.

We summarize all the previous results in the following table. The arrows indicate the direction of change in R&D investment under unilateral and bilateral trade protection. The last row indicates the net change in R&D investment that is, the differences between free trade and bilateral protection.

Table 1: Effects of Trade Protection on Firms' R&D

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	North vs. North		North vs. South		South vs. North		South vs. South	
Innovation efficiency	$\phi_a = 0, \phi_b = 0$		$\phi_a = 0, \phi_b = 1$		$\phi_a = 1, \phi_b = 0$		$\phi_a = 1, \phi_b = 1$	
R&D Investment	g_a	g_b	g_a	g_b	g_a	g_b	g_a	g_b
Country:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
A protects **(a)**	↓	↑	↑	↓	↑	↓	↑	↓
B retaliates **(bb)**	↑	↓	↓	↑	↓	↑	↓	↑
Net Effect of (a) and (b)	Θ	Θ	⊕	Θ	Θ	⊕	Θ	Θ

Note: When country A liberalizes this is a reduction of t_A compared to the benchmark equilibrium. When country A protects this is an increase in t_A compared to the benchmark equilibrium. When B retaliates this implies that we compare firms' responses to the unilateral protection equilibrium. The "Net effect" row implies that we compare firms' responses under bilateral protection to the benchmark equilibrium.

5. Discussion of Results and Implications

The first two columns in Table 1 above suggest that protection is unlikely to occur between developed countries in the North, where IPR law enforcement is strict. The reason is that unilateral protection reduces R&D of the protected home firm while it increases that of the foreign firm. Hence from the home country in the North's perspective there is little incentive to take protection. Moreover, the foreign country in the North has no incentive to retaliate since that would reduce its firm's investment in R&D. Therefore, our analysis predicts few instances of antidumping activities amongst developed countries in the North.

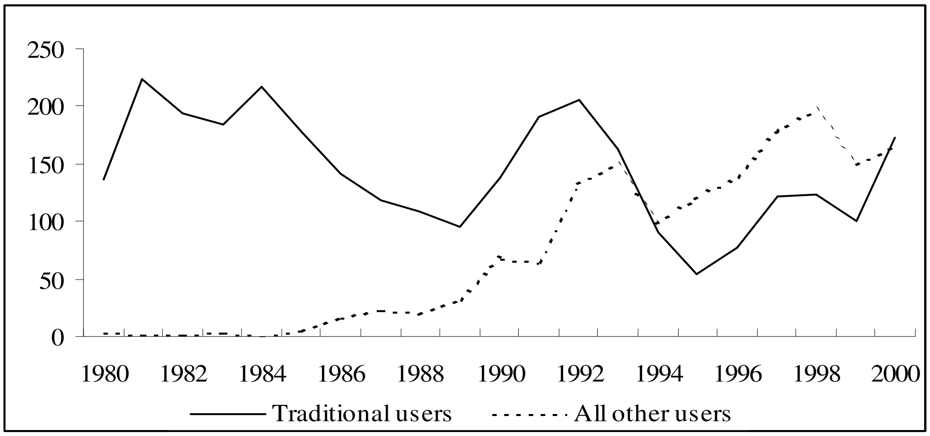
In contrast, the results in columns 3 and 4 suggest that a "Northern" country wants to use protection to boost its R&D and to counter the IPR violation by its

"Southern" trading partner. In addition the "South" has an incentive to retaliate, since that would increase its own R&D. Therefore based on the model we would expect to see most antidumping protection occurring between North and South, where South reacts to the North in a retaliatory fashion.

These theoretical results seem to fit in well with the historical and stylized facts surrounding antidumping protection. Historically it can be noted that until quite recently only a handful of "Northern" countries including the US, EU, Australia, Canada and New Zealand were using antidumping protection in a unilateral fashion. They did not use this type of protection amongst themselves, but predominantly targeted developing countries in the South. Also, recently, there has been a diffusion ("proliferation") of antidumping laws and practices whereby the number of countries adopting antidumping laws more than doubled over the last 20 years (Zanardi, 2004). Empirically, it has been established that the motives underlying this proliferation are mainly retaliatory aspects i.e. developing countries in the "South" have become active antidumping users and target developed countries in the "North" which used to target them heavily. Zanardi (2004) reports that while 37 countries had an AD law in 1980, this number increased to 93 countries by the end of 2000 including countries like Mexico, China, India, Taiwan, Turkey, Peru, Egypt etc. to name just a few. Several empirical papers have by now established that both the adoption of antidumping laws as well as its use by the "South" are mainly driven by retaliatory motives (Vandenbussche and Zanardi, 2008; Prusa, 2001). Indeed, the last four columns of Table 1 show that a country of the "South" does not have an incentive to start using antidumping protection in an offensive unilateral fashion irrespective of whether the trading partner is "North" or "South", since this unilateral protection is likely to trigger retaliatory actions leaving the country that triggered protection in the "South" worse off. Our model therefore confirms the empirical finding that the “South”’s use of antidumping is mainly of the retaliation type.

Theoretically, it can be seen from the results in column 3 in Table 1 that when the “South” retaliates, R&D investment of the firm in the “North” under bilateral protection is still higher than what it would have been under free trade, although it would have been higher in the absence of retaliation. As a result the “North” has a somewhat lower incentive to trigger protection once retaliation by the “South” becomes a distinct possibility. A casual look at antidumping numbers seems to confirm that. Ever since the proliferation of antidumping laws in recent years, the number of AD initiations by the traditional users seems to have slowed down. This is illustrated in Figure 3. Around the same time as the AD initiations by the “new users” of AD started to shoot up as indicated by the dotted line, we observe a slowdown in the number of AD cases initiated by the traditional users as indicated by the full line. This slowdown of AD cases by traditional users is in line with the predictions of our model. Based on our findings we would expect that when retaliation becomes a distinct possibility there will be less AD protection initiated by the traditional users in the first place.

Figure 3: **Antidumping Initiations by Traditional and New Antidumping users**



Notes: i) Traditional users include Australia, Canada, EU, New Zealand, and United States.

ii) all other users: a complete list of all new users can be found in Vandenbussche and Zanardi (2008)

6. Conclusion

This paper looks at the interaction of trade policy, IPR enforcement and firms' incentives to innovate. We use a two-country two-firm model with firms in each country both selling at home and exporting abroad. Our results suggest that trade protection by the "North" against countries that violate IPRs, can spur R&D investment in the "North". In the absence of a good international mechanism to enforce IPRs worldwide, trade protection is likely to be used as a second best instrument to foster R&D. "Northern" countries do not have an incentive to use antidumping protection against other developed countries since that would be detrimental for R&D investment. These theoretical findings seem to be consistent with empirical patterns of antidumping protection described in earlier literature whereby the "North" predominantly targets the "South" with antidumping initiations.

We also shed some new light on the recent proliferation wave of trade protection laws amongst developing countries of the "South". Our theoretical findings clearly show that when targeted by the "North", countries of the "South" have an incentive to retaliate. Our model also predicts that the prospect of retaliation for traditional users of antidumping protection like the US, EU, Australia and Canada reduces their incentive to use protection in the first place since bilateral protection results in a loss of R&D for their firms compared to a situation where neither country takes protection. Therefore based on our model we would expect a slowdown in the number of antidumping protection cases by traditional users. A casual look at the data seems to support this prediction.

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