Theory of International Policy Coordination in the Protection of Ideas

Edwin L.-C. Lai

Federal Reserve Bank of Dallas

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1 Introduction

Why do we need international policy coordination? Typically, the answer is that in choosing their own policies individual governments do not take into account the effects those policies have on other nations. As a result, individual national policies are subject to a market failure arising from international externalities. The World Trade Organization (WTO) is a classic example of a body designed to facilitate international policy coordination — in this case, for trade-related issues. For example, Bagwell and Staiger (1999, 2002) and Staiger (1995) hold the view that terms of trade externalities are the core reason for having an organization such as the WTO. The optimal tariffs set by large countries seeking solely to maximize their own welfare are too high from the global welfare point of view, for no country considers the negative impact on export prices of its trading partners. Therefore, a multilateral institution that facilitates international coordination of trade policy to reduce tariffs can overcome this international policy failure and improve global welfare.

In this chapter I address similar questions regarding the protection of intellectual property rights (IPR). Do we need international coordination of IPR? If so, where are the underlying sources of policy failure? How should the coordination be done? Is global harmonization of IPR standards the best means of achieving welfare-maximizing policies? If so, on what level should harmonization take place? The WTO contains an ambitious attempt to manage this problem. The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) is an effort to coordinate IPR policies across member countries. What is TRIPS supposed to do and what has it actually achieved? Is it desirable for IPR to be included in world trade talks and be negotiated along with other trade issues?

In order to answer such questions, we need first to understand the nature of the problem at hand. What would the global policy equilibrium look like in the absence of international coordination of protection of ideas? What would the global optimum set of policies be? To answer these questions, I shall rely primarily on a simple model of policy formation with free trade and welfare-maximizing governments. I will see how tensions arise naturally in this context between technology-developing nations (the "North") and technology-importing countries (the "South"). Governments in he South naturally want to protect IPR less than the North does in Nash equilibrium. Next, I examine how the global optimum differs from the non-cooperative equilibrium. Then, I relax the assumptions of free trade and benevolent governments, analyzing the basic model in a world with trade barriers and firm-biased governments.

In the basic model I focus on international coordination in length and enforcement of patents in a world with free trade. However, IPR protection includes not only patents, but also copyrights and trademarks, among other things. Even if one focuses on only patent protection, there are other relevant issues, such as patent breadth, parallel trade, lobbying, trade barriers, and non-discrimination, which are not addressed in the basic model. How do these factors affect the optimal policy coordination? I will extend the basic model by incorporating some of these elements in the analysis. Towards the end of the chapter, I discuss other extensions to the basic model and speculate on how they might affects the major results.

The chapter is organized as follows. In Section 2 I briefly describe attempts at international coordination prior to, and including, the TRIPS Agreement. In Section 3 I review other papers that have analyzed policy coordination problems in the IPR context. I turn in Section 4 to my basic model, while in Section 5 I consider empirical evidence on its essential predictions. Further interpretation, extensions, and comments on potential extensions of the analysis are made in Sections 6 to 11, with concluding remarks in the final section.

2 The Development of Global Policy Coordination

Countries have long sought to coordinate their intellectual property policies, though the first major international efforts came in the late 19th century. The Paris Convention for the Protection of Industrial Property, which focuses primarily on patent protection, came into force in 1883. The Berne Convention for the Protection of Artistic and Literary Property, which focuses mainly on copyrights, was established in 1886. Both treaties were signed by a small number of countries with strong or emerging interests in IPR. These conventions have been renegotiated numerous times and their basic standards remain the essential framework of global IPR protection. A number of additional treaties have come into force over the intervening period, including the Madrid Agreement (covering registration and protection procedures in trademarks), the Rome Convention (covering protection for performers, broadcasters, and producers of audio recordings), and the Washington Treaty (aimed at protecting computer chip designs). Further, the World Intellectual Property Organization (WIPO), was elevated to the status of a United Nations specialized agency in 1974. Under its auspices a number of additional agreements have come into force, including the WIPO Copyright Treaty and the WIPO Performers and Phonograms Treaty, both negotiated in the late 1990s. WIPO is charged with facilitating negotiations on standards in intellectual property, overseeing the operation of its various conventions, serving as a clearinghouse for national laws in IPR, and accepting patent applications under the PCT and trademark applications under the Madrid Protocol.

