LICOS Centre for Institutions and Economic Performance
Centre of Excellence

LICOS Discussion Paper Series

Discussion Paper 200/2008

Trade Policy and Innovation

Huasheng Song and Hylke Vandenbussche

Katholieke Universiteit Leuven

LICOS Centre for Institutions and Economic Performance
Huis De Dorlodot
Deberiotstraat 34 – mailbox 3511
B-3000 Leuven
BELGIUM

TEL:+32-(0)16 32 65 98
FAX:+32-(0)16 32 65 99
http://www.econ.kuleuven.be/licos

Trade Policy and Innovation

By Huasheng Song[(a)] and Hylke Vandenbussche[(b)]
(a) CRPE and College of Economics, Zhejiang University, China
(b) Université catholique de Louvain, CORE
February 2008

Abstract[1]

This paper develops a model where firms across countries differ in their capacity to innovate. Our main goal is to study firm level innovation under various trade policy shocks. We consider two countries where firms across countries are heterogeneous in their innovation efficiencies. We find that the benefits of trade liberalization and trade protection differ across firms. One of the main results we obtain is that trade protection hurts the productivity of highly efficient firms while it increases the productivity of lowly efficient firms. The predictions of our model are in line with recent empirical evidence that while trade protection fosters the productivity of lowly efficient firms, it reduces productivity of highly efficient firms.

JEL codes: F12, F13, L13
Keywords: Trade Policy, Innovation, Exports
Addresse for Correspondence: Hylke Vandenbussche, Department of Economics, Université Catholique de Louvain, Place Montesquieu 3, 1348 Louvain-la-neuve, Belgium. hylke.vandenbussche@uclouvain.be.

[1] We are grateful to CORE for the hospitality during the stay of Huasheng Song and to LICOS for financial support. We thank Jacques Thisse, Paul Belleflamme, Kaz Miayagiwa, Claude d'Aspremont, Jim Hartigan, Ray Riezman and Maurizio Zanardi for useful comments on an earlier version.

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. Increasingly countries like the EU and US turn to the use of trade protection such as Antidumping measures (AD) to protect industry specific factors in certain sectors. A recent phenomenon is that developing countries 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).

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 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 across countries. 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). In the first period firms can invest in productivity improvements and in the second period firms produce and sell differentiated products and compete in prices. Firms in this model sell both domestically and export abroad. First we consider how unilateral trade protection by a domestic country affects the incentives of domestic firm and foreign firm to innovate. Second we study innovation incentives when the foreign country follows suit and bilateral protection is in place.

Our results show that firm-level responses to unilateral and bilateral trade policy differs depending on firms’ efficiency in innovation. Unilateral protection hurts the productivity of highly efficient domestic firms while it increases the productivity of lowly efficient domestic firms. High versus low productivity are defined in terms of cost of innovation. Bilateral protection reduces domestic R&D to a level that is lower compared to a situation where neither country takes protection. More in particular when one country uses trade policy to increase R&D, retaliation by a second country will lower R&D in the domestic country to a level that is lower than if it had never engaged in protection to begin with.

The endogenization of productivity has been the subject of many studies in industrial economics. Therefore our findings can also be related to some recent papers in that field like Boone (2000) and Aghion et al. (2005). Both have shown that a firm's response to competition depends on its efficiency level. For instance, Aghion et al. (2005) show both theoretically and empirically that an increase in product market competition reduces innovation incentives for laggards.

In previous literature on innovation and trade protection, the maintained assumption was that firms in the model were symmetric (Gao & Miyagiwa, 2005) (G-M). In the absence of heterogeneous firms, G-M show that firm-level R&D investments across countries are always strategic substitutes. Our model extends G-M by introducing heterogeneity in innovation efficiency across countries and has a broader set of predictions. We find that R&D investments can either be strategic substitutes or strategic complements depending on firms' ability to innovate. 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. Our model encompasses the results of G-M but at the same time we obtain various possibilities for the effects of trade policy on firm-level R&D investment. More specifically, our findings show that while unilateral trade protection spurs innovation of lowly efficient firms, it reduces innovation of highly efficient firms. When protection of lowly efficient firms by one country results in retaliation by another country, the net effect on the first country's firm-level R&D is always negative.

Our theoretical findings correspond well with recent empirical findings of Konings and Vandenbussche (2007). Empirically they show that the effects of antidumping protection on productivity of firms depend on firms' initial productivity. They find that "frontier" firms with a high initial productivity lower their productivity during trade protection while “laggard” firms with a low initial productivity firms increase productivity during protection.

Another way to interpret our results is to think of a lowly efficient innovator as a firm in a developing country and a highly efficient innovator as a firm in a developed country. Recent empirical evidence has shown that in certain sectors notably “Apparel, textiles” and “Footwear”, a number of countries notably China have closed the productivity gap with countries like the EU and the US (Fadinger and Fleiss, 2008). This observation is in line with the predictions of our model that suggests that in sectors where developed countries have lost their edge in innovation there exists an incentive to protect domestic industries. Our model also yields insights that are in line with the predictions by Acemoglu et al. (2003). They find that more ‘backward’ economies have stronger incentives to limit product market competition in order to move closer to the world technology frontier.

This paper is by means in favor of trade protection. The recent proliferation wave of trade protection laws amongst developing countries implies that retaliation is now much more likely than ever before. One of the important results arising from our analysis is that in the face of retaliation domestic R&D is lower compared to a situation where neither country takes protection. Our model predicts that the prospect of retaliation reduces the incentive for traditional users of trade protection laws to use protection in the first place. We present some casual evidence in line with this prediction.

