TRIPS under no enforcement of the national treatment commitment rule

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Abstract

This paper analyzes international intellectual property rights (IPR) protection. Our focus is on the National Treatment Commitment Rule (NTCR), under which each country is obliged to treat equally national and foreign patent applicants and to protect equally their rights once the patent is granted. The actual literature on the topic takes its enforcement as granted, in spite of clear empirical evidence on countries' misbehavior.

We use the setup of Lai and Qiu (2003), relaxing the assumption on the respect to the National Treatment Commitment Rule. The results of the model change dramatically. We find that at equilibrium the case where both the North and the South protect northern and southern IPRs is only one possibility among several others. We analyze the conditions on the countries' market sizes and innovative capability under which each corner solution arises. Moreover, we find that the social optimum requires the South not to protect any IPRs and the North to protect them on both northern and southern products to a larger extent than the North does at equilibrium. Further remarks on the lack of optimality of the actual international IPR protection system are also made.

I - Introduction

The patent system has always given rise to controversies, which have increased with the development of international trade in the actual globalized world. The acceptance of intellectual property rights (IPRs) as an essential tool is recent and not universal. The recognition of its importance came up with the signature of the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs), included in the final Act of the Uruguay Round of WTO negotiations (1994). Countries like Argentina, India, Egypt or South Africa had by that time no patent protection at all.

For the developing countries where innovative industries are absent, patents are most likely seen as barriers to consumption. Many of these countries are very poor and their population suffers from specific diseases. Consequently, TRIPS will possibly play a central role in the field of pharmaceutical drugs in these economies.

Many industrialized countries only introduced patent protection on pharmaceutical products in their legal system quite recently. That was the case of the United Kingdom (1949), France (1960), Germany (1968), Japan (1976), Switzerland (1977), Italy and Sweden (1978) and Spain (1992)[1]. Bermudez (1992) affirms that these countries had made use of this absence of patent rights for developing their pharmaceutical industries and only started to recognize patents once they achieved competitiveness. The author also mentions the Brazilian CEME (Central Office of Medicines) as a failed tentative of following a similar track. India, in contrast, developed a quite successful policy in this way (Ramani and Maria, 2004).

Developing countries argue they were led to sign the TRIPS Agreement by the pressure of rich countries, and the promise of liberalization in other sectors, such as the reduction of barriers to trade in agricultural and textile products. They say they will incur large welfare losses under the TRIPS patent system. According to them, it is a mechanism responsible for perpetuating the technology and patents concentration in developed economies, at the same time that it restricts access of consumers of poor countries to medicines.

In the TRIPS world, developing countries are compelled to protect existent and future patents, concentrated in rich countries. Governments and firms of poor countries will then have to pay great amounts of money as royalties[2]. This money will mostly flow abroad and

[1] The source of these dates is Fiuza and Lisboa (2001).
[2] This issue has been exploited in Morais (2002).

finance R&D in the developed countries[3]. Moreover, a large fraction of the population in these countries can simply not afford the existing drugs which are sometimes essential to human life, because they are priced above marginal cost[4]. These high prices[5] are usually more related to the market power of the patent holder than to the production and distribution costs (Scherer (1993) and Chien (2003)).

Like in Lai and Qiu (2003), our main concern are the positive externalities generated by one country when it grants patents, particularly in terms of consumers' access to better and more (differentiated) products.

When country X grants patents to products developed in Y, above the consumers' loss, there is a direct positive impact on Y firms' profits; additionally more products are going to be invented in Y, which will benefit consumers in both X and Y. Therefore there is a positive externality of X's patents of Y's innovations not only on the profits of firms in Y but also on the surplus of consumers in Y – at least in the long run, through the increase in the number of products available to consumers in Y. On the other hand, when country X grants patents to its domestic innovations, firms are statically better off at the expense of consumers in X but consumers (in both X and Y) dynamically benefit from a greater variety of products. As so, there is also a positive externality here, but effective only on consumers in Y (and not on firms in Y).

In Lai and Qiu (2003), since government X is constrained to provide the same protection to its own innovations and Y's innovations, all these effects are added up and therefore undistinguishable. In our framework, each set of effects is the consequence of a change in a distinct choice variable, as described in the previous paragraph.

This principle has been present in International Law since the Paris Convention for the Protection of Industrial Property (May 1883). The objective of the NTCR was to guarantee expatriated inventors making an effective R&D effort abroad the same rights as native ones when applying for an IPR protection. According to a 1964 report by the United Nations Secretary General[6], most countries were respectful of this principle, including the majority of the developing ones. The interpretation of the principle has been broadened in recent times in

[3] This was discussed in Chien (2003). Worse than those taxable royalties, the subsidiaries in the developing countries are commonly charged artificially inflated transfer prices, in order to reduce their profitability, causing fiscal evasion.
[4] This point has recently been discussed by Grossman and Lai (2004) but has still not been incorporated to the economic analysis explicitly.
[5] Prices are high but non-discriminatory. Producers are not allowed to discriminate and charge lower prices to the southern countries. If they do so, they will face not only a public campaign in the media against high prices in the North, but also parallel imports.
[6] See the bibliography for the precise reference: United Nations Secretary General (1964)

order to require every country to recognize and protect IPRs developed abroad. Much diplomatic pressure has been exerted by the developed economies in order to ensure protection overseas, especially for pharmaceuticals, where the amount of money involved is particularly huge.

This has been questioned by most developing countries since they do not benefit of any counterpart from such protection – what would be the case if the R&D expenses were made in their territory – except from the long-run benefits to consumers of a greater product variety. Poor countries' consumers, however, pay in the short run the costs of such protection: high medicine prices and, in many cases, no access to existing drugs.[7]

In the real world, the National Treatment Commitment Rule in its broader sense is most of the time legally respected but not effectively implemented, being OCDE countries the only possible exception[8]. The non enforcement of this principle with respect to IPRs other than patents is clear given the amount of piracy and illegal copying and imitations concerning all sorts of differentiated goods. For patents, a relevant example concerns the gap between patent applications and concessions, as shown by the following 2000 data extracted from the WIPO website.

- Patent applications (1st column) and patents granted (2nd): residents X non-residents
  - Albania: 1 X 11609 0 X 203
  - Armenia: 123 X 58154 96 X 72
  - Australia: 10367 X 70354 1301 X 12615
  - USA: 175582 X 156191 85071 X 72425

This small sample reveals the gap between numbers for big and small economies. Moreover, in the USA and Australia we see no distinction between residents and non-residents: roughly half of the applications turn into a grant in the USA and Australia even seems to be tougher towards residents than non-residents. Albania and Armenia represents the preference for residents and a tendency not to grant patents to foreigners, a common feature in small economies.

Lai and Qiu (2003) and Grossman and Lai (2004) take the respect to the National Treatment Commitment Rule in its extended interpretation as granted. In the former each country has only one choice variable, since the term of patent protection is assumed to be the

[7] In our model, as in Lai and Qiu (2003), the short-run loss is comes from having to pay the monopoly price.
[8] Hoekman (1994) mentions that flows associated with Intellectual Property (IP) are smaller than merchandise trade, but are quite substantial. For 1990, global merchandise trade accounted for US$ 3.5 trillions, while global receipts for IP accounted for US$ 33 billions. A relevant point is that 97,6% of these US$ 33 billions are transferred between OCDE countries.

same irrespective of the product origin. The latter article goes even further by assuming each country to be not only legally protecting both national and foreign patents for the same number of years, but also explicitly takes any country to be effectively enforcing both to the same extent in practice.

In our model, we relax this assumption. Once the NTCR is violated, countries are allowed to choose the two levels of protection of IPRs independently: one for domestically developed goods and one for goods invented abroad. We show that in this case the results of Lai and Qiu (2003) do not hold anymore.

In the following list we summarize some of the main results of our paper:

- Having the market for differentiated products in the North larger than the one in the South is enough to ensure that the North always protects its own innovations to some extent, with or without NTCR. It ensures that no matter the magnitude of the free-riding of the small economy on the big one, it will never lead the big one to completely give up protecting IPRs.
- The higher the gap between market sizes, the lower shall be the protection granted by the South and the higher the protection granted by the North to both national and foreign innovations. In other words, the larger that gap the larger will be the free-riding of the South on the North's behavior as regards IPRs.
- No matter how much larger the market in the North is vis-à-vis the market in the South, innovations from the South are always somehow protected. It can be the case that only the South issues property rights on southern inventions, that only the North protects them or that both do it.
- An interior solution (where both the North and the South protect northern and southern innovations to some strictly positive extent) requires a moderate level of the ratio between market sizes, the innovation cost in the North to be small enough and the one in the South not to be too large.
- The social optimum requires the South not to protect any IPRs and the North to protect them on both northern and southern products to a larger extent than the North does in equilibrium.

II - The Model

II.1 - The Setup

We build a model with two countries (or two regions), denoted by S (South) and N (North). There is no a priori assumption on the legal adoption or on full enforcement of the national-treatment commitment rule (NTCR).

Let T be the length of the product cycle. After T periods, each product becomes obsolete and has no economic value.

The government of region k sets patent lengths T_{kk} and T_{-kk} for k Є {S, N} where the first subscript denotes the region where the good has been invented/developed and the second one denotes the region where it is sold/consumed. It is important to emphasize that the second subscript determines whose choice variable a T_{jk} is: the government of k sets the duration of the patents it issues, whatever the origin of the products.[9]

Let M_k be the number of differentiated products developed in region k in each period. We assume a repetitive environment of scarce resources, so that M_k is constant. In other words, although we have a dynamic model – with the familiar dilemma of patent creating between short-term losses due to reduced competition and long-term benefits due to increased innovation – we compute the steady state and then perform static optimization.

Before time T, the number of goods available to consumers is growing from period to period. After T, M_S and M_N become steady. To simplify the analysis of this steady state, we assume a zero discount rate. As a consequence, we can focus exclusively on the steady-state flow welfare for the purpose of welfare analysis. We consider exclusively the market for differentiated goods, with a highly innovative component and therefore where IPR protection plays a crucial role.

In every steady-state period, there are TM_S and TM_N South-invented products and North-invented products, respectively, which are economically viable. Out of those, $T_{SS}M_S$ + $T_{NS}M_N$ products' patents are still in force in the South and $T_{NN}M_N$ + $T_{SN}M_S$ products' patents are still in force in the North.

[9] The reader should keep this definition in mind throughout the paper since this will be essential for the understanding of the model.

Keeping the Lai and Qiu's quasi-linear structure for the utility function, the steady state flow utility of the representative consumer in region k, coming from the differentiated products is:

$$u_k(t) = T_{kk}\left[\int_0^{M_k} x_{kk}(i)^\alpha\, di\right] + T_{-kk}\left[\int_0^{M_{-k}} x_{-kk}(i)^\alpha\, di\right] + (T - T_{kk})\left[\int_0^{M_k} \tilde{x}_{kk}(i)^\alpha\, di\right] + (T - T_{-kk})\left[\int_0^{M_{-k}} \tilde{x}_{-kk}(i)^\alpha\, di\right]$$

where $x_{jk}(i)^\alpha$ is the utility from the consumption of a quantity x of good i invented in region j and consumed in region k. The tilde identifies those products whose patent has expired.