While the international IPR system centered on WIPO and its various treaties is sophisticated and has been central in raising awareness about protection for technologies and information goods, it suffered from three serious shortcomings from the standpoint of global policy. First, virtually all international agreements on IPR within that system lacked any binding power to resolve disputes and commit countries to adopting and enforcing minimum standards. Second, the various conventions were based largely on a national treatment obligation, though even this mild form of non-discrimination was frequently subject to exceptions. This feature meant that the conventions failed to prevent countries from adopting weak standards of protection. Third, few of these conventions attracted significant numbers of countries, implying that they did not really extend the reach of IPR into much of the developing world.

Since the late 1980s, the United States, various EU countries and Japan began to exert ever higher pressure for other countries to adopt more stringent standards in protecting patents, trademarks, copyrights, and other elements in both the real world and the cyber-world. These efforts culminated in the signing of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), as part of the Uruguay Round of negotiations founding the WTO, in 1994. By January 1, 1996, all developed countries were required to adopt the universal minimum IPR standards set out in TRIPS. The corresponding deadline for all developing and transition economies was January 1, 2000, and that for the least-developed countries was January 1, 2006. The Doha Declaration of 2001 offered an additional extension to 2016 for pharmaceutical patent protection in the least-developed countries.

The TRIPS Agreement goes a long way toward resolving the three problems with the UN system mentioned above. Because it is part of the WTO, violations of IPR obligations accepted in TRIPS are now subject to binding dispute resolution procedures.[1] Second, it set out substantive minimum standards in all areas of intellectual property protection, which required virtually all nations, especially the developed countries, to strengthen their rules markedly. Third, because WTO membership is virtually universal, nearly all countries in the world are now bound by the IPR requirements in TRIPS. This applies equally to countries still acceding to the WTO, for they must adopt or exceed TRIPS standards. Thus, while TRIPS remains some distance from global harmonization of IPR, it has markedly strengthened and universalized international protection.

What does TRIPS cover? In general, there are three main aspects of coordination: national treatment, most-favored nation (MFN) treatment and a significant tendency toward harmonization of IPR standards. National treatment requires all members to treat nationals of other countries no less favorably than their own nationals. The MFN principle requires that advantages and privileges granted by a member to the nationals of any other country should be extended unconditionally to the nationals of all other WTO members. Harmonization refers to the establishment of universal minimum IPR standards. Note that these are minimum standards and countries are free to make their own regulations even more protective. In this sense TRIPS does not achieve full harmonization. The IPR standards to be coordinated cover patents, copyrights, trademarks, geographical indications, industrial designs, layout designs of integrated circuits, plant varieties, and trade secrets, among other things.[2]

It has been argued elsewhere (e.g., Maskus 2000) that TRIPS is probably the most impor-

[1]This process is discussed in detail by Beshkar and Bond in their chapter in this volume.

[2]See, for example, UNCTAD (1997, pp. 8-12) and Maskus (2000, pp.18-19).

tant international IPR agreement ever signed, because of the number of countries involved and the scope of changes implied, especially in the developing countries. Most importantly, TRIPS can be enforced by the WTO through the dispute settlement procedure. One country can impose trade retaliation on another country if the latter violates some TRIPS obligation and thereby nullifies or impairs the benefits of TRIPS that should be enjoyed by the former. Important as it is, formal economic analyses of TRIPS are scarce. Some legal scholars (e.g., Reichman 1995) have argued that TRIPS is basically backward-looking in nature, enshrining what the developed world had been adopting before the agreement was negotiated as the world minimum standard. Reichman goes on to argue that the reason the developing nations signed the TRIPS agreement was that the advanced industrial countries promised to open up their markets in agriculture and traditional goods in exchange for the former countries agreeing to abide by TRIPS.

3 Models of IPR Policy Coordination

3.1 Models of North-South IPR without Coordination

There have been theoretical and empirical studies of the welfare effects of the global systems of IPR protection, mostly in the North-South setting. Both Chin and Grossman (1990) and Deardorff (1992) examine welfare effects of extending IPR protection from the North to the South. They find that many results depend on the size of the South's market. Their studies are based on two important assumptions. First, they assume that the South does not have innovative capability. Second, they examine only the case where the South has either full or no IPR protection. Diwan and Rodrik (1991) also consider various degrees of IPR protection in the North and the South. Interestingly, they find that to maximize global welfare, which is the equally weighted sum of the North's and the South's welfare, the rates of patent protection in the two regions must be identical. They emphasize the taste difference between the two regions and assume no innovative capability in the South. Helpman (1993) studies IPR protection, growth and welfare using a two-country general equilibrium model (with North and South), where the North specializes in innovation and the South specializes in imitation. He finds that tightening IPR protection in the South hurts the South and may or may not benefit the North.