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. Theoretical Model

2.1. The Benchmark (Free Trade) Model

2.1.1. Setup

We consider a world consisting of two countries, which we call A and B. Each country hosts one firm, firm a and firm b, respectively. The firms engage in a two-stage game, first choosing a level of investment in cost-reducing R&D, g, and then compete in prices in both national markets. More specifically, at stage 1: firm a and b

simultaneously and independently decide on the level of cost-reducing R&D investment at a quadratic cost $\gamma(g^2)/2$. As in d'Aspremont and Jacquemin (1988), we assume that the R&D environment is deterministic and that in the following stage each of the firms has constant marginal production cost given by $c_a = \overline{c_a} - g_a$ for firm a (and accordingly $c_b = \overline{c_b} - g_b$ for firm b , $a \neq b$), where g_a is the level of investment in R&D firm a makes in the first stage and similar for g_b which are the variables that interests us most. Similar to Miyagiwa and Gao (2005) and without loss of generality, we assume $\overline{c_a} = \overline{c_b} = \overline{c}$, that means initially the firms have the same marginal production cost [2], but once cost-reduction R&D is taken, their marginal production cost can be different. Our main assumption is that firms have a different efficiency in innovation hence $\gamma_a \neq \gamma_b$. In stage 2, following Anderson *et al*., (1995), we assume that the firms produce differentiated products [3] and compete in prices. By assuming there are trade barriers between the domestic and foreign market and no profitable arbitrage opportunity exits, each firm regards each market as segmented.

We let (*) denote the variables pertaining to a firm's export market. Thus, x_a^* and p_a^* respectively denote firm a 's export demand and price, while x_a and p_a respectively denote the corresponding variables for the domestic market. We assume demands are linear and symmetric in the two national markets. Thus, firm a 's domestic demand and export demand is respectively given by

$$x_a(p_a, p_b^*) = \alpha - p_a + \beta p_b^* \qquad (1)$$

$$x_a^*(p_b, p_a^*) = \alpha - p_a^* + \beta p_b \qquad (2)$$

where α is the parameter pertaining to demand function and is normalized into 1 without loss of generality, and β is the degree of differentiation between the products produced by the firms, we assume $0 < \beta < 1$ so the products are substitutes.

2.2 The second-stage (product market) game

In the second stage the marginal production costs, $c_a = \overline{c_a} - g_a$, are pre-determined by R&D investment in the first stage. Markets are separated by an initial barrier to

[2] Our calculation shows the initial level of marginal cost is irrelevant, firm-specific initial marginal cost causes more computational difficulty while leads to qualitatively the same results.
[3] Brander and Krugman (1983) show that reciprocal dumping does not arise in the homogeneous product case when firms compete *a la Bertrand.*

trade of size $\overline{t}_A$ for firm b (and $\overline{t}_B$ for firm a) per unit shipped between them. The trade barrier can be a transport cost or any non-tariff barrier[4].

Given this assumption on barriers to trade, firm a's second-stage profits is written as

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

Each firm maximizes this profit by choosing prices for each national market independently, taking as given its competitor's prices in the two markets. The first order conditions for firm a are as follow

$$1 + c_a - 2p_a + \beta p_b^* = 0 \qquad (4)$$

for the domestic market and

$$1 + c_a - 2p_a^* + \beta p_b + \overline{t}_B = 0 \qquad (5)$$

for the export market.

Eqs. (4) and (5) define firm a's best-response function in the domestic and the foreign market, written $p_a = r_a(p_b^*, c_a)$, and $p_a^* = r_a^*(p_b, c_a, \overline{t}_B)$, respectively.

Due to the existence of barriers to trade and linear marginal costs the two national markets are effectively segmented and the equilibrium can be obtained by considering each national market separately. That is, we can get the Nash equilibrium $\{\hat{p}_a, \hat{p}_b^*\}$ for the market in country a by first interchanging subscripts a and b in (5) to get firm b's best-response function in its export market (market in country a), and then solving it and (4) simultaneously:

$$\hat{p}_a = \frac{2(1 + c_a - g_a) + \beta(1 + c_b - g_b + \overline{t}_A)}{4 - \beta^2},$$

$$\hat{p}_b^* = \frac{2(1 + c_b + \overline{t}_A - g_b) + \beta(1 + c_a - g_a)}{4 - \beta^2} \qquad (6)$$

where we denote with ($\wedge$) the values pertaining to the benchmark equilibrium.

In this model there is reciprocal dumping, implying that each firm dumps into each other's market. The dumping margin is defined as the difference between the ex-factory export price $p_a^* - \overline{t}_B$ and the home price p_a of the product. The ex-factory price is the theoretical price of the product of country a as it leaves the factory or put differently it is the price charged by a in the export market after deducting all the

[4] Non-tariff barriers (NTB) are trade issues such as technical, bureaucratic or legal questions, which can result in impediments to trade.

costs related to entering its export market b (p_a^* - $\overline{t}_B$). Thus, the dumping margin is defined as.

$$\Delta_a = p_a - (p_a^* - \overline{t}_B) \tag{7}$$

It is easy to show that the dumping margin is positive for firm a, or $\tilde{\Delta}_a = \dfrac{\beta\overline{t}_A + (2-\beta^2)\overline{t}_B}{4-\beta^2} > 0$. It holds for firm b as well, confirming indeed that reciprocal dumping occurs.

Note that

$$\frac{\partial\tilde{\Delta}_a}{\partial\beta} = \frac{(4+\beta^2)\overline{t}_A - 4\beta\overline{t}_B}{(4-\beta^2)^2} > 0 \;\; iff \;\; \overline{t}_B < \frac{(4+\beta^2)\overline{t}_A}{4\beta} \tag{8}$$

which generally holds provided $\overline{t}_A$ is not too different from $\overline{t}_B$. It implies that the dumping margin is an increasing function of β (decreasing in product differentiation) suggesting that less product differentiation leads firms to compete more intensively and to more aggressively dump into each other's home market.