The parameter α is between 0 and 1 and is an index of the marginal utility of consumption of each good[10], which is taken to be equal across goods, no matter where the product is invented or whether its patent is still in force or not. Moreover it is also taken to be the same for consumers in the North and in the South.

Because all consumers are identical and goods are perfectly differentiated, all individual demand functions are generically derived from $\max_x x^\alpha - px$ where p is the unit price. As a consequence, we get:

$$x_{jk}(i) = \left[\frac{p_{jk}(i)}{\alpha}\right]^{-\frac{1}{1-\alpha}} \text{ and } \tilde{x}_{jk}(i) = \left[\frac{\tilde{p}_{jk}(i)}{\alpha}\right]^{-\frac{1}{1-\alpha}}$$

The aggregate demands are given by:

$X_{jk}(i) = N_k . x_{jk}(i)$ and $\tilde{X}_{jk}(i) = N_k . \tilde{x}_{jk}(i)$, where N represents the size of the market.

The individual firm's problem is not changed at all. The firm still maximizes its per-period operating profit, as a monopolist when it is got a patent, or facing competition once the patent has expired. We assume a technology with constant marginal cost equal to 1. Consequently, when the patent on a product has expired, its price is just equal to 1. When the patent is still in force, the price is the solution to $\max_p N\left(\frac{p}{\alpha}\right)^{-\frac{1}{1-\alpha}}(p-1)$. We then obtain:

[10] Actually α is equal to the direct elasticity of consumption of each good. If consuming good x provides u(x), then $\alpha = \frac{\partial u(x)}{\partial x} . \frac{x}{u(x)}$, i.e. the percentage change in the utility due to a percentage change in the consumption of the good.

$$p_{jk}(i)=\frac{1}{\alpha} \qquad \tilde{p}_{jk}(i)=1$$

$$X_{jk}(i)=N_k.\alpha^{\frac{2}{1-\alpha}} \qquad \tilde{X}_{jk}(i)=N_k.\alpha^{\frac{1}{1-\alpha}}$$

$$\pi_{jk}=N_k.(1-\alpha).\alpha^{\frac{(1+\alpha)}{(1-\alpha)}} \qquad \tilde{\pi}_{jk}=0$$

where the first column represents goods with valid patents and the second one represents those with expired patents.

From here on, the problem gets completely different from Lai and Qiu (2003), although we keep the same structure for the innovation costs: the cost of developing good i being equal to $-a_k.i^{\frac{1}{b_k}}$. Products are indexed in the ascending order of innovation costs. The parameter b_k is between 0 and 1 and is equal to the inverse of the elasticity of the innovation cost with respect to the position of the good in the ordering. So, $1/b_k$ is the (percentage) increase in the innovation cost when there is a (percentage) increase in the position of the good in the list, i.e. when we move from a good easy to develop to another with a higher innovation cost[11]. For each position in the list (for each i), it is reasonable to assume that this elasticity is smaller in the North than in the South.

The life-time profit of firm i based in region k is[12]:

$$\Pi_k(i)=\int_0^{T_{kS}}\pi_{kS}(i)dt+\int_0^{T_{kN}}\pi_{kN}(i)dt-a_k.i^{\frac{1}{b_k}}$$

$$=(N_S T_{kS}+N_N T_{kN}).Z-a_k.i^{\frac{1}{b_k}}$$

where $Z\equiv(1-\alpha).\alpha^{(1+\alpha).\varepsilon}$, $\varepsilon\equiv\frac{1}{1-\alpha}$ and $-a_k.i^{\frac{1}{b_k}}$ is the innovation cost.

We then define marginal firms both in the South and in the North as the last ones to invest profitably in R&D and, as a consequence, as the ones earning zero profits. Thanks to this definition and the ascending order assumed for the innovation costs, one gets the number of products developed in each period in both the South (M_S) and the North (M_N). Here we

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[11] The elasticity of the innovation cost (IC) is $\frac{\partial IC(i)}{\partial i}.\frac{i}{IC(i)}=-\frac{1}{b_k}.a_k.i^{\frac{1}{b_k}-1}.\frac{i}{IC(i)}=\frac{1}{b_k}.\frac{IC(i)}{i}.\frac{i}{IC(i)}=\frac{1}{b_k}$

[12] We take each good to be produced by a different firm in order to simplify the notation. Each firm sells its good in both markets S and N.

also assume the sets of products developed in the North and in the South to be non-intersecting, i.e. one product invented in the North is completely different from another invented in the South. In other words, inventions do not compete against each other, what makes the analysis simpler.

Therefore, from $\Pi_S(M_S) = 0$ and $\Pi_N(M_N) = 0$, we obtain respectively:

$$M_S = \left[\left(N_S T_{SS} + N_N T_{SN} \right) \frac{Z}{a_S} \right]^{b_S}$$

$$M_N = \left[\left(N_S T_{NS} + N_N T_{NN} \right) \frac{Z}{a_N} \right]^{b_N}$$

Then $1/b_k$ also represents the marginal increase in total innovation cost when there is a marginal increase in the total number of differentiated goods developed in each period in region k. Its meaning remains intuitive since the North has a comparative advantage over the South in terms of innovative skills. Following such reasoning, later in the paper we shall assume $1/b_N < 1/b_S$, or $b_S < b_N$.[13]

The steady state welfare flow in region k is given by:

$$W_k\left(T_{SS}, T_{SN}, T_{NN}, T_{NS}, M_S, M_N\right) = N_k . u_k(t) + \int_0^{M_k} \Pi_k(i) di + U_{zk}$$

$$= N_k T_{kk} M_k \alpha^{2\alpha\varepsilon}(1-\alpha) + N_k T_{-kk} M_{-k} \alpha^{2\alpha\varepsilon}(1-\alpha) +$$
$$+ N_k (T - T_{kk}) M_k \alpha^{\alpha\varepsilon}(1-\alpha) + N_k (T - T_{-kk}) M_{-k} \alpha^{\alpha\varepsilon}(1-\alpha) +$$
$$+ M_k (N_S T_{kS} + N_N T_{kN}).Z - \frac{b_k}{1+b_k} M_k^{\frac{1+b_k}{b_k}} + U_{zk}$$

where U_{zk} represents the steady state flow welfare in region k derived exclusively from markets of traditional goods and therefore not affected by the choice of patent protection lengths.

II.2 - The Reaction Functions

Since the reaction functions of the North and the South are symmetric up to the values of the parameters, let us focus on the South for the time being. We first assume an interior

[13] The parameter a_k needs only to be positive. It represents a shift parameter in the total innovation cost and we will ignore it in the forthcoming analysis: $a_k \equiv 1$.

solution – and will check for the necessary conditions afterwards. We begin by searching for the South's optimal choice for the level of protection of its national patents by totally differentiating W_S with respect to T_{SS}:

$$\frac{dW_S}{dT_{SS}} = \frac{\partial W_S}{\partial T_{SS}} + \frac{\partial W_S}{\partial M_S}\frac{\partial M_S}{\partial T_{SS}} + \frac{\partial W_S}{\partial M_N}\frac{\partial M_N}{\partial T_{SS}} = 0$$

where

$$\frac{\partial W_S}{\partial T_{SS}} = -N_S M_S \alpha^{\alpha\varepsilon}(1-\alpha)\left[1-\alpha^{\alpha\varepsilon}(1+\alpha)\right] < 0$$

$$\frac{\partial W_S}{\partial M_S}\frac{\partial M_S}{\partial T_{SS}} = \left[\left(N_S(1-\alpha)\alpha^{\alpha\varepsilon}\right)\left(T - T_{SS}\left(1-\alpha^{\alpha\varepsilon}\right)\right)\right]\left[\frac{N_S}{(N_S T_{SS} + N_N T_{SN})} b_S M_S\right] > 0$$

$$\frac{\partial W_S}{\partial M_N}\frac{\partial M_N}{\partial T_{SS}} = 0$$

We observe several differences from the case where T_{SS} and T_{NS} must be equal. The third term is zero since the protection of one region's own patents has no impact on the number of products invented in the other region, once we assume no *a priori* respect of the NTCR and given that the sets of invented products are non-intersecting.

Consider now the first term. The direct decrease in the South's welfare is here smaller than when $T_{SS} = T_{NS}$. The direct impact is given by the total gains in terms of firms' profits and the losses in terms of consumers' surplus. In the Lai-Qiu setup, by strengthening T_{SS}, the South also strengthens T_{NS} because of the NTCR, and therefore there is an additional negative impact in the consumers' surplus in the North. Here T_{SS} and T_{NS} are dissociated and there is no direct effect on northern consumers. The other two components of $\frac{\partial W_S}{\partial T_{SS}}$ are not affected by the NTCR constraint.

From the above equations we obtain the South's reaction function for the protection of southern products.

$$T_{SS} = \frac{b_S T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_S} - \frac{1-(1+\alpha)\alpha^{\alpha\varepsilon}}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_S}.\frac{N_N}{N_S}.T_{SN}$$

So, $\frac{\partial T_{SS}}{\partial T_{SN}} = -\frac{1-(1+\alpha)\alpha^{\alpha\varepsilon}}{1-(1+\alpha)\alpha^{\alpha\varepsilon}+\left(1-\alpha^{\alpha\varepsilon}\right)b_S}.\frac{N_N}{N_S}$ < 0 and decreasing in $\frac{N_N}{N_S}$. This means that the more the North protects patents generated in the South, the less incentive the South has for protecting patents on differentiated goods developed domestically. The dimension of the reaction is larger the larger the gap between market sizes in the North and in the South. In other words, the larger $\frac{N_N}{N_S}$, the more sensitive the (negative) response of T_{SS} to a small increase in T_{SN}.

By symmetry, the North's reaction function is given by:

$$T_{NN} = \frac{b_N T}{1-(1+\alpha)\alpha^{\alpha\varepsilon}+\left(1-\alpha^{\alpha\varepsilon}\right)b_N} - \frac{1-(1+\alpha)\alpha^{\alpha\varepsilon}}{1-(1+\alpha)\alpha^{\alpha\varepsilon}+\left(1-\alpha^{\alpha\varepsilon}\right)b_N}\frac{N_S}{N_N}.T_{NS}$$

Concerning the protection granted by the South to goods invented in the North, the first order condition for an interior solution is:

$$\frac{dW_S}{dT_{NS}} = \frac{\partial W_S}{\partial T_{NS}} + \frac{\partial W_S}{\partial M_S}\frac{\partial M_S}{\partial T_{NS}} + \frac{\partial W_S}{\partial M_N}\frac{\partial M_N}{\partial T_{NS}} = 0$$

where

$$\frac{\partial W_S}{\partial T_{NS}} = -N_S M_N (1-\alpha)\left(1-\alpha^{\alpha\varepsilon}\right)\alpha^{\alpha\varepsilon} < 0$$

$$\frac{\partial W_S}{\partial M_S}\frac{\partial M_S}{\partial T_{NS}} = 0$$

$$\frac{\partial W_S}{\partial M_N}\frac{\partial M_N}{\partial T_{NS}} = \left[\left(N_S(1-\alpha)\alpha^{\alpha\varepsilon}\right)\left(T - T_{NS}\left(1-\alpha^{\alpha\varepsilon}\right)\right)\right]\left[\frac{N_S}{(N_S T_{NS} + N_N T_{NN})} b_N M_N\right] > 0$$

We then obtain the South's reaction function for northern goods:

$$T_{NS} = \frac{b_N T}{\left(1-\alpha^{\alpha\varepsilon}\right)\left(1+b_N\right)} - \frac{N_N}{\left(1+b_N\right)N_S}.T_{NN}$$

So, $\frac{\partial T_{NS}}{\partial T_{NN}} = -\frac{N_N}{\left(1+b_N\right)N_S}$ < 0 and decreasing in $\frac{N_N}{N_S}$. Similarly to above, it means that the more the North protects its own patents, the less incentive the South has for protecting patents on differentiated goods developed in the North. The magnitude of this sensitivity is larger the larger the gap between market sizes in the North and in the South.