How does IPR affect trade, foreign direct investment (FDI), licensing and technology transfer between the North and South? Drawing on the endogenous product-cycle model of Grossman and Helpman (1991, Ch.11), Lai (1998) shows that an increase in the rate of imitation caused by a weakening of IPR protection leads to less FDI from the North to the South, as Northern firms prefer exporting so as to lower the risk of being imitated. This leads to a decrease in the rate of innovation and a decrease in the terms of trade of the South, as there is less technology transfer. Markusen (2001) shows that (intellectual) property rights enforcement may lead to a shift from exporting to a local subsidiary, and this mode shift improves the welfare of both the multinational corporation and the host country. Yang and Maskus (2001) examine the effects of IPR on licensing and innovation in the context of an international product-cycle model. Glass and Saggi (2001), on the other hand, study the effects of IPR protection on licensing versus direct investment, which in turn have an effect on economic growth.

An interesting empirical study by McCalman (2001) finds that TRIPS generates large income transfer between countries, with the total sum of net outward transfers from all countries equal to $U.S. 6.23 billion. The United States gets more than 70 percent of all inward transfers, followed distantly by Germany, France, and Italy. Surprisingly, developing countries account for only 40 percent of all the outward transfers. Even more surprisingly, the largest amounts of outward transfer come from Canada, Brazil, the United Kingdom, India, Mexico and Japan. This is certainly a mixed basket of Northern and Southern countries. This reveals the fact the many developed countries did not protect IPR as strongly as the United States before TRIPS came into being. However, McCalman does not estimate the total deadweight losses or the benefits that arise out of TRIPS, such as increased innovation, trade and technology transfer.

3.2 IPR-Trade Policy Tradeoffs

How does IPR protection interact with trade policy? Since import barriers effectively subsidize domestic firms but tax foreign firms, they encourage innovation by domestic firms but discourage innovation by foreign firms. Qiu and Lai (2004) point out that in a world where the North specializes in innovation and the South in imitation, a Northern tariff is pro-innovation, and therefore is a substitute for IPR protection, while a Southern tariff discourages innovation, and therefore offsets IPR protection. They find that the globally optimal Northern tariff increases as IPR protection in the North or the South decreases. Consequently, global welfare may rise as the Northern tariff increases, but necessarily declines as the Southern tariff increases. Zigic (2000) finds a similar motive for the North to protect trade, and that a Northern tariff can be globally welfare improving, though he uses a more complicated four-stage game to demonstrate his result.

Goh and Olivier (2002) use an innovation-driven endogenous growth model (of the expanding-variety type) to study the interaction between trade protection and IPR protection. Their model focuses on the IPR-sensitive sector. An import tariff taxes foreign firms while a narrowing of patent breadth taxes both domestic and foreign firms. Thus, heightening import tariff and reducing patent breadth are partially substitutable policies. Since they both confer a negative externality on foreign countries, the non-cooperative equilibrium is characterized by the Prisoner's-Dilemma problem in both policies, which presumably have to be corrected by international coordination.

One has to bear in mind that the tradeoffs (or offsetting effects) between tariffs and IPR protection is true only for tariffs on IPR-sensitive goods. In a general-equilibrium model, tariffs on non-IPR-sensitive goods can penalize the domestic IPR-sensitive sector and discourage innovation. Conversely, tariffs on IPR-sensitive goods can have general-equilibrium effects on non-IPR-sensitive sectors. Welfare and growth analyses should take these effects into account.

3.3 IPR Externalities and Coordination Problems

Central to the need for international coordination is the possible failure of self-serving national policies to deliver a globally efficient outcome. This is often linked to the existence of cross-border externalities. Noting the shortcomings of analyzing Southern IPR decisions as all-or-nothing in Chin and Grossman (1990) and Deardorff (1992), McCalman (2002) shows that when countries are allowed to set their own patent strengths, the non-cooperative equilibrium is globally suboptimal. He argues that global optimality requires that the country faced with a demand curve such that the ratio of deadweight losses to monopoly profits is lowest be the sole provider of IPR in the world. Therefore, when countries have to set their own national patents, their patent strengths are too low, due to the existence of two externalities. First is the free-rider effect, whereby all countries benefit from the IPR-strengthening policies of a single country, and second is the fact that the policy chosen by an individual country neglects to take into account the surplus that accrues elsewhere.