Substituting the equilibrium prices into the profits function, we have firm a's equilibrium profit

$$\tilde{\pi}_a(c_a, c_b) \equiv [\tilde{p}_a(c_a, c_b) - c_a]\tilde{x}_a(c_a, c_b) + [\tilde{p}_a^*(c_a, c_b) - \overline{t}_B - c_a]\tilde{x}_a^*(c_a, c_b) \tag{9}$$

and the equilibrium output levels for domestic and foreign markets

$$\tilde{x}_a(c_a, c_b) = \frac{(2+\beta) - (2-\beta^2)c_a + \beta(c_b + \overline{t}_A)}{4-\beta^2} \tag{10}$$

$$\tilde{x}_a^*(c_a, c_b) = \frac{(2+\beta) - (2-\beta^2)(c_a + \overline{t}_B) + \beta c_b}{4-\beta^2} \tag{11}$$

Eqs. (10) and (11) show that, in both the domestic market and the export market, the market share of firm a decreases with its own marginal cost and increases with the marginal cost of its competitor. That implies that firm a has an incentive to conduct cost-reducing R&D investment to expand its market share.

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

Substituting $c_a = \overline{c} - g_a$ into the equilibrium profit (9) and equilibrium output level (10), (11) yields the following expressions of them as functions of R&D investment level.

$$\pi_a(g_a, g_b) = \frac{1}{A^2}((B + \beta(C + \overline{t}_A))^2) + (B - 2\overline{t}_B + \beta(C + \beta\overline{t}_B))^2) \quad (12)$$

and the corresponding equilibrium output levels are

$$x_a(g_a, g_b) = \frac{B + \beta(C + \overline{t}_A)}{A} \quad (13)$$

$$x_a^*(g_a, g_b) = \frac{B - 2\overline{t}_B + \beta(C + \beta\overline{t}_B)}{A} \quad (14)$$

where $A = 4 - \beta^2$, $B = 2 + \beta + (\beta^2 - 2)\overline{c} + 2g_a$ and $C = \overline{c} - \beta g_a - g_b$.

In this stage, the firms simultaneously and independently choose R&D investment levels, g_a and g_b, to maximize overall profit

$$\Pi_a = \pi_a(g_a, g_b) - \frac{\gamma_a}{2}(g_a)^2$$

$$= \frac{1}{A^2}((B + \beta(C + \overline{t}_A))^2) + (B - 2\overline{t}_B + \beta(C + \beta\overline{t}_B))^2) - \frac{\gamma_a}{2}(g_a)^2 \quad (15)$$

where the second term on the RHS is the quadratic R&D cost function taken from d'Aspremont and Jacquemin (1988), in which the quadratic form is used to model the nature of decreasing return to scale on innovation (the increasing difficulty to obtain innovation). That is, to obtain an innovation (a reduction on marginal production cost) level of g_a, a firm has to invest $\frac{\gamma_a}{2}(g_a)^2$. Different from Gao and Miyagiwa (2005), we adopt firm-specific innovation efficiency parameters, *i.e.*, γ_a for firm a and γ_b for firm b, to investigate the effect of asymmetry in terms of innovation efficiency between firms.

Differentiating the overall profit function Π_a with respect to R&D investment level g_a, we have

$$\frac{\partial \Pi_a}{\partial g_a} = \frac{1}{A^2}[2(2 - \beta^2)(2(B - \overline{t}_B) + \beta(2C + \overline{t}_A + \beta\overline{t}_B)) - A^2 g_a \gamma_a] \quad (16)$$

Let (16) be equal to 0, and from this first-order condition we have that at the optimum:

$$g_a = \frac{2(\beta^2 - 2)(4 + 2\beta + \beta(2(\overline{c} - g_b) + \overline{t}_A) + (\beta^2 - 2)(2\overline{c} + \overline{t}_B))}{4(\beta^2 - 2)^2 - (\beta^2 - 4)^2 \gamma_a} \quad (17)$$

To see how firm a reacts to firm b's R&D investment choice, differentiating g_a with respect to g_b yields

$$\frac{\partial g_a}{\partial g_b} = \frac{4\beta(2-\beta^2)}{4(\beta^2-2)^2-(\beta^2-4)^2\gamma_a} \qquad (18)$$

Thus $\frac{\partial g_a}{\partial g_b} > 0$ if and only if $\gamma_a < \bar{\gamma} = \frac{4(\beta^2-2)^2}{(\beta^2-4)^2}$[5]. That implies firm a's optimal R&D investment level increases with that of firm b if firm a is sufficiently efficient in conducting innovation ($\gamma_a < \bar{\gamma}$), otherwise it decreases.

Proposition 1: *Firm b's R&D investment is a strategic complement for firm a's R&D investment provided firm a is sufficiently efficient in conducting innovation* ($\gamma_a < \bar{\gamma}$), *otherwise it is a strategic substitute for firm a's R&D investment if $\gamma_a > \bar{\gamma}$.*

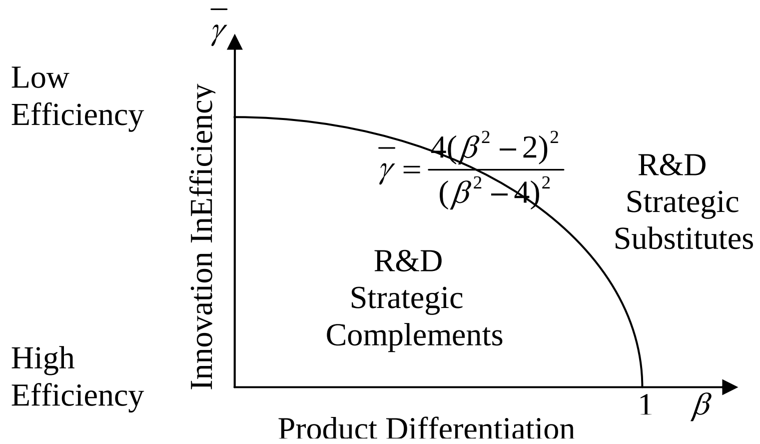
Intuitively this implies that how firm *a* reacts to a change on its foreign competitor b's R&D investment depends on how efficient firm *a* is in innovation. Or put differently when firm a finds it easy to innovate, an increase in firm *b*'s R&D levels will induce it to do the same. This is what is referred to as strategic complementarity of R&D. However, when firm *a* has a weak capacity to innovate as it faces high costs of innovation, an increase in firm *b*'s R&D level will meet a decrease in the R&D level of *a*. This is referred to a strategic substitutability.