Once again, by symmetry we get:

$$T_{SN} = \frac{b_S T}{(1-\alpha^{\alpha\varepsilon})(1+b_S)} - \frac{N_S}{(1+b_S)N_N}.T_{SS}$$

Based on the above analysis, we can state our first primary results.

Lemma 1:

The higher the gap between market sizes, the lower shall be the protection granted by the smaller country and the higher the protection granted by the larger country to both national and foreign patents, given that the larger one has an innovative advantage *vis-à-vis* the smaller one.

Comment: As we can see from the above reaction functions, both the derivatives of T_{SS} and T_{NS} with respect to the ratio N_N/N_S are negative. On the other hand, both the derivatives of T_{NN} and T_{SN} with respect to the ratio N_N/N_S are positive. As so, N_N much larger than N_S tends to reduce T_{SS} and T_{NS} at the same time as it tends to increase T_{NN} and T_{SN}. In other words, the larger the ratio N_N/N_S the larger will be the free-riding of the South on the North's behavior as regards IPRs.

Lemma 2:

There are two distinct games, defined according to the product origin. In one game the South and the North interact for determining the protection for products developed in the South; in the other game both agents strategically decide on the protection for northern products.

Comment: For a given country there is no strategic interaction between its two choice variables. The inter-regional externality, however, is still present due to the interaction between the protection level for goods developed in k chosen by k itself and the protection level for goods developed in k chosen by the other region (–k). In other words, the optimal choice of each country for patent protection is independent across goods (of different origins) but is chosen strategically for a given good (of a given origin).

As a consequence, we have four equations displayed in two systems of two equations each, while in Lai and Qiu (2003) there was only one system of two equations to determine T_S and T_N. Here we have one system of two equations for obtaining T_{SS} and T_{SN} and another one for T_{NN} and T_{NS}. The interesting feature then concerns the independency of the two systems. Such non-interaction between variables concerning goods of different origins is driven by the zeros in the partial derivatives: $\frac{\partial W_S}{\partial M_N}\frac{\partial M_N}{\partial T_{SS}} = 0$ and $\frac{\partial W_S}{\partial M_S}\frac{\partial M_S}{\partial T_{NS}} = 0$, and the analogous ones for W_N. These zeros, in turn, are due to the violation of the national treatment commitment rule and the assumption on the non-intersection between M_S and M_N. Since the sets of inventions are orthogonal spaces, one is not affected by variable changes affecting the other one. As so, the number of goods invented in the North is not affected by the protection given to goods from the South and vice-versa: $\frac{\partial M_N}{\partial T_{Sk}} = 0$ and $\frac{\partial M_S}{\partial T_{Nk}} = 0$. Consequently, the steady state welfare flows coming from differentiated goods are not affected either.

II.3 - The Solution

In this subsection we present the solution to the game where both the North and the South strategically choose the patent lengths for differentiated goods originated domestically and abroad.

Solving for the equilibrium for goods developed in the South means to solve the following system:

$$T_{SS} = \frac{b_S T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_S} - \frac{1-(1+\alpha)\alpha^{\alpha\varepsilon}}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_S} \cdot \frac{N_N}{N_S} . T_{SN}$$

$$T_{SN} = \frac{b_S T}{\left(1-\alpha^{\alpha\varepsilon}\right)\left(1+b_S\right)} - \frac{N_S}{\left(1+b_S\right)N_N} . T_{SS}$$

Both the reaction functions feature a negative slope. It means that T_{SS} and T_{SN} are strategic substitutes, what is at the origin of the free-riding problem.

The main difference *vis-à-vis* the Lai-Qiu's model is that they have only one interaction, only one variable of each country interacts in their setup. Here, since T_{SS} and T_{NS} may differ, and symmetrically T_{NN} and T_{SN} may differ, there are two interactions. The level of protection chosen by the South for southern products (T_{SS}) interacts with the level of protection chosen by the North for the same products (T_{SN}); the level of protection chosen by the North for northern products (T_{NN}) interacts with the level of protection chosen by the

South for the same products (T_{NS}). However, it is crucial to emphasize that the two choice variables of each country are strategically independent from each other when the NTCR is not assumed (Lemma 2).

Let us continue to focus on the goods produced in the South, and exploit the features of the interaction of T_{SS} and T_{SN}.

We first compare the independent components of the reaction functions and will later compare their slopes.

$$T_{SS}(0) = \frac{b_S T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_S}$$

$$T_{SN}(0) = \frac{b_S T}{\left(1-\alpha^{\alpha\varepsilon}\right)\left(1+b_S\right)}$$

Since $\alpha > 0$, one gets that $T_{SS}(0) > T_{SN}(0)$. The South has then a larger natural propensity to protect patents generated in the South than the North does. This is a direct consequence of the effect of patent protection on profits. The firms in the South are the ones who directly benefit from T_{SS} and T_{SN}, and this is reflected in this independent term of T_{SS} being larger than the one of T_{SN}.

Concerning the slopes of the reaction functions, we have:

$$\frac{\partial T_{SS}}{\partial T_{SN}} = -\frac{1-(1+\alpha)\alpha^{\alpha\varepsilon}}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_S} \cdot \frac{N_N}{N_S}$$

$$\frac{\partial T_{SN}}{\partial T_{SS}} = -\frac{N_S}{\left(1+b_S\right)N_N}$$

One can show that $\frac{1-(1+\alpha)\alpha^{\alpha\varepsilon}}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_S}$ is smaller than $\frac{1}{\left(1+b_S\right)}$. Therefore we can state that if both markets have the same size ($N_N = N_S$) the North is more responsive to changes in patent protection of southern products than the South is. This is because the South is more concerned about such protection; as so, the South tends to stick more to its choice than the North, instead of changing it due to a change in North's behaviour. It is interesting to notice that $\frac{1-(1+\alpha)\alpha^{\alpha\varepsilon}}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_S} = \frac{1}{\left(1+b_S\right)}$ if $\alpha = 0$. So, if $N_N = N_S$ and $\alpha = 0$, the importer's reasoning works as if consumers did not benefit from acquiring the imported good, i.e. as if their marginal utility with respect to the imported good was zero.

It is possible to have the slope of $T_{SN}(T_{SS})$ smaller than the slope of $T_{SS}(T_{SN})$ if the market for differentiated goods in the North is larger than the one in the South. These incentives might in this case be reversed because of the existence of the so-called inter-regional externality, which represents an incentive for the North to protect southern patents since this generates more products in the South, and this will benefit – among others – consumers in the North. If $N_N > N_S$, it may even be the case that there are so many more consumers in the North that the North has even more incentives to protect southern patents than the South itself does. This possibility will be analyzed more in depth later in the paper.

In order to plot the equilibrium on a graph, it is necessary to invert the South's Reaction Function (SRF) and write T_{SN} as a function of T_{SS}. One gets:

$$T_{SN} = \frac{b_S T}{1-(1+\alpha)\alpha^{\alpha\varepsilon}}.\frac{N_S}{N_N} - \frac{1-(1+\alpha)\alpha^{\alpha\varepsilon}+\left(1-\alpha^{\alpha\varepsilon}\right)b_S}{1-(1+\alpha)\alpha^{\alpha\varepsilon}}\frac{N_S}{N_N}.T_{SS}$$

Remember the North's Reaction Function (NRF) is given by:

$$T_{SN} = \frac{b_S T}{\left(1-\alpha^{\alpha\varepsilon}\right)\left(1+b_S\right)} - \frac{N_S}{\left(1+b_S\right)N_N}.T_{SS}$$

We can infer from the previous step that $\frac{1-(1+\alpha)\alpha^{\alpha\varepsilon}+\left(1-\alpha^{\alpha\varepsilon}\right)b_S}{1-(1+\alpha)\alpha^{\alpha\varepsilon}} > \frac{1}{\left(1+b_S\right)}$, so that in a graph of T_{SN} as a function of T_{SS} the slope of the NRF is smaller in absolute value than the one of the SRF. In other words, whatever the relationship between market sizes, we have that the SRF is steeper than the NRF in a graph of T_{SN} as a function of T_{SS} [14].

As a consequence, for ensuring the existence of $T_{SS} > 0$ in equilibrium, the necessary and sufficient condition requires $T_{SN}(0)$ in the NRF to be smaller than the $T_{SN}(0)$ in the SRF. In terms of the equations just above, it means that we need:

$$\frac{N_N}{N_S} < \frac{\left(1-\alpha^{\alpha\varepsilon}\right)\left(1+b_S\right)}{1-(1+\alpha)\alpha^{\alpha\varepsilon}}$$

The expression in the right hand side is strictly larger than 1.

Inversely, if we isolate T_{SS} in the above equations, we get T_{SS} as a function of T_{SN}. For ensuring $T_{SN} > 0$ at equilibrium, one needs $T_{SS}(0)$ in the NRF to be larger than $T_{SS}(0)$ in the SRF. The condition that comes out is:

$$\frac{N_N}{N_S} > \frac{1-\alpha^{\alpha\varepsilon}}{1-(1+\alpha)\alpha^{\alpha\varepsilon}+\left(1-\alpha^{\alpha\varepsilon}\right)b_S}$$

So, the existence of an interior equilibrium for the pair (T_{SS} ; T_{SN}) is conditional on the relative sizes of the markets for differentiated products in this specific way.

[14] The opposite holds for a graph of T_{NS} as a function of T_{NN}: the SRF is flatter than the NRF.

We can now take advantage of the symmetry of the model. If we solve the other system of two reaction functions, searching for the equilibrium pair (T_{NN} ; T_{NS}), we will obtain analogous solutions and conditions. Consequently, for the existence of an interior solution for T_{NN} we need:

$$\frac{N_N}{N_S} > \frac{1-(1+\alpha)\alpha^{\alpha\varepsilon}}{\left(1-\alpha^{\alpha\varepsilon}\right)\left(1+b_N\right)} = \frac{1}{1+b_N} - \frac{\alpha^{\varepsilon}}{\left(1-\alpha^{\alpha\varepsilon}\right)\left(1+b_N\right)}$$

The term on the right is strictly smaller than one. Therefore, when the market in the North for differentiated products is larger than the one in the South, the condition is always verified. In other words, $N_N > N_S$ ensures that T_{NN} is larger than zero in any possible equilibrium.