The relationship between IPR agreements and other trade agreements is captured in a theoretical analysis by Lai and Qiu (2003). They point out that as a country protects IPR more, the rest of the world (ROW) gains because the ROW's innovating firms make more profit in the country that protects, and its consumers enjoy more new products at no extra costs. On the other hand, the loss in consumer surplus as a consequence of strengthening IPR is solely borne by the country that strengthens the protection. These externalities point to the suboptimality of the non-cooperative Nash equilibrium. The paper shows that, because of the externality created by the strengthening of Southern protection, it is globally welfare-improving for the South to strengthen IPR protection sufficiently to harmonize with the North's current level of protection, though it benefits the North at the expense of the South. This creates a case for a *quid pro quo* between the two regions: the North opens up its traditional goods market to the South in exchange for the South harmonizing IPR protection with the North. This paper will be discussed in more detail later in this chapter.

Casting the IPR coordination problem in a broader context, Scotchmer (2004a) studies the optimality of IPR treaty in a world where national governments have two technology-policy instruments: funding public R&D and negotiating an IPR treaty with foreign countries based on the principles of national treatment and, possibly, harmonization. She recognizes that total R&D in the world is too low in any non-cooperative equilibrium, as the benefits of R&D are partly enjoyed by foreigners. However, when comparing IPR protection and public spending on R&D, she concludes that an IPR treaty based on national treatment and harmonization would provide too much IPR protection and too little public R&D spending. This is because patent protection will encourage private firms to undertake R&D in order to earn profits abroad, while public sponsors are only interested in domestic consumer surplus. She therefore suggests that a better remedy to the problem of under-provision of total R&D is to seek international agreements on public spending for R&D, rather than negotiating treaties to strengthen IPR.

To guide empirical studies, a more detailed framework is needed to analyze the incentives to protect IPR in an open economy, why the strengths of IPR protection differ across countries, and whether and how international policy coordination is needed. Grossman and Lai (2004) is an attempt in this direction. The framework they use in the analysis of IPR is close to that of Lai and Qiu (2003). Grossman and Lai (2004), likewise, recognize the existence of positive cross-border externalities in IPR protection. The paper concludes that global welfare can be maximized by raising the strength of global IPR protection from the Nash-equilibrium level, where the strength of global IPR protection is defined as a variable proportional to the value of a global patent. There is a continuum of combinations of IPR strength in the two regions that can achieve a global optimum with Pareto improvements in welfare for both North and South. Whether or not strict harmonization is an element of this Pareto-optimal set depends on whether the North and the South are sufficiently similar in their innovativeness and the sizes of their domestic markets.

Although Grossman and Lai's (2004) paper generates valuable insights, the model may be regarded as too simple when used to answer the question "Would global patent protection be too weak without TRIPS?" Some commentators (such as Reichman, 1998, p.588) think that patent protection was already too strong before TRIPS, while there is no hard evidence to show one way or the other. A straightforward application of Grossman and Lai (2004) would answer "yes" to the question. However, two important factors can create counteracting forces that reverse the answer to "no". They are government bias toward the interests of domestic firms and the existence of trade barriers. Lai (2005) is an attempt to model these questions. He concludes that under reasonable assumptions about the strengths of government-bias and trade barriers, global patent protection is still too weak in Nash equilibrium. In other words, global patent protection would still be too weak without international coordination and an agreement such as TRIPS can potentially improve global welfare.

Since the model in Grossman and Lai (2004) covers most of the issues in the literature, and can be easily extended to cover additional ones, I shall introduce a simple IPR coordination model based on that paper in the next section as a basis for analysis.

4 The IPR Coordination Model

I shall use the model set out in Grossman and Lai (2004) as my essential framework for analysis. First, I need to clarify that IPR protection includes not just patents, but also copyrights and trademarks, plus other devices that are similar to these canonical forms. I will, however, focus on patent protection in the formal analysis. The analysis of copyrights should follow the same principle, while trademarks should probably be analyzed differently. Second, bear in mind that not all innovations require patent or copyright protection. Some inventions, such as Coca-Cola, use trade secrets to protect their intellectual property, because the recipe is hard to reverse engineer from inspection of the product. Patent protection is offered in exchange for disclosure of technological detail. Therefore, trade secrets, rather than patent protection, are used when the imitation lag without disclosure is long relative to patent length. Other innovations, such as new management methods, may not seek any formal intellectual property protection, since the first-mover advantage is enough to keep the innovator ahead of other competitors. It takes time for rivals to imitate and the imitation lag may be long enough for the first inventor to make a sufficient profit to recapture investment costs. Moreover, the innovator might have already established a brand name or reputation that can sustain its ability to earn economic rents for a long period of time.