When firms have the same efficiency in innovation, $\gamma_a = \gamma_b$, firm-level R&D investments are strategic substitutes as shown by Gao & Miyagiwa (2005). But once allowing for heterogeneity in innovation efficiency between firms, there is a threshold value, $\bar{\gamma}$, that delineates R&D complementarity from R&D substitutability. This threshold value on the innovation efficiency parameter varies with the parameter of product differentiation, β. As products become more similar (increasing β), this threshold value $\bar{\gamma}$ delineating R&D complementarity from substitutability decreases, as depicted in Fig.1.[6] Or, as β gets closer to 1, the R&D investment of each firm is

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

[6] The range of β is between 0 and 1, and the range of $\bar{\gamma}$ is between 4/9 and 1. That is, when β equals to 0 (with the highest level of product differentiation), the corresponding value of $\bar{\gamma}$ is 1; with the increase of β, $\bar{\gamma}$ decreases, when β reaches 1 (with the lowest product differentiation), the corresponding value of $\bar{\gamma}$ is 4/9.

more likely to be strategic substitute for each other when the products are more different. The economic explanation is straightforward: with higher degree of product differentiation, firms compete less intensely.



High **Fig.1** Low

Corollary 1: *Given a firm's innovation efficiency level γ, when product differentiation increases (decreasing β), a firm's R&D investment is more likely to be a strategic complement for another firm's R&D investment.*

2.4. R&D and Trade Policy

The benchmark model discussed above implies reciprocal dumping arises due to the existing trade impediments between countries. For the purpose of our analysis on the impact of (unilateral and bilateral) trade policy, we now distinguish between $\overline{t_A}$ the *initial* level of trade impediments (status quo benchmark) and t_A the *change* in trade barriers resulting from trade policy by country A which can be positive or negative. Hence the total amount of trade barriers in the model under new trade policy are $\overline{t_A} + t_A$. A positive value of t_A represents additional trade protection for instance in the form of antidumping protection (AD)[7] imposed by country A. Clearly, $t_A + \overline{t_A}$ is a simple linear combination of t_A and $\overline{t_A}$, thus all the previous results naturally extend to the cases of new trade policy, simply by substituting $t_A + \overline{t_A}$ the new tariff into the

[7] In principle our results hold for a continium of values of t_A. The antidumping duty which would set t_A equal to the dumping margin Δ_b as in Blonigen and Haynes (2002) is just a special case in our model

corresponding equations. While our benchmark model is just a special case in which $t_A = t_B = 0$. Without loss of generality, for the moment we further assume $\overline{t_A} = \overline{t_B}$ and $t_A = t_B = 0$, that is we start from the status quo situation in which both countries have the same level of trade barriers. Substituting them into the corresponding equilibrium equations, we get the relevant equilibrium values for the status quo (the benchmark).

To investigate how firm a's R&D investment decision is affected by the tariff levels, we derive the first order differentiation of g_a with respect to the tariff t_B imposed by country b on firm a's exports to country b market, and the tariff t_A imposed by country a on imports from firm b located in foreign country B. Immediately, we have the following lemma that summarizes the result on unilateral protection:

Lemma 1: *Firm A's R&D investment increases with foreign tariff* t_B *if and only if* $\gamma_a < \overline{\gamma}$*, and increases with tariff* t_A *against foreign imports if and only if* $\gamma_a > \overline{\gamma}$.

Intuitively this implies that when a domestic firm faces a tariff in its export market it will increase its R&D provided it is a good innovator meaning the cost of innovation is low. And the opposite holds when the domestic firm is a bad innovator. In that case a tariff abroad will reduce its R&D levels. This is what we call the *direct effect*. The second part of the Lemma deals with the situation where a domestic firm is protected by a domestic tariff against imports from abroad. In this case the domestic firm has an incentive to increase its R&D spending but only in the case where it is a bad innovator. And the opposite holds when the domestic firm has a low cost of innovation. This is what we call the *indirect effect*. When country A imposes a tariff on imports from B, the tariff t_A is not directly targeted at the firm in A, but it has an indirect effect on firm A's R&D choice via its competitor B's R&D choice.

It can be easily verified that in terms of magnitude, a tariff abroad sorts more effect on R&D levels than a domestic tariff. Or put differently, the direct effect on R&D dominates the indirect effect which can be seen from (19).

$$\left|\frac{\partial g_a}{\partial t_B}\right| = \left|\frac{2(\beta^2-2)^2}{4(\beta^2-2)^2-(\beta^2-4)^2\gamma_a}\right| > \left|\frac{2\beta(\beta^2-2)}{4(\beta^2-2)^2-(\beta^2-4)^2\gamma_a}\right| = \left|\frac{\partial g_a}{\partial t_A}\right| \quad \ldots\ldots. (19)$$

Which implies that firm a's investment is more significantly affected by t_B than by t_A. Thus lemma 2 follows:

Lemma 2: *The impact on a firm's equilibrium R&D investment level of a foreign tariff is more significant than the tariff imposed by its home country on the imports from a foreign firm, i.e., the direct effect dominates the indirect effect.*

Now we derive the Nash equilibrium level of R&D investment $\{\tilde{g}_a, \tilde{g}_b\}$ by first interchanging subscripts a and b in (17) to get firm b's best-response function in its R&D decision, and then solving it and (17) simultaneously:

$$\tilde{g}_a = \frac{2(\beta^2-2)(D+E+F)}{4(\beta^2-2)^2[4(1-\beta^2)+(\beta^2-4)\gamma_b]-(4-\beta^2)\gamma_a[4(\beta^2-2)^2-(\beta^2-4)^2\gamma_b]} \quad \ldots (20)$$

where $D = 2(1+c(\beta-1))((\beta^2-4)(2+\beta)\gamma_b - 4(1+\beta)(\beta^2-2))$, $E = 4(1-\beta^2)(\beta^2-2)t_B$ and $F = (\beta^2-4)(\beta t_A + (\beta^2-2)t_B)\gamma_b$.