The necessary and sufficient condition for $T_{NS} > 0$ is:

$$\frac{N_N}{N_S} < \frac{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_N}{1-\alpha^{\alpha\varepsilon}} = 1 + b_N - \frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}}$$

The above result concerning T_{NN} can be stated as an additional lemma.

Lemma 3:

The country holding the largest market for differentiated products always sets a positive level of protection for patents developed domestically. This is true for any kind of equilibrium in the game of patent protection setting, no matter whether the national treatment commitment rule does apply or not.

Comment:

In Lai and Qiu (2003), the statement was shown to be true under the NTCR. In our setting (no NTCR), countries have different incentives to protect their own patents, since the choice of T_{kk} is dissociated from the choice of T_{-kk}. Protecting T_{kk} is more beneficial *vis-à-vis* protecting T_{-kk} because the country also gains through the increase in the profits of its firms, additionally to the gains from increasing the consumers' surplus thanks to the increase in product variety. On the other hand, since there is no NTCR, protecting T_{kk} has no positive impact through M_{-k} but has also a smaller direct negative impact, so that we can not say a priori that a country has more incentives to protect T_{kk} than it had to protect T_k in Lai and Qiu (2003). So, although it is quite intuitive, it is not straightforward that if $N_N > N_S$ then $T_{NN} > 0$ in any case.[15]

[15] If we had instead $N_S > N_N$ then T_{SS} would be strictly positive for sure, due to the symmetry of the model.

This is a very important result since it ensures that no matter the magnitude of the free-riding of the small economy on the big one, it will never lead the big one to completely give up protecting IPRs.

Corollary 1: There is no (corner) equilibrium where all four choice variables are set equal to zero.

Corollary 2: There is no (corner) equilibrium where the South's protection of Northern patents achieves its upper bound or intercept.

Comment: Because T_{NS} and T_{NN} are strategic substitutes, once $T_{NN} > 0$ always, we can deduce that T_{NS} is never maximal, i.e. it is always strictly smaller than $\frac{b_N T}{\left(1-\alpha^{\alpha\varepsilon}\right)\left(1+b_N\right)}$.

II.4 - The Results

Having computed the above conditions and established the first three lemmas, we can now move to our main results.

Let us first define A, B and C as follows, in order to simplify the notation from now on.

$$\frac{\left(1-\alpha^{\alpha\varepsilon}\right)(1+b_S)}{1-(1+\alpha)\alpha^{\alpha\varepsilon}} \equiv A$$

$$\frac{1-\alpha^{\alpha\varepsilon}}{1-(1+\alpha)\alpha^{\alpha\varepsilon}+\left(1-\alpha^{\alpha\varepsilon}\right)b_S} \equiv B$$

$$\frac{1-(1+\alpha)\alpha^{\alpha\varepsilon}+\left(1-\alpha^{\alpha\varepsilon}\right)b_N}{1-\alpha^{\alpha\varepsilon}} = 1+b_N-\frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}} \equiv C$$

Proposition 1:

Under no national treatment commitment rule, an equilibrium where both the North and the South set strictly positive patent lengths for both their own patents and patents generated abroad requires conditions (I) and (II) below to hold and the ratio $\frac{N_N}{N_S}$ to fall in the following interval: $\max\{1;B\} < \frac{N_N}{N_S} < \min\{A;C\}$

Condition (I): $b_N > \frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}}$

Condition (II): $\left(1+b_N-\frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}}\right)\left(1+b_S-\frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}}\right)>1$

Proof:

The existence of an interior solution for the equilibrium (where all the four choice variables are set at strictly positive levels) is subject to the respect of the four conditions previously established, which reduces to the following three, once we take $N_N > N_S$.

$\frac{N_N}{N_S} < A$

$\frac{N_N}{N_S} > B$

$\frac{N_N}{N_S} < C$

Allowing the above three conditions to hold at the same time requires the respect of the following necessary conditions (once $N_N > N_S$):

A > 1, C > 1, A > B and C > B

The first one always holds.

The second one only holds if $b_N > \frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}}$, what we call condition (I).

The third one always holds.

The forth one only holds if $\left(1+b_N-\frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}}\right)\left(1+b_S-\frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}}\right)>1$, what we call condition (II).

Consequently, conditions (I) and (II) are necessary for an interior solution (given that $N_N > N_S$). If one of them is violated it will be impossible to have the ratio $\frac{N_N}{N_S}$ smaller than A and C and larger than B at the same time, and therefore impossible to have all choice variables set at strictly positive levels. However, they are not sufficient; it may well be the case that (I) and (II) are respected but $\frac{N_N}{N_S}$ does not satisfy: $\max\{1;B\} < \frac{N_N}{N_S} < \min\{A;C\}$

Comments:

Under no national treatment commitment rule, an equilibrium where both the North and the South set strictly positive patent lengths for both their own patents and patents generated abroad is an improbable outcome. It requires, additionally to a moderate level of the ratio $\frac{N_N}{N_S}$, the innovation cost in the North to be small enough (I) and the one in the South not to be too large (II).

The North is for sure protecting its own patents to some extent (Lemma 3). However, if the innovation cost in the North is not small enough, that is if $0 < b_N < \frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}}$, it will induce the South not to protect IPRs on northern products. The idea is that although southern consumers benefit from higher M_N, this low efficiency of the North in generating M_N, will make the South not wish to incur the cost of protecting northern patents.

If the innovation cost in the South is too large with respect to the one in the North, yielding b_S so small that $\left(1+b_N-\frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}}\right)\left(1+b_S-\frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}}\right)<1$, then we obtain C < B [16]. This implies that we cannot have T_{NS} and T_{SN} larger than zero at the same time, i.e. one of the two countries is for sure free-riding on the goods developed abroad.

Remember that we assume that the North has an advantage over the South in terms of innovative capability, so that one might think of having $b_S < b_N$ as the benchmark case[17]. Take for example α = 0,15 and b_S = 0,05, so that $\left(1+b_S-\frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}}\right)=0{,}67$; any b_N smaller than 0,85 will yield C < B [18]. The same happens for α = 0,25 and b_S = 0,10; any b_N smaller than 0,95 will yield C < B. For α larger than 0,45, b_S smaller than 0,16 is enough to ensure C < B, no matter the value of b_N.

Some additional comment is necessary here. Once we assume $N_N > N_S$, we rule out the possibility of T_{NN} to be zero at equilibrium. The variable T_{NN} interacts with T_{NS} for the determination of the equilibrium[19]. The equilibrium T_{NS} is positive or zero according to the

[16] As we can see from the tables in Appendix 1, C < B can be obtained by different combinations of the values of the parameters.
[17] Remember 1/b represents the marginal increase in total innovation cost when there is a marginal increase in the number of differentiated goods developed in each period in region k.
[18] The computed values are taken from the tables in Appendix 1.
[19] See Lemma 3 and its Corollary 2.

location of the ratio $\frac{N_N}{N_S}$ vis-à-vis C. If the innovation cost in the North is too large (b_N very small), condition (I) is violated, yielding C > 1. Consequently, the ratio $\frac{N_N}{N_S}$ will be for sure larger than C and the equilibrium T_{NS} will be zero and T_{NN} will be maximal. [20]

Concerning the other pair of interacting variables, we have that the condition A > B always holds in our model. It ensures that in equilibrium at least one of the two regions will protect the IPRs generated in the South. For T_{NS} and T_{NN} the certainty that some protection is provided for northern products is given by the fact that the assumption $N_N > N_S$ ensures that $T_{NN} > 0$ at equilibrium.

For T_{SS} and T_{SN} we do not need any extra assumption. The fact that A > B guarantees that if one of T_{SS} or T_{SN} is zero in equilibrium, the other one is strictly positive. Moreover, since they are strategic substitutes, if one of them is zero, the other one achieves its maximum. In other words,

- If $T_{SS} = 0$, then $T_{SN} > 0$ and maximal
- If $T_{SN} = 0$, then $T_{SS} > 0$ and maximal

This brings us to our forth lemma.

Lemma 4:

In spite of the absence of the national treatment commitment, Research and Development in the South is always protected. Moreover, if one of the countries does not protect southern patents, the other one protects it maximally.

Comment:

In Lai and Qiu (2003), where the NTCR was taken as granted, an additional assumption was needed in order to ensure that T_S was strictly larger than zero. It concerned the relative size of the markets and required N_N not to be too much larger than N_S, otherwise the South would not have any incentives to protect IPRs at all.

In our framework, if it is the case that the South has no incentive to protect its own IPRs, the solution to the model shows that the North will provide some protection to southern products. The intuition is as follows: the South has no incentive to protect southern patents if the North has a much larger market for differentiated products. However, if so, the North has

[20] A remark should be made on the possibility of achieving this equilibrium outcome even without violating condition (I), as will be made clear later in the paper.

an incentive to protect southern products, because no protection at all would represent a huge loss for the North in terms of consumers' surplus since there are numerous consumers in the North, and they benefit from more products being invented in the South. Therefore the North provides the protection for southern IPRs in the absence of interest from the South itself.

On the other hand, if it is the case that $T_{SN} = 0$, it is because the market in the North is just a bit larger than the one in the South, and the innovative advantage is large in favour of the North. As a consequence, the North prefers not to protect southern patents at equilibrium, and the South compensates for this by setting a maximal T_{SS}.

Let us now move to the analysis of the possible corner solutions in our model. Their nature is covered by the following proposition:

Proposition 2:

Under no national treatment commitment rule, there are five distinct possibilities for an equilibrium which is a corner solution, i.e., where at least one of North and South sets at least one of the patent lengths for domestic innovations and for foreign ones equal to zero.

In the first possible case, the South does not protect innovations developed in the North. In the second, the North does not grant patent on products developed in the South. In the third one, both occurs: the South neglects northern patentable goods and the North neglects the southern ones. In the forth, the South does not protect its own national innovations but does protect the northern. In the fifth case, the South does not grant patent on goods of any origin.

Proof and Comments[21]:

The proof is established by showing and discussing the five possible cases. It is important, however, to make some comments before. Since $T_{NN} > 0$ in any case (Lemma 3), we are *a priori* left with 7 possibilities, according to the combinations of T_{SN}, T_{SS} and T_{NS} being positive or zero[22]. However, we also know that we cannot have T_{SS} and T_{SN} equal to zero at the same time (Lemma 4). Consequently, the case where $T_{SS} = T_{SN} = 0$ and $T_{NS} > 0$ is excluded, as well as the one where $T_{SS} = T_{SN} = T_{NS} = 0$. We are then left with five cases,

[21] Since the proof is long and divided in cases, we prefer to make the comments at the same time as defining the cases.
[22] Theoretically there are $2^3 = 8$ possible combinations, but we exclude the one where all three variables are positive (previously analysed) since here we deal with corner solutions.

defined according to the location of the ratio between market sizes *vis-à-vis* the constants A, B and C.

1st Case: $\max\{B,C\} < \frac{N_N}{N_S} < A$

This case happens when we violate uniquely the condition for ensuring $T_{NS} > 0$, i.e. when the computed C is too small vis-à-vis the ratio between market sizes. This may occur because $b_N < \frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}}$, i.e. because of having condition (I) of Proposition 1 violated, which means that the North does not have a sufficiently low innovation cost. However, the violation of such condition is not necessary [23]: the ratio between market sizes can be located between C and A in spite of having $C > 1$ [24].

In any case, what occurs here is that the costs for the South of protecting northern IPRs are not compensated by the benefits to southern consumers of having more products, and therefore the South does not have incentive to grant patent on products developed in the North. As a consequence, we will have at equilibrium $T_{NS} = 0$ and T_{NN} equal to its maximal possible value – since T_{NS} and T_{NN} are strategic substitutes.

$$T_{NN} = \frac{b_N T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_N}$$

Given that $B < \frac{N_N}{N_S} < A$, we have $T_{SN} > 0$ and $T_{SS} > 0$. Their exact values are obtained by solving the system of equations concerning goods produced in the South, as if we were dealing with an interior solution.[25]

2nd Case: $\frac{N_N}{N_S} < \min\{B,C\}$

Since B < A always, it implies that under this case $\frac{N_N}{N_S} < A$ and therefore $T_{SS} > 0$.

[23] It is not sufficient either for falling on the 1st case: we can have it violated and be in the 3rd case instead, as we will argue shortly.
[24] Remember this condition (I) from Proposition 1 is the one for ensuring C > 1.
[25] In this first case, what we actually have is an interior solution for the system involving T_{SN} and T_{SS}, and a corner solution for the other system of two equations, dealing with T_{NS} and T_{NN}. Refer to Lemma 2.

Given $\frac{N_N}{N_S} < B$, T_{SN} will be equal to 0. Consequently, T_{SS} reaches its maximal value, which is the symmetric of the value for T_{NN} in the former case:

$$T_{SS} = \frac{b_S T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_S}$$

This case happens when B attains a large value *vis-à-vis* the ratio of market sizes, due to a small b_S or/and a small ratio $\frac{N_N}{N_S}$. The South has a quite developed innovative capability and/or a quite large market size. As a consequence, the North knows that the South will protect its domestic innovations and prefers to have its consumers free-riding on southern products. It is important to mention that this result does not even require to assume $b_S < b_N$.

Given $\frac{N_N}{N_S} < C$, T_{NS} will be strictly positive. The equilibrium pair (T_{NN} ; T_{NS}) is the interior solution of the game for goods invented in the North.

3rd Case: $C < \frac{N_N}{N_S} < B$

Since B < A, we have that $\frac{N_N}{N_S} < A$ and therefore $T_{SS} > 0$ for sure.

A necessary condition for this case to happen is that condition (II) of Proposition 1 does not hold, so that C is smaller than B[26]. Since this is necessary but not sufficient, what in the end determines this 3rd case is the effective location of the market sizes ratio.

In other words, this case appears when C is sufficiently low and B is sufficiently large, so that C < B, and moreover the ratio of market sizes falls in-between. C is low if b_N is relatively low, i.e. if the North does not have such a great innovative capability and consequently does not generate many new products. B is large if b_S is relatively high[27], i.e. if the South itself is capable of generating a relatively large number of innovations, instead.

It is possible that condition (I) be also violated. If it is the case – as mentioned in the 1st case analysis – we have $T_{NS} = 0$ at equilibrium because $C < \frac{N_N}{N_S}$ as C < 1 is ensured by the

[26] However, this is not sufficient: condition (II) being violated does not imply falling on this 3rd case. We can have condition (II) violated and be in case 1 or in case 2, because in both cases it does not matter whether condition (II) holds or not, i.e. if B is larger than C or the opposite.
[27] The definition of what "relatively high" and "relatively low" mean depends on the exact value α takes. This is clearer when one sees the tables in Appendix 1. Remember that α is the direct elasticity of consumption of each good (footnote 10).

violation of condition (I). If instead condition (I) holds and C > 1, the violation of condition (II) requires $b_S < \frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}}$. Since the South cannot have a very low innovative capability (we need a B large enough), this situation only arises for large values of α. In this case we would have $b_S < \frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}} < b_N$, what is in line with the idea of having the North being more inventive than the South.

In any circumstance, we are violating the condition for having a strictly positive T_{NS}. Since T_{NS} and T_{NN} are strategic substitutes, T_{NN} takes its maximal possible value.

$$T_{NN} = \frac{b_N T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_N}$$

Moreover, since in this case we also violate the necessary condition for $T_{SN} > 0$, in equilibrium we will also have $T_{SN} = 0$ and T_{SS} maximal.

$$T_{SS} = \frac{b_S T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_S}$$

This is an interesting case because a reciprocal (mis)behavior comes up as Nash equilibrium. The best choice of the North is not to protect Southern innovations, while the best choice of the South is not to protect Northern innovations.

4th Case: $A < \frac{N_N}{N_S} < C$

This case is a very peculiar one. It requires a quite low α, a very low b_S and a very high b_N. In other words, we need a low elasticity of consumption of the representative consumer in each country, and the North to have a much greater innovation capacity than the South. As we can see from the tables in Appendix 1, we have A < C only when α is roughly smaller than 0.2 and b_S is close to 0 and b_N is close to 1. Having α that small means that in this case the goods we are dealing with are not essential to consumers.

For moderate values of α, this case is not even possible, as for example when α is equal to ½.

Because $A < \frac{N_N}{N_S}$, we have that in equilibrium T_{SS} is equal to 0 and T_{SN} is maximal.

$$T_{SN} = \frac{b_S T}{\left(1-\alpha^{\alpha\varepsilon}\right)\left(1+b_S\right)}$$

Since $\frac{N_N}{N_S} < C$, T_{NS} is larger than zero. The exact values of T_{NS} and T_{NN} are obtained as the interior solution to the system of equations concerning goods produced in the North.

5th Case: $\max\{A, C\} < \frac{N_N}{N_S}$

Since B < A, we have that $B < \frac{N_N}{N_S}$ and therefore $T_{SN} > 0$.

In this case, the relationship between the magnitudes of A and C does not matter. The market in the North is so much larger than the one in the South that in equilibrium the South has no incentive at all to protect IPRs.

Because $A < \frac{N_N}{N_S}$, we have that in equilibrium T_{SS} is equal to 0 and T_{SN} is maximal.

$$T_{SN} = \frac{b_S T}{\left(1-\alpha^{\alpha\varepsilon}\right)\left(1+b_S\right)}$$

Since $C < \frac{N_N}{N_S}$, T_{NS} is also equal to zero, and therefore T_{NN} is maximal.

$$T_{NN} = \frac{b_N T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_N}$$

III - Bilateral Games

In this section we explore the connection between the different possible outcomes analysed above and observed stylized facts in various countries. Actually the model is designed for a game between the (whole) North and the (whole) South, where the outcome is determined by the features of the (whole) set of developed economies and the ones for the (whole) set of developing countries. Nevertheless, in order to illustrate our results, in this section we play with bilateral games, where 2 countries set patent policies as if they where the only ones in the world.

We deal with 4 possibilities for a southern country and other 4 possibilities for a northern country, according to the different combinations of small or large market size with a low or high innovative capability. Therefore we end up with 16 different games, which would be too long to analyse in this section. In Appendix 2 we thoroughly analyse all the possible outcomes in bilateral games involving northern and southern countries.

We restrain our attention in this section to the discussion of a key example. In a game between the USA (or the European Union) and a big southern country with a considerable R&D structure (like China, Brazil or India) we have the following:

- Given the structure of the innovation technologies of both players, we do have a very large b_N (close to 1) and a quite large b_S. Therefore, we end up with a quite large A, quite low B and a very large C, in such a way that conditions (I) and (II) are for sure satisfied. If ever the market sizes were such that the ratio N_N/ N_S is larger than B but smaller than A and C, one should expect to find an interior solution.

- However, it is not clear that the ratio between market sizes is moderate enough in this example, since the relevant market for differentiated goods in the North seems to be much larger than the one in the South. If this is true, we should expect reaching the 1st case (where the South does not protect northern inventions), or even the 5th case (where the South does not protect IPRs at all) if the discrepancy between market sizes is huge.

Ending up in the situation of this 1st or possibly 5th case is even more probable if the southern country has a smaller relevant market than China, India or Brazil. That would be the case of South Africa, Pakistan or Argentina.

On the other hand, if we think of a game between the USA or the EU and the whole set of big southern countries featuring high b_S, we should in this case achieve an interior solution. This can be stated as an argument in favour of multilateral negotiations, where developing countries are able to exert pressure on more developed partners through grouping their forces. In our setting, this would mean that there would be a natural move towards an interior solution to the unconstrained game of patent policy setting if southern countries with high b_S made their decisions as if they were a single country.

IV - Welfare Analysis

We now proceed to the analysis of the characteristics of the social optimum. We define world (or global) welfare simply as the sum of the North's and the South's welfare, i.e., $W = W_S + W_N$. Consequently, we obtain the following expression for the global welfare:

$$
\begin{aligned}
W &= W_S(T_{SS}, T_{SN}, T_{NN}, T_{NS}, M_S, M_N) + W_N(T_{SS}, T_{SN}, T_{NN}, T_{NS}, M_S, M_N) \\
&= N_S.u_S(t) + \int_0^{M_S} \Pi_S(i)di + U_{zS} + N_N.u_N(t) + \int_0^{M_N} \Pi_N(i)di + U_{zN} \\
&= N_S T_{SS} M_S \alpha^{2\alpha\varepsilon}(1-\alpha) + N_S T_{NS} M_N \alpha^{2\alpha\varepsilon}(1-\alpha) + \\
&+ N_S(T - T_{SS}) M_S \alpha^{\alpha\varepsilon}(1-\alpha) + N_S(T - T_{NS}) M_N \alpha^{\alpha\varepsilon}(1-\alpha) + \\
&+ M_S(N_S T_{SS} + N_N T_{SN}).Z - \frac{b_S}{1+b_S} M_S^{\frac{1+b_S}{b_S}} + U_{zS} + \\
&+ N_N T_{NN} M_N \alpha^{2\alpha\varepsilon}(1-\alpha) + N_N T_{SN} M_S \alpha^{2\alpha\varepsilon}(1-\alpha) + \\
&+ N_N(T - T_{NN}) M_N \alpha^{\alpha\varepsilon}(1-\alpha) + N_N(T - T_{SN}) M_S \alpha^{\alpha\varepsilon}(1-\alpha) + \\
&+ M_N(N_N T_{NN} + N_S T_{NS}).Z - \frac{b_N}{1+b_N} M_N^{\frac{1+b_N}{b_N}} + U_{zN}
\end{aligned}
$$