We have the equilibrium level for firm b simply by interchanging the subscripts a and b in (20). By substituting the equilibrium R&D investment levels into the previous functions, we immediately obtain the equilibrium outputs and profits. But in the remainder of the paper we focus on R&D incentives and we evaluate the impact of (unilateral and bilateral) trade protection on them.

3. Unilateral Trade Protection

First, we analyze the effect of unilateral trade protection, that is, when only one country adopts trade protection. Without loss of generality, we assume it is country A that increases its tariff t_A against imports from country B.

Under unilateral protection by country A we assume this tariff is not prohibitively high for the firms from country B to keep exporting in the presence of trade protection.

For the remainder of the analysis, in particular Lemma 1 and Lemma 2 are important. From **Lemma 1** we know that when country A imposes a tariff against imports, the R&D effect on its own firm in A depends on its efficiency in innovation.

If the firm in A is an efficient innovator, the protection will lower its R&D spending, but if the firm in A is a "laggard" and innovation is costly, the tariff will increase its R&D. In terms of the R&D of the trade partner, **Lemma 1** tells us that R&D response by the foreign firm in B to trade protection by country A also depends on the innovation efficiency of the firm in B. If the firm in B is an efficient innovator it will increase its R&D spending when facing protection in its export market. However, when the firm in B is a lowly efficient innovator, trade protection by country A will reduce its R&D spending.

Finally, Lemma 2 points out that the effect in terms of R&D investment change of tariff protection by country A in equilibrium will be stronger for the firm in B than for the firm in A. This is important for the graphical analysis we pursue below since it limits the relative magnitude of the shifts of firms' best response functions due to trade protection by A.

Thus, conditioned on the innovation efficiency of firms, we have several possible configurations as demonstrated below.

3.1.) Unilateral Protection: "Developed versus Developed"

We first consider the case where both firms in both countries A and B are efficient in innovation that is their cost to innovate lies below a threshold value $\gamma_a < \overline{\gamma}$ and $\gamma_b < \overline{\gamma}$. Proposition 1 stated that in such a case for each firm the R&D investment of its competitor is a strategic complement for its own R&D investment. Thus firm a and firm b have upward sloping reaction functions depicted as in Fig.2.a, in which the reaction curve of firm a is R_a and the reaction curve of firm b is R_b, and E is the original benchmark equilibrium. With unilateral trade protection imposed by country a, firm b's reaction curve moves outward (right-ward) to $R_b^{'}$, and firm a's reaction curve moves inward (down-ward) to be $R_a^{'}$. Thus with unilateral protection by country A we have a new equilibrium E', in which the firm in A reduces its investment in R&D and the firm in B increases its R&D investment.

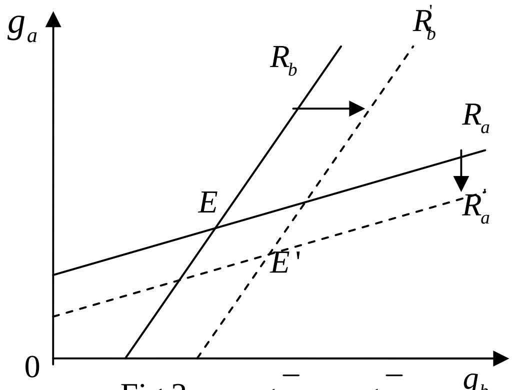


Fig.2.a. $\gamma_a < \bar{\gamma}$, $\gamma_b < \bar{\gamma}$

$g_a^{E'} < g_a^{E}$ and $g_b^{E'} > g_b^{E}$

Or, put differently, in an industry where two countries have a strong capacity to innovate, unilateral trade protection slows down the innovation efforts of the domestic firms but spurs R&D investment by the foreign firms.

3.2.) Unilateral Protection: "Developed versus Developing"

Next we turn to the case where country A is a developed country with the firm in A highly-efficient in innovation and the firm in a developing country B is lowly efficient in innovation. From Proposition 1 we know that for the efficient innovator in A, the R&D investment of the firm in B is a strategic complement, resulting in an upward sloping best response function. While for the firm in B, the R&D investment of its competitor in A is a strategic substitute, resulting in a downward sloping best response function. Thus firm a and firm b have their reaction functions depicted as in Fig.2.b, in which E is the original equilibrium under the benchmark case. From Lemma 1 we know that with unilateral trade protection by country A, the firm b's reaction curve moves inward (down-ward), and firm a 's reaction curve moves outward (right-ward). Thus we have a new equilibrium E', in which firm a reduces its R&D investment and firm b also reduces its R&D investment.

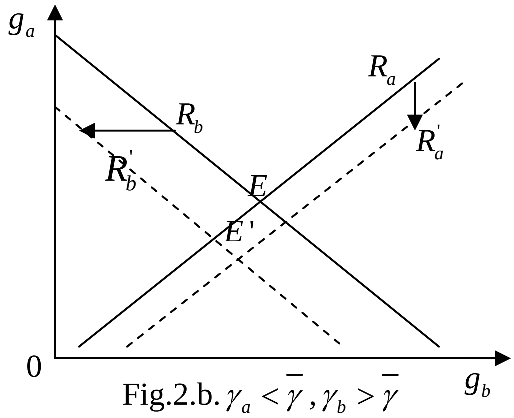


Fig.2.b. $\gamma_a < \bar{\gamma}$, $\gamma_b > \bar{\gamma}$

$g_a^{E'} < g_a^{E}$ and $g_b^{E'} < g_b^{E}$

3.3) Unilateral Protection: "Developing" versus "Developed"

For completeness we also want to consider what happens in the case where country A is a developing country with low innovation efficiency would use unilateral trade protection against a developed country B with high innovation efficiency. The analysis would be exactly the opposite as the one described in the section above (3.2.). Unilateral protection by the developing country A would increase R&D of its domestic firms and also increase R&D spending of firms in B.

3.4.) Unilateral Protection: "Developing versus Developing"

Finally let us consider the case where both countries have high costs of innovation, This can be thought of as two developing countries competing with each other. From Proposition 1 we know that in such a case for each firm the R&D investment of its competitor is a strategic substitute for its own R&D investment and best response functions are decreasing. Thus firm a and firm b have their reaction functions depicted as in Fig.2.c, in which E is the original equilibrium under free trade (the benchmark case). With unilateral trade protection imposed by country A, the firm in B's reaction curve moves inward (left-ward), and firm a's reaction curve moves outward (right-ward). Thus we have a new equilibrium, in which the firm in A increases its investment on R&D while the firm in B decreases its R&D investment.

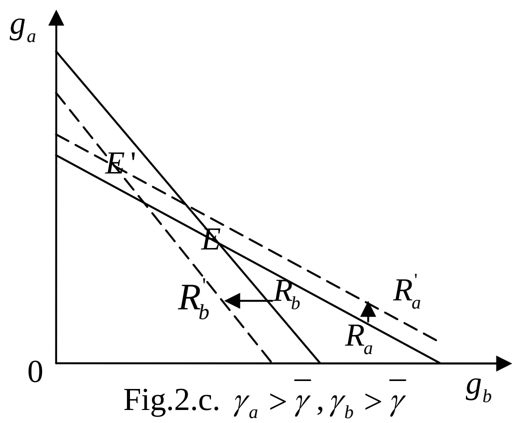


Fig.2.c. $\gamma_a > \bar{\gamma}, \gamma_b > \bar{\gamma}$

$g_a^{E'} > g_a^E$ and $g_b^{E'} < g_b^E$

4. Bilateral Trade Protection

After considering unilateral protection by country A, we now turn to the scenario of bilateral protection in which country B follows suit and also adopts an import tariff of the same level that is $t_A = t_B$. Again we assume this tariff is not prohibitively high and allows all firms to continue exporting even in the presence of bilateral trade protection. Obviously this is a simplifying assumption but it allows us to easily distinguish the effects of unilateral versus bilateral protection.[8]

From **Lemma 1** and **Lemma 2** we know that a tariff by country B increases the R&D level of firm *b* if and only if the firm in B is lowly efficient in innovation. The effect on firm *a* of a tariff by B also depends on the innovation efficiency of the firm in A. If the firm in A is a highly-efficient innovator a tariff by B will raise its R&D levels otherwise it will lower them. Moreover, we know that the direct effect dominates the indirect effect. That is, for the firm in A, the effect of a tariff by B on its R&D dominates the effect of a domestic tariff imposed by country A. and similarly for the firm in B. Thus, conditioned on the innovation efficiency of firms, again we have several configurations as demonstrated below.

4.1.) Bilateral Protection: "Developed versus Developed"

If both countries are developed countries and efficient in innovation, firms' best response functions are upward sloping as depicted in Fig.3.a. Starting from the

[8] In this paper we do not go in search of the first-best type of trade policy. The symmetry we assume largely simplifies things and allows us to focus on R&D incentives.

unilateral protection scenario (see 3.1. above) in which only country A adopts trade protection, if country B also adopts protection, *i.e.*, increases t_B, the reaction curve of the firm in B shifts back (left-ward), but to a lesser degree (by **Lemma 2),** the new one is $R_b^{''}$; and the reaction curve of the firm in A shifts back as well (up-ward), but by more (by **Lemma 2**) and the new reaction curve $R_a^{''}$ overtakes the original reaction curve R_a. Thus we have the corresponding equilibrium under bilateral trade protection, E'', in which $g_a^{E'} < g_a^{E} < g_a^{E''}$, $g_b^{E} < g_b^{E''} < g_b^{E'}$.

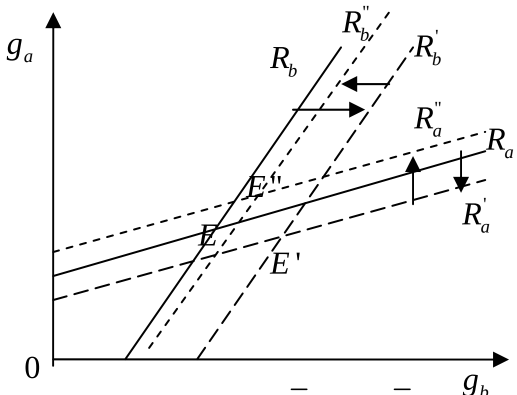


Fig.3.a. $\gamma_a < \bar{\gamma}$, $\gamma_b < \bar{\gamma}$

$g_a^{E'} < g_a^{E} < g_a^{E''}$ and $g_b^{E} < g_b^{E''} < g_b^{E'}$

So with the adoption of trade protection by a developed country B, the firm in A increases R&D investment while the firm in B reduces R&D investment. However, the total R&D investment level is greater for both firms compared to that under the benchmark case in the absence of any AD. Thus the net effect of bilateral trade protection on R&D is positive for both firms.