We a priori take for granted that there is an interior solution for the maximization of this expression. The next step therefore is computing its first-order conditions. We start by totally differentiating W with respect to T_{SS}:

$$\frac{dW}{dT_{SS}} = \frac{dW_S}{dT_{SS}} + \frac{dW_N}{dT_{SS}} = 0$$

where

$$\frac{dW_S}{dT_{SS}} = \frac{\partial W_S}{\partial T_{SS}} + \frac{\partial W_S}{\partial M_S}\frac{\partial M_S}{\partial T_{SS}} + \frac{\partial W_S}{\partial M_N}\frac{\partial M_N}{\partial T_{SS}} \text{ as computed before.}$$

and

$$\frac{dW_N}{dT_{SS}} = \frac{\partial W_N}{\partial T_{SS}} + \frac{\partial W_N}{\partial M_N}\frac{\partial M_N}{\partial T_{SS}} + \frac{\partial W_N}{\partial M_S}\frac{\partial M_S}{\partial T_{SS}}.$$

We already know that:

$$\frac{\partial W_S}{\partial T_{SS}} = -N_S M_S \alpha^{\alpha\varepsilon}(1-\alpha)\left[1 - \alpha^{\alpha\varepsilon}(1+\alpha)\right] < 0$$

$$\frac{\partial W_S}{\partial M_S}\frac{\partial M_S}{\partial T_{SS}} = \left[\left(N_S(1-\alpha)\alpha^{\alpha\varepsilon}\right)\left(T - T_{SS}\left(1-\alpha^{\alpha\varepsilon}\right)\right)\right]\left[\frac{N_S}{(N_S T_{SS} + N_N T_{SN})} b_S M_S\right] > 0$$

$$\frac{\partial W_S}{\partial M_N}\frac{\partial M_N}{\partial T_{SS}} = 0$$

Moreover, given that M_S and M_N are non-intersecting:

$$\frac{\partial W_N}{\partial T_{SS}} = 0$$

$$\frac{\partial W_N}{\partial M_N}\frac{\partial M_N}{\partial T_{SS}} = 0$$

$$\frac{\partial W_N}{\partial M_S}\frac{\partial M_S}{\partial T_{SS}} = \left[\left(N_N(1-\alpha)\alpha^{\alpha\varepsilon}\right)\left(T - T_{SN}\left(1-\alpha^{\alpha\varepsilon}\right)\right)\right]\left[\frac{N_S}{(N_S T_{SS} + N_N T_{SN})} b_S M_S\right] > 0$$

After proceeding to some computation, we finally get:

$$T^*_{SS} = \frac{b_S T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_S}.\frac{N_S + N_N}{N_S} - \frac{N_N}{N_S}.T^*_{SN}$$

This expression is quite different from the one we got for the South's reaction function when computing the equilibrium T_{SS}, since now we are taking into account the positive externality of the increase in the number of goods generated in the South on the consumers' surplus in the North.

By symmetry, concerning T_{NN} we have:

$$T^*_{NN} = \frac{b_N T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_N}.\frac{N_S + N_N}{N_N} - \frac{N_S}{N_N}.T^*_{NS}$$

Solving for the socially optimal level of protection in the South for patents developed in the North yields:

$$\frac{dW}{dT_{NS}} = \frac{dW_S}{dT_{NS}} + \frac{dW_N}{dT_{NS}} = 0$$

where

$$\frac{dW_S}{dT_{NS}} = \frac{\partial W_S}{\partial T_{NS}} + \frac{\partial W_S}{\partial M_S}\frac{\partial M_S}{\partial T_{NS}} + \frac{\partial W_S}{\partial M_N}\frac{\partial M_N}{\partial T_{NS}}$$ as computed before.

and

$$\frac{dW_N}{dT_{NS}} = \frac{\partial W_N}{\partial T_{NS}} + \frac{\partial W_N}{\partial M_N}\frac{\partial M_N}{\partial T_{NS}} + \frac{\partial W_N}{\partial M_S}\frac{\partial M_S}{\partial T_{NS}}.$$

We already know that:

$$\frac{\partial W_S}{\partial T_{NS}} = -N_S M_N (1-\alpha)\left(1-\alpha^{\alpha\varepsilon}\right)\alpha^{\alpha\varepsilon} < 0$$

$$\frac{\partial W_S}{\partial M_S}\frac{\partial M_S}{\partial T_{NS}} = 0$$

$$\frac{\partial W_S}{\partial M_N}\frac{\partial M_N}{\partial T_{NS}} = \left[\left(N_S(1-\alpha)\alpha^{\alpha\varepsilon}\right)\left(T - T_{NS}\left(1-\alpha^{\alpha\varepsilon}\right)\right)\right]\left[\frac{N_S}{(N_S T_{NS} + N_N T_{NN})} b_N M_N\right] > 0$$

Moreover, given that M_S and M_N are non-intersecting:

$$\frac{\partial W_N}{\partial T_{NS}} = Z.M_N.N_S$$ [28]

$$\frac{\partial W_N}{\partial M_N}\frac{\partial M_N}{\partial T_{NS}} = \left[\left(N_N(1-\alpha)\alpha^{\alpha\varepsilon}\right)\left(T - T_{NN}\left(1-\alpha^{\alpha\varepsilon}\right)\right)\right]\left[\frac{N_S}{(N_S T_{NS} + N_N T_{NN})} b_N M_N\right] > 0$$

$$\frac{\partial W_N}{\partial M_S}\frac{\partial M_S}{\partial T_{NS}} = 0$$

After proceeding to some computation, we finally get:

$$T_{NS}^* = \frac{b_N T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_N}.\frac{N_S + N_N}{N_S} - \frac{N_N}{N_S}.T_{NN}^*$$

This expression is quite different from the one we got for the South's reaction function when computing the equilibrium T_{NS}, since now we are taking into account the positive externality of the increase in the number of goods generated in the North on the consumers' surplus and profits in the North, due to protection provided by the South.

By symmetry, concerning T_{SN} we have:

$$T_{SN}^* = \frac{b_S T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_S}.\frac{N_S + N_N}{N_N} - \frac{N_S}{N_N}.T_{SS}^*$$

One might then think that we now could solve the 2 systems of 2 equations each, as we did for computing the equilibrium. However, we in fact have only 2 equations here. The equation for T_{SS} and the one for T_{SN} are identical, the same applying to the ones for T_{NN} and T_{NS}.

We therefore face an indetermination: 2 equations for determining 4 variables.

[28] Remember $Z \equiv (1-\alpha).\alpha^{(1+\alpha).\varepsilon}$ and $\varepsilon \equiv \frac{1}{1-\alpha}$.

Looking closer, however, allows us to find the following relationships:

$$\frac{N_S.T_{SS}^* + N_N.T_{SN}^*}{N_S + N_N} = \frac{b_S T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_S}$$

$$\frac{N_N.T_{NN}^* + N_S.T_{NS}^*}{N_S + N_N} = \frac{b_N T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_N}$$

The terms on the left represent a weighted average of the patent lengths for products of a given origin, weighted by the market size of the destination country and averaged by the sum of the market sizes.

In fact, the Social Optimum Problem could be rewritten as the maximization of the following expression:

$$\begin{aligned} W = {} & M_S\alpha^{2\alpha\varepsilon}(1-\alpha)\left[N_S T_{SS} + N_N T_{SN}\right] + M_N\alpha^{2\alpha\varepsilon}(1-\alpha)\left[N_S T_{NS} + N_N T_{NN}\right] + \\ & + T\alpha^{\alpha\varepsilon}(1-\alpha)\left[\left(M_S + M_N\right)\left(N_S + N_N\right)\right] - \\ & - M_S\alpha^{\alpha\varepsilon}(1-\alpha)\left[N_S T_{SS} + N_N T_{SN}\right] - M_N\alpha^{\alpha\varepsilon}(1-\alpha)\left[N_S T_{NS} + N_N T_{NN}\right] + \\ & + M_S(N_S T_{SS} + N_N T_{SN}).Z - \frac{b_S}{1+b_S} M_S^{\frac{1+b_S}{b_S}} + U_{zS} + \\ & + M_N(N_N T_{NN} + N_S T_{NS}).Z - \frac{b_N}{1+b_N} M_N^{\frac{1+b_N}{b_N}} + U_{zN} \end{aligned}$$

We now define the following new variables: $G_S \equiv N_S T_{SS} + N_N T_{SN}$ and $G_N \equiv N_S T_{NS} + N_N T_{NN}$. From this rearrangement it is easier to notice that the total welfare is a function of G_S and G_N, and not of the patent lengths individually. Note that the steady state number of goods invented per period can also be written as a function of G_S and G_N: $M_S = \left[G_S\left(N_S + N_N\right)Z\right]^{b_S}$ and $M_N = \left[G_N\left(N_S + N_N\right)Z\right]^{b_N}$.

In other words, from the Efficiency viewpoint, for an interior solution it does not matter who protects the IPR on a specific good: the North or the South. What is important is that protection is provided on a good of a given origin.

Solving the maximization of W with respect to G_S and G_N yields obviously the same relationships for the social optimum:

$$\frac{G_S^*}{N_S + N_N} = \frac{N_S.T_{SS}^* + N_N.T_{SN}^*}{N_S + N_N} = \frac{b_S T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_S}$$

$$\frac{G_N^*}{N_S + N_N} = \frac{N_N.T_{NN}^* + N_S.T_{NS}^*}{N_S + N_N} = \frac{b_N T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_N}$$

These conditions then hold for an interior solution for the maximal welfare. It should be mentioned, however, the possible existence of some implementation cost of IPR protection which varies across regions. If we introduce such cost in the model as a convex function of the patent length, we stick to the interior Pareto solution just described. On the other hand, if we introduce some non-increasing marginal implementation cost, the efficient outcome will be a corner solution where only the country where it is cheaper to enforce IPR protection provides it. Imagining that it is cheaper to enforce IPRs in the North due to available expertise and lower cost of public funds, the social optimum requires the South not to protect any IPRs.

If $T_{SS}^* = T_{NS}^* = 0$ in the Pareto solution, we will have:

$$T_{SN}^* = \frac{b_S T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_S} \cdot \frac{N_S + N_N}{N_N}$$

and

$$T_{NN}^* = \frac{b_N T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_N} \cdot \frac{N_S + N_N}{N_N}$$

Nevertheless, from the equilibrium (Section II.3) we know that the maximal possible equilibrium value for T_{SN} (achieved when $T_{SS} = 0$) is:

$$T_{SN}^{\max} = \frac{b_S T}{1-(1+\alpha)\alpha^{\alpha\varepsilon}} \cdot \frac{N_S}{N_N}$$

However, it is straightforward to show that this expression is strictly smaller than the above one for T_{SN}^*. As a consequence, the socially optimal value for T_{SN} can never be achieved in the presence of such implementation cost.

The same happens in the comparison of T_{NN}^* and $T_{NN}^{\max} = \dfrac{b_N T}{1-(1+\alpha)\alpha^{\alpha\varepsilon} + \left(1-\alpha^{\alpha\varepsilon}\right)b_N}$.

As far as N_S is larger than zero, the social optimum for goods invented in the North can not be achieved under such implementation cost.