4.2.) Bilateral Protection: "Developed versus Developing"

Now let us suppose that country A is a developed country with a firm in A that is highly efficient in innovation while the firm in B is not. Thus firm in A and the firm in B have their reaction functions depicted as in Fig.3.b. We start from the unilateral protection scenario in which only country A adopted trade protection. When a developing country B that hosts an inefficient firm retaliates and adopts protection, *i.e.*, increases t_b, the reaction curve of the firm in B shifts back (right-ward), the new one is $R_b^{''}$; and the reaction curve of the firm in A shifts back (up-ward) as well and overtakes the original reaction curve R_a, the new reaction curve is $R_a^{''}$. Thus we have the corresponding equilibrium under bilateral trade protection, E'', in which $g_a^{E'} < g_a^{E} < g_a^{E''}$, $g_b^{E'} < g_b^{E''} < g_b^{E}$. So with the adoption of trade protection by the developing country B, both firms increase R&D investment. However, compared to that under the benchmark equilibrium, the efficient firm in A's R&D investment level is greater while the inefficient firm in B's R&D investment is lower. Thus the net effect of bilateral trade protection is positive for the firm in A, but negative for the firm in B.

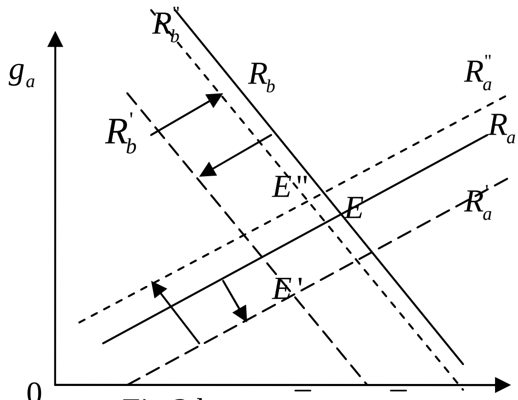


Fig.3.b. $\gamma_a < \bar{\gamma}, \gamma_b > \bar{\gamma}$

$g_a^{E'} < g_a^{E} < g_a^{E''}$ and $g_b^{E'} < g_b^{E''} < g_b^{E}$

4.3.) Bilateral Protection: "Developing versus Developing"

Next we consider what happens if both countries are developing countries with firms lowly efficient in innovation. Thus both firms have downward sloping best response functions depicted as in Fig.3.c, Starting from the unilateral protection scenario in which only country A adopts trade protection, then if country B also adopts protection, *i.e.*, increases t_B, the reaction curve of the firm in B shifts back (right-ward)**,** the new one is $R_b^{''}$; and the reaction curve of the firm in A shifts back (down-ward) as well and overtakes the original reaction curve R_a, that is the new reaction curve $R_a^{''}$. Thus we have the corresponding equilibrium under bilateral trade protection, E'', in which $g_a^{''} < g_a^{E} < g_a^{E'}$, $g_b^{E'} < g_b^{E''} < g_b^{E}$. So with the adoption of trade protection by country B, the firm in A reduces R&D investment while the firm in A increases R&D investment. However, the R&D investment level under bilateral protection is lower for both firms compared to that under free trade. Thus the net effect of bilateral trade protection is negative for both firms.

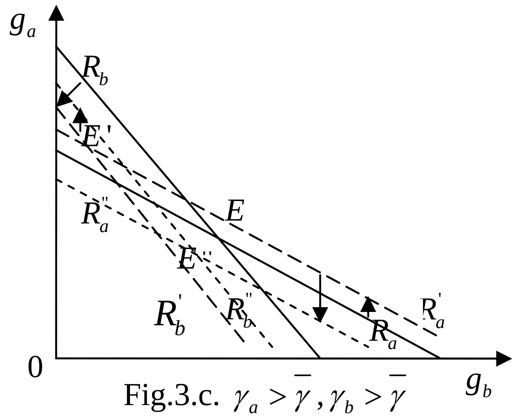


Fig.3.c. $\gamma_a > \bar{\gamma}, \gamma_b > \bar{\gamma}$

$$g_a^{''} < g_a^E < g_a^{E'} \text{ and } g_b^{E'} < g_b^{E''} < g_b^E$$

We summarize all the previous results in the following table. Using arrows in Table 1 we indicate the direction of R&D investment in the firm in A and the firm in B under different trade policy scenarios: unilateral trade protection and bilateral trade protection. The last row indicates the “net effect” that is the total amount of R&D per firm compared to the benchmark equilibrium.

Table 1: Effects of Trade Protection on Firm’s R&D

.

	Developed vs. Developed		Developed vs. Developing		Developing vs. Developed		Developing vs. Developing	
Innovation efficiency	$\gamma_a < \bar{\gamma}, \gamma_b < \bar{\gamma}$		$\gamma_a < \bar{\gamma}, \gamma_b > \bar{\gamma}$		$\gamma_a > \bar{\gamma}, \gamma_b < \bar{\gamma}$		$\gamma_a > \bar{\gamma}, \gamma_b > \bar{\gamma}$	
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

Note: When country A liberalizes this is a reduction of compared to the benchmark equilibrium. When country A protects this is an increase in 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.

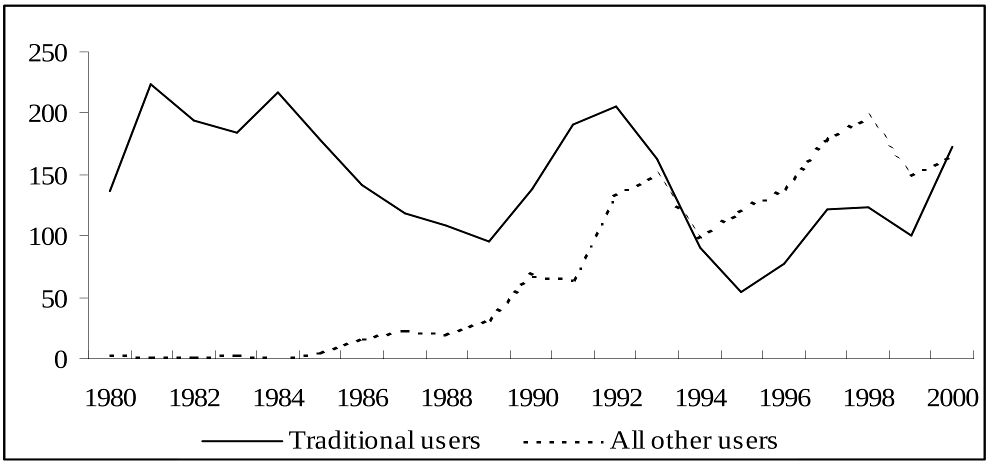
5. Discussion of Results and Implications

Our results show that the effects of trade protection on firm-level R&D differ across firms. While unilateral trade protection by country A can boost productivity of lowly efficient firms in A (cells 5a and 7a), it hurts the productivity of highly efficient firms in A (1a and 3a).