As a consequence, only some kind of *ad hoc* multi-sectoral agreement could make it incentive-compatible for the North. Remember that in LQ the optimal outcome required the South to protect IPRs to a larger extent than the North, and multi-sectoral agreements were put in place to make TRIPs incentive-compatible for the South.

V - Conclusion

The main intention of our work is to analyse an IPR policy setting game where the respect to the National Treatment Commitment Rule (NTCR) is not imposed. The NTCR requires giving the same treatment to IPR applicants no matter their nationality and providing nationals and foreigners with protection on equal basis, what requires – among others – for an equal period of time. This is an assumption commonly taken by the related literature but not respected in practice by most of the countries in what concerns IPR protection.

Our paper then proposes a game where there are two countries setting simultaneously the level of IPR protection for goods developed nationally and for the ones developed abroad. When making their best choices, they compare the short-term losses and long-term benefits of providing such protection, ignoring however the positive externalities of their choices. The short-term losses are the consumers' losses due to the lack of competition once the monopoly power is granted to a specific firm (the inventor), minus the increase in the short-term profits of inventive firms from having IPR protection. The long-term benefits come from the increase in the consumers' surplus in the long-run due to the larger number of products available, a direct consequence of the incentives given to R&D when IPRs are protected. The positive externality concerns these long-term benefits, since goods are made available worldwide as there are no barriers to trade.

The two countries are different from each other and this asymmetry comes from the size of the internal market for differentiated products and from each one's innovative capability. The North is assumed to have a larger market and a larger innovative capability in such a way that in each period it generates more new goods than the South.

We first showed the importance of the gap between market sizes for the magnitude of the free-riding problem (Lemma 1). Moreover, we noticed the complete disconnection between the choice of the protection for southern products and the one for northern goods (Lemma 2). In other words, when we do not impose the NTCR, in spite of the presence of positive externalities, the IPR policies are set strategically across countries but independently across goods' origins.

We then prove that some protection is always given to IPRs (Lemma 3). Under no circumstance it is possible to have an equilibrium outcome where no R&D is stimulated worldwide. The North, because of its innovative advantage and larger number of consumers, is always setting a positive IPR protection, at least for goods developed domestically.

After that, we stated the conditions under which an interior solution for the game is achieved (Proposition 1). It requires the innovation cost in the North to be small enough and the one in the South to be not that large, as well as a market in the North only a bit larger than the one in the South.

Proposition 2 completes the job of Proposition 1 in showing that an interior solution to this game is not easy to be obtained. We showed that there are five possibilities of equilibria represented by corner solutions, where one of them is not always possible as it requires very restrictive conditions (4^{th} case). The analysis pursued after the statement of the result intends to give a rough idea of what our results might imply in practice.

The results strengthens the argument that the imposition of the National Treatment Commitment Rule and its effective enforcement is not a necessary tool for ensuring protection of northern IPRs in the South and for increasing R&D in the world. If the South is quite competitive in R&D and has a market for differentiated goods which is not much smaller than the one in the North, enforcing patents on northern products comes as a natural optimizing choice, as argued in Section II.

In Section III we discussed a real world example of an application of the results obtained in the Section II. We end it arguing that a move towards an interior solution can be made by increasing the relevant market in the South, what could be done for example by having developing countries negotiating IPR agreements in bloc, additionally to any other policy increasing the purchasing power of poor consumers in the South.

In Section IV, however, we showed that the social optimum requires only overall incentives to IPRs. Moreover, in the presence of non increasing marginal implementation cost higher in the South than in the North, it is the case that the social optimum requires the South not to protect IPRs at all.

Consequently, once the artificial and unrealistic National Treatment Commitment Rule is left aside, increasing welfare requires rich countries to strengthen IPR protection. TRIPs should be rethought, and standardization makes no sense for efficiency.

VI - Appendix

VI.1 - Appendix 1: Tables for the values of A, B and C.

$$\frac{\left(1-\alpha^{as}\right)\left(1+b_S\right)}{1-(1+\alpha)\alpha^{as}} \equiv A$$

α \ b_S	0,01	0,05	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,55	0,60	0,65	0,70	0,75	0,80	0,85	0,90	0,95	0,99
0,05	1,43	1,48	1,56	1,63	1,70	1,77	1,84	1,91	1,98	2,05	2,12	2,19	2,26	2,33	2,40	2,47	2,55	2,62	2,69	2,76	2,81
0,10	1,54	1,60	1,67	1,75	1,83	1,90	1,98	2,05	2,13	2,21	2,28	2,36	2,44	2,51	2,59	2,66	2,74	2,82	2,89	2,97	3,03
0,15	1,62	1,69	1,77	1,85	1,93	2,01	2,09	2,17	2,25	2,33	2,41	2,49	2,57	2,65	2,73	2,81	2,89	2,97	3,05	3,13	3,20
0,20	1,69	1,76	1,84	1,93	2,01	2,10	2,18	2,26	2,35	2,43	2,52	2,60	2,68	2,77	2,85	2,94	3,02	3,10	3,19	3,27	3,34
0,25	1,76	1,83	1,92	2,00	2,09	2,18	2,26	2,35	2,44	2,52	2,61	2,70	2,79	2,87	2,96	3,05	3,13	3,22	3,31	3,39	3,46
0,30	1,82	1,89	1,98	2,07	2,16	2,25	2,34	2,43	2,52	2,61	2,70	2,79	2,88	2,97	3,06	3,15	3,24	3,33	3,42	3,51	3,58
0,35	1,87	1,95	2,04	2,13	2,22	2,32	2,41	2,50	2,60	2,69	2,78	2,87	2,97	3,06	3,15	3,24	3,34	3,43	3,52	3,61	3,69
0,40	1,92	2,00	2,10	2,19	2,29	2,38	2,48	2,57	2,67	2,76	2,86	2,95	3,05	3,14	3,24	3,33	3,43	3,52	3,62	3,71	3,79
0,45	1,97	2,05	2,15	2,25	2,34	2,44	2,54	2,64	2,73	2,83	2,93	3,03	3,13	3,22	3,32	3,42	3,52	3,61	3,71	3,81	3,89
0,50	2,02	2,10	2,20	2,30	2,40	2,50	2,60	2,70	2,80	2,90	3,00	3,10	3,20	3,30	3,40	3,50	3,60	3,70	3,80	3,90	3,98
0,55	2,07	2,15	2,25	2,35	2,45	2,56	2,66	2,76	2,86	2,96	3,07	3,17	3,27	3,37	3,48	3,58	3,68	3,78	3,88	3,99	4,07
0,60	2,11	2,19	2,30	2,40	2,51	2,61	2,71	2,82	2,92	3,03	3,13	3,24	3,34	3,44	3,55	3,65	3,76	3,86	3,97	4,07	4,15
0,65	2,15	2,24	2,34	2,45	2,56	2,66	2,77	2,87	2,98	3,09	3,19	3,30	3,41	3,51	3,62	3,73	3,83	3,94	4,05	4,15	4,24
0,70	2,19	2,28	2,39	2,50	2,60	2,71	2,82	2,93	3,04	3,15	3,25	3,36	3,47	3,58	3,69	3,80	3,91	4,01	4,12	4,23	4,32
0,75	2,23	2,32	2,43	2,54	2,65	2,76	2,87	2,98	3,09	3,20	3,31	3,42	3,53	3,64	3,76	3,87	3,98	4,09	4,20	4,31	4,40
0,80	2,27	2,36	2,47	2,58	2,70	2,81	2,92	3,03	3,15	3,26	3,37	3,48	3,60	3,71	3,82	3,93	4,05	4,16	4,27	4,38	4,47
0,85	2,31	2,40	2,51	2,63	2,74	2,86	2,97	3,08	3,20	3,31	3,43	3,54	3,66	3,77	3,88	4,00	4,11	4,23	4,34	4,46	4,55
0,90	2,34	2,44	2,55	2,67	2,79	2,90	3,02	3,13	3,25	3,37	3,48	3,60	3,71	3,83	3,95	4,06	4,18	4,29	4,41	4,53	4,62
0,95	2,38	2,47	2,59	2,71	2,83	2,95	3,06	3,18	3,30	3,42	3,54	3,65	3,77	3,89	4,01	4,12	4,24	4,36	4,48	4,60	4,69

$$\frac{1-\alpha^{\alpha\varepsilon}}{1-(1+\alpha)\alpha^{\alpha\varepsilon}+\left(1-\alpha^{\alpha\varepsilon}\right)b_S} \equiv B$$

α \ b_S	0,01	0,05	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,55	0,60	0,65	0,70	0,75	0,80	0,85	0,90	0,95	0,99
0,05	1,39	1,32	1,24	1,17	1,10	1,04	0,99	0,95	0,90	0,86	0,83	0,80	0,76	0,74	0,71	0,69	0,66	0,64	0,62	0,60	0,59
0,10	1,50	1,41	1,32	1,24	1,17	1,10	1,04	0,99	0,95	0,90	0,86	0,83	0,80	0,77	0,74	0,71	0,69	0,66	0,64	0,62	0,61
0,15	1,58	1,49	1,38	1,29	1,22	1,15	1,08	1,03	0,98	0,93	0,89	0,85	0,82	0,79	0,76	0,73	0,70	0,68	0,66	0,64	0,62
0,20	1,65	1,55	1,44	1,34	1,26	1,18	1,12	1,06	1,00	0,96	0,91	0,87	0,84	0,80	0,77	0,74	0,72	0,69	0,67	0,65	0,63
0,25	1,71	1,60	1,48	1,38	1,29	1,21	1,14	1,08	1,03	0,98	0,93	0,89	0,85	0,82	0,78	0,76	0,73	0,70	0,68	0,66	0,64
0,30	1,77	1,65	1,52	1,42	1,32	1,24	1,17	1,10	1,05	0,99	0,95	0,90	0,87	0,83	0,80	0,77	0,74	0,71	0,69	0,66	0,65
0,35	1,82	1,70	1,56	1,45	1,35	1,27	1,19	1,12	1,06	1,01	0,96	0,92	0,88	0,84	0,81	0,78	0,75	0,72	0,69	0,67	0,65
0,40	1,87	1,74	1,60	1,48	1,38	1,29	1,21	1,14	1,08	1,03	0,98	0,93	0,89	0,85	0,82	0,78	0,75	0,73	0,70	0,68	0,66
0,45	1,92	1,78	1,63	1,51	1,40	1,31	1,23	1,16	1,10	1,04	0,99	0,94	0,90	0,86	0,83	0,79	0,76	0,73	0,71	0,68	0,67
0,50	1,96	1,82	1,67	1,54	1,43	1,33	1,25	1,18	1,11	1,05	1,00	0,95	0,91	0,87	0,83	0,80	0,77	0,74	0,71	0,69	0,67
0,55	2,00	1,85	1,70	1,56	1,45	1,35	1,27	1,19	1,12	1,06	1,01	0,96	0,92	0,88	0,84	0,81	0,78	0,75	0,72	0,69	0,68
0,60	2,04	1,89	1,73	1,59	1,47	1,37	1,28	1,21	1,14	1,08	1,02	0,97	0,93	0,89	0,85	0,81	0,78	0,75	0,73	0,70	0,68
0,65	2,08	1,92	1,76	1,61	1,49	1,39	1,30	1,22	1,15	1,09	1,03	0,98	0,93	0,89	0,85	0,82	0,79	0,76	0,73	0,70	0,69
0,70	2,12	1,96	1,78	1,64	1,51	1,41	1,31	1,23	1,16	1,10	1,04	0,99	0,94	0,90	0,86	0,83	0,79	0,76	0,73	0,71	0,69
0,75	2,16	1,99	1,81	1,66	1,53	1,42	1,33	1,25	1,17	1,11	1,05	1,00	0,95	0,91	0,87	0,83	0,80	0,77	0,74	0,71	0,69
0,80	2,20	2,02	1,83	1,68	1,55	1,44	1,34	1,26	1,18	1,12	1,06	1,01	0,96	0,91	0,87	0,84	0,80	0,77	0,74	0,72	0,70
0,85	2,23	2,05	1,86	1,70	1,57	1,45	1,36	1,27	1,19	1,13	1,07	1,01	0,96	0,92	0,88	0,84	0,81	0,78	0,75	0,72	0,70
0,90	2,27	2,08	1,88	1,72	1,59	1,47	1,37	1,28	1,20	1,14	1,07	1,02	0,97	0,93	0,88	0,85	0,81	0,78	0,75	0,72	0,70
0,95	2,30	2,11	1,91	1,74	1,60	1,48	1,38	1,29	1,21	1,14	1,08	1,03	0,98	0,93	0,89	0,85	0,82	0,78	0,76	0,73	0,71

$$\frac{1-(1+\alpha)\alpha^{\alpha\varepsilon}+\left(1-\alpha^{\alpha\varepsilon}\right)b_N}{1-\alpha^{\alpha\varepsilon}}=1+b_N-\frac{\alpha^{\varepsilon}}{1-\alpha^{\alpha\varepsilon}}\equiv C$$

α \ b_N	0,01	0,05	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,55	0,60	0,65	0,70	0,75	0,80	0,85	0,90	0,95	0,99
0,05	0,72	0,76	0,81	0,86	0,91	0,96	1,01	1,06	1,11	1,16	1,21	1,26	1,31	1,36	1,41	1,46	1,51	1,56	1,61	1,66	1,70
0,10	0,67	0,71	0,76	0,81	0,86	0,91	0,96	1,01	1,06	1,11	1,16	1,21	1,26	1,31	1,36	1,41	1,46	1,51	1,56	1,61	1,65
0,15	0,63	0,67	0,72	0,77	0,82	0,87	0,92	0,97	1,02	1,07	1,12	1,17	1,22	1,27	1,32	1,37	1,42	1,47	1,52	1,57	1,61
0,20	0,61	0,65	0,70	0,75	0,80	0,85	0,90	0,95	1,00	1,05	1,10	1,15	1,20	1,25	1,30	1,35	1,40	1,45	1,50	1,55	1,59
0,25	0,58	0,62	0,67	0,72	0,77	0,82	0,87	0,92	0,97	1,02	1,07	1,12	1,17	1,22	1,27	1,32	1,37	1,42	1,47	1,52	1,56
0,30	0,57	0,61	0,66	0,71	0,76	0,81	0,86	0,91	0,96	1,01	1,06	1,11	1,16	1,21	1,26	1,31	1,36	1,41	1,46	1,51	1,55
0,35	0,55	0,59	0,64	0,69	0,74	0,79	0,84	0,89	0,94	0,99	1,04	1,09	1,14	1,19	1,24	1,29	1,34	1,39	1,44	1,49	1,53
0,40	0,53	0,57	0,62	0,67	0,72	0,77	0,82	0,87	0,92	0,97	1,02	1,07	1,12	1,17	1,22	1,27	1,32	1,37	1,42	1,47	1,51
0,45	0,52	0,56	0,61	0,66	0,71	0,76	0,81	0,86	0,91	0,96	1,01	1,06	1,11	1,16	1,21	1,26	1,31	1,36	1,41	1,46	1,50
0,50	0,51	0,55	0,60	0,65	0,70	0,75	0,80	0,85	0,90	0,95	1,00	1,05	1,10	1,15	1,20	1,25	1,30	1,35	1,40	1,45	1,49
0,55	0,50	0,54	0,59	0,64	0,69	0,74	0,79	0,84	0,89	0,94	0,99	1,04	1,09	1,14	1,19	1,24	1,29	1,34	1,39	1,44	1,48
0,60	0,49	0,53	0,58	0,63	0,68	0,73	0,78	0,83	0,88	0,93	0,98	1,03	1,08	1,13	1,18	1,23	1,28	1,33	1,38	1,43	1,47
0,65	0,48	0,52	0,57	0,62	0,67	0,72	0,77	0,82	0,87	0,92	0,97	1,02	1,07	1,12	1,17	1,22	1,27	1,32	1,37	1,42	1,46
0,70	0,47	0,51	0,56	0,61	0,66	0,71	0,76	0,81	0,86	0,91	0,96	1,01	1,06	1,11	1,16	1,21	1,26	1,31	1,36	1,41	1,45
0,75	0,46	0,50	0,55	0,60	0,65	0,70	0,75	0,80	0,85	0,90	0,95	1,00	1,05	1,10	1,15	1,20	1,25	1,30	1,35	1,40	1,44
0,80	0,45	0,49	0,54	0,59	0,64	0,69	0,74	0,79	0,84	0,89	0,94	0,99	1,04	1,09	1,14	1,19	1,24	1,29	1,34	1,39	1,43
0,85	0,45	0,49	0,54	0,59	0,64	0,69	0,74	0,79	0,84	0,89	0,94	0,99	1,04	1,09	1,14	1,19	1,24	1,29	1,34	1,39	1,43
0,90	0,44	0,48	0,53	0,58	0,63	0,68	0,73	0,78	0,83	0,88	0,93	0,98	1,03	1,08	1,13	1,18	1,23	1,28	1,33	1,38	1,42
0,95	0,43	0,47	0,52	0,57	0,62	0,67	0,72	0,77	0,82	0,87	0,92	0,97	1,02	1,07	1,12	1,17	1,22	1,27	1,32	1,37	1,41

VI.2 - Appendix 2: Full description of bilateral games between North and South

The group North contains countries quite different from each other, like the United States, France, Sweden and Ireland. One might think of the USA as the typical example of a very big market and a very low innovation cost. France is a big market with an innovation cost not that low. Sweden represents a quite small market with a well developed innovative capability, while Ireland is a quite small market with a moderate innovation cost.

Among countries in South, there are Brazil, Indonesia, South Africa and Angola. Brazil is a good example of a quite large market for differentiated goods and quite well established R&D structure. Indonesia here is thought as a quite large market but high innovation cost. South Africa represents a small market but quite high innovative capability, while Angola is a country with small market and very low innovative capability.

The table below summarizes these statements in terms of variables in our model:

		Market Size	Innovation Cost
North			
	USA	large N_N	large b_N
	France	large N_N	small b_N
	Sweden	small N_N	large b_N
	Ireland	small N_N	small b_N
South			
	Brazil	large N_S	large b_S
	Indonesia	large N_S	small b_S
	South Africa	small N_S	large b_S
	Angola	small N_S	small b_S

As a consequence, in a game between Sweden and Brazil we might expect to get a quite large A, quite low B and a very large C. Although the population in Brazil is much larger than the Swedish one, only a small fraction of it represents an effective demand for differentiated products, allowing us to assume N_N larger than N_S in such game. These countries represent the ideal ones in the above table for having conditions (I) and (II) satisfied, and the ratio between market sizes moderate. Therefore, in a bilateral game between countries featuring similar characteristics to these ones, one should expect to find an interior solution.

The same might occur in a game between the USA and Brazil, as well as in one between Sweden and South Africa. Since the structure of the innovation technologies is not changed, we also get a quite large A, quite low B and a very large C, in such a way that conditions (I) and (II) are for sure satisfied. The only difference concerns the ratio between market sizes being moderate. Between USA and Brazil, it is possible that N_N is much larger than N_S, making us leave the interior solution and reach probably the 1st case (where the South does not protect northern inventions) or even the 5th case (where the South does not protect IPRs at all) if the discrepancy between market sizes is huge. Between Sweden and South Africa, the same might happen but less probably since the disparity between market sizes seems to be smaller, making us stick to the interior solution, or possibly 1st case.

In a game between the USA and Indonesia we have the typical example for a possible achievement of the peculiar 4th case – if ever the elasticity of consumption (α) is sufficiently low. In this case, because of having many consumers but high innovation cost, Indonesia does not protect national innovations but grants patents to goods developed in the USA. The USA, on the other hand, because of also having a large market and despite the high innovation cost in Indonesia, strategically protects not only its domestic innovations, but also the ones developed in Indonesia.

In a game between USA or France (high N_N), and South Africa or Angola (low N_S), one might expect to be in the 5th case, where the South does not protect IPRs at all since N_N is much larger than N_S. Between France and South Africa the outcome could be different. We have in this case a high A, low B and C not that high. We could then end up in the 1st case, where South Africa protects goods developed domestically but does not respect IPRs on French goods.

France *versus* Brazil also generates a high A, low B and quite low C. Because of the ratio of market sizes, it is even more probable than France *versus* South Africa that we fall in the 1st case.

In a game with France and Indonesia, we have quite low A, quite large B[29] and quite low C, and a moderate market sizes ratio. We can reach an interior solution, or be in the 1st case, or in the 2nd one, or the 3rd, or even in the 5th one.

Ireland *versus* Brazil generates high A, low B and quite low C and a moderate ratio of market sizes. We should expect to be in the 1st case, instead, or in the 2nd possibly.

In a game between Sweden and Indonesia, we have quite low A, quite large B[30] and high C, and a even more moderate market sizes ratio, in comparison with France *versus* Indonesia. Therefore the probability of having an interior solution increases, although the 2nd case is also a good possibility. Because of its large market size and in spite of its high

[29] Remember, however, that $B < A$ always.
[30] Remember, however, that $B < A$ always.

innovation cost, Indonesia protects its domestic innovations and Sweden free-rides on this, not granting patents on goods developed in Indonesia – driving us to the 2nd.case.

A game between Sweden and Angola produces a low A, quite high B and large C, and a moderate market sizes ratio. This is the other game where we can achieve the peculiar 4th case instead of having an interior solution.

Ireland *versus* Indonesia generates a low A, quite high B and quite small C, and a moderate market sizes ratio. We could expect in theory to fall in the 4th case, but since the numeric computation showed we need very high b_N, one should find an interior solution to this game.

Ireland *versus* South Africa generates a high A, low B and quite small C. We can expect to fall in the 1st case or the 2nd[31], or stick to the interior solution.

Ireland *versus* Angola generates a low A, quite high B and quite small C. We should find an interior solution or be in the 1st case of the corner solutions.

[31] But less probably in the 2nd than Ireland *versus* Brazil, where the market sizes ratio is lower.

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