Interestingly, in those cases where unilateral trade protection boosts R&D efforts of domestic firms, once retaliation is allowed for and bilateral protection kicks in, these same domestic firms loose. This can be seen from the "net effect" at the bottom of column 5 and 7 in Table 1. Hence, while a country may be inclined to protect its lowly efficient firms through antidumping protection, retaliatory action by a trade partner implies that the net amount of R&D spending will be lower than under the benchmark equilibrium in the absence of any antidumping protection. Results in Table 1 would suggest that in the absence of any retaliation, countries may be inclined to use unilateral (AD) protection to boost R&D investment of domestic firms in industries where they lag behind in innovation ability. However, once retaliation becomes a distinct possibility, countries are more likely to refrain from using antidumping protection since the results in Table 1 show that R&D efforts under bilateral protection are below benchmark levels.

The recent proliferation of Antidumping laws especially amongst developing countries has substantially increased the retaliatory power of these developing countries (Prusa, 2001). 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. The proliferation does not seem to be confined to any particular region but includes developing countries from Asia, Latin-America and former Eastern Europe and seems to be primarily driven by retaliation motives. That is, especially those countries that in the past were subject to antidumping duties in their export markets seem more likely to pass trade protection laws of their own (Vandenbussche and Zanardi, 2008). Before the diffusion of Antidumping laws took off, there were only a handful of countries using AD protection unilaterally. They involved the US, EU, Australia, Canada and New Zealand. The countries these traditional users targeted mainly involved less developed countries in Latin-America, Asia and former Eastern-Europe. At that time these traditional users of antidumping did not face much risk of retaliation and cases were plentiful. However, in recent years the number of AD initiations by the traditional users seems to have slowed down. This is illustrated in Figure 1. 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.

Figure 1: **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)

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.

6. Conclusion

This paper looks at the interaction of trade policy 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 countries whose domestic firms lag behind in terms of innovation efficiency have an incentive to unilaterally protect their industry to boost R&D investment. This incentive only arises when domestic firms are laggards in innovation. Unilateral protection would hurt the R&D investment of already efficient firms. We also shed some new light on the recent proliferation wave of trade protection laws amongst developing countries. Our model 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.

References

Aghion, P., N. Bloom, R. Blundell, R.Griffith and P.Howitt, 2005. Competition and Innovation: An Inverted-U Relationship, *The Quarterly Journal of Economics*, 120, 701-728.

Anderson, S., N. Schmitt and J. Thisse, 1995, Who Benefits from Antidumping Legislation, *Journal of International Economics,* 38, 321-337.

Belleflamme, P., 2001, Oligopolistic competition, IT use for product differentiation and the product paradox, *International Journal of Industrial Organization*, 19,227-248.

Blonigen, A. and S. Haynes, 2002, Anti-dumping investigations and the pass-through of anti-dumping duties and exchange rates, *American Economic Review,* 92, 1044-1061.

Brander, J., and P. Krugman, 1983, A 'Reciprocal Dumping' Model of International Trade, *Journal of International Economics*, 15, 313-321,

Boone, J., 2000, Competitive Pressure: The Effects on Investments in Product and Process Innovation', *RAND Journal of Economics*, 31, 549-569.

Cheng, L., L. Qiu and K. Wong, 2001 Anti-dumping measures as a tool of protectionism: a mechanism design approach, *Canadian Journal of Economics*, 34, 639-690.

d'Aspremont, C., and A. Jacquemin, 1988, Cooperative and non-cooperative R&D in duopoly with spillover, *American Economic Review*, 78, 1133-1137.

Demidova, S., and A. Rodriguez-Clare (2007),"Trade Policy under firm-level heterogeneity in a small economy", *NBER working paper* n° 13688.

Ederington, J., and P. McCalman, 2008, Endogenous firm heterogeneity and the dynamics of trade liberalization, *Journal of International Economics,* (Article in press).

H. Fadinger and P. Fleiss, 2008,"Trade and Sectoral Productivity", ECORE discussion paper 2008/4.

Gao, X., and K. Miyagiwa, 2005, Antidumping protection and R&D competition, *Canadian Journal of Economics*, 38, 211-227(17).

Konings, J., and H. Vandenbussche, 2008, "Heterogeneous Responses of Firms to Trade Protection: A Firm Level Analysis, *CEPR Discussion Paper*, n° 6724, London.

Melitz, M., 2003, The impact of trade on intra-industry reallocations and aggregate industry productivity, *Econometrica,* **71,** 1695–1725.

Prusa, J., 2001, On the spread and impact of anti-dumping, *Canadian Journal of Economics*, 34, 591-611.

Spencer, J. and J. Brander, 1983, International R&D rival and industrial strategy, *Review of Economic Studies*, 50, 702-722.

Vandenbussche, H and M. Zanardi , 2008, "What Explains the Proliferation of Antidumping Laws?", *Economic Policy* 53, January.

Zanardi, M., 2004, Antidumping: What are the Numbers to Discuss at Doha?, *The World Economy* 27(3), 403-433.