In the model to come, I assume that there will be no innovation without IPR protection since imitation is costless and can be done immediately. This is true to different extents in different industries. For example, imitation costs are quite low in many components of the pharmaceutical, chemical and biotechnology industries (Mansfield 1986; Maskus 2000). These industries are especially sensitive to patents. Similarly, digital products can be downloaded, copied and distributed at virtually zero cost, making content providers keen to be protected with copyrights. These two commercial complexes are often called IPR-sensitive industries.

4.1 Model Preview

In the basic model, I consider a trading world with two countries that differ by the sizes of their domestic markets for IPR-sensitive goods and innovative capabilities. Assume also that consumers love more variety of differentiated goods, the blueprints of which are developed by investing in R&D. I consider ongoing product innovation done by firms in both countries. After a firm develops a new product, it seeks patent protection from each country separately. It follows that a firm's profits increase as the degree of patent protection in either country increases. Moreover, when a country's market is larger, a strengthening of IPR protection there generates more profits for firms in both countries. When more profits can be earned from owning patents, more firms will innovate, creating more variety for consumers.

I assume that the two countries' governments play a Nash game in setting their strengths of patent protection, taken here to be patent length. Given the duration of patent protection of the other country, each government chooses its duration of patent protection to maximize the present discounted value of the sum of domestic consumer welfare and the profits of domestic firms. This behavior generates the best-response function of each country. A government's best response strikes a balance between the marginal costs and marginal benefits of strengthening domestic patents, given the duration of protection of the other country.

The marginal costs of strengthening IPR protection arise from the fact that innovative firms charge monopoly prices instead of competitive prices for a larger fraction of the domestic market or product life. This market power increases prices domestic consumers have to pay. It also increases domestic firms' profits but not by enough to offset the losses in consumer surplus, resulting in deadweight losses. Furthermore, each country is required to uphold the national treatment principle, under which domestic and foreign firms must be protected to the same extent. Thus, it loses more from IPR protection provided to foreign firms than from that accorded domestic firms, since the domestic government only cares about domestic firms' profits. Therefore, if a country innovates a smaller fraction of world goods than it consumes, its cost of strengthening patents is larger.

On the other hand, the marginal benefits of strengthening IPR protection arise from increasing the incentives of both domestic and foreign firms to innovate, thus providing more variety for domestic consumers. Because there is free trade, inventions from domestic and foreign firms are equally beneficial. For the same increase in length of patent rights, the country with the larger market provides more incentives for firms to innovate. Thus, the benefit a country reaps from strengthening its IPR protection is greater if the country's domestic market is larger.

When a country strengthens its patents, it increases the profits of foreign firms and also induces more inventions from all over the world, benefiting foreign consumers. Thus, a country's strengthening of IPR conveys positive spillovers to other countries. In other words, choosing policy on its own a country cannot capture all the benefits of its action. This is the key insight explaining why world IPR protection is too weak in the Nash equilibrium compared with the coordinated global optimum.

4.2 A North-South Model of IPR Choice

Here I present the formal model in some detail, referring the reader to Grossman and Lai (2004) for additional analysis. At any point in time, consumers are faced with a continuum of differentiated consumer products, which are the result of product innovations, and one outside good. There is ongoing innovation, the rate of which is endogenous. Each product has an exogenously given useful life of length $\bar{\tau}$. Define $\bar{T} = \frac{1-e^{-\rho\bar{\tau}}}{\rho}$, which is the present discounted value of one dollar from time 0 to $\bar{\tau}$. The two countries, North and South, each chooses its strength of patent protection, Ω_N and Ω_S, respectively, where $\Omega_j = \omega_j T_j$.

The variable ω_j is the fraction of country j's market that protects patented goods and is interpreted as the degree of enforcement of patents. Variable $T_j = \frac{1-e^{-\rho\tau_j}}{\rho}$, where τ_j is patent length, is the present discounted value of one dollar from time 0 to τ_j.

Consumers in both countries have the same preferences. The utility function of a consumer in country j at time z is given by

$$u_j(z) = y_j(z) + \int_0^{n_S(z)+n_N(z)} h[x_j(i,z)]di$$

where $y_j(z)$ is consumption of the outside good, $n_k(z)$ is the measure of economically active differentiated goods that have been developed by country $k = N, S$, and $h[x_j(i,z)]$ is the utility derived from consumption of x_j units of differentiated good indexed by i at time z. For simplicity, we assume the demand curve faced by all consumers for all differentiated goods are the same. I make the usual assumptions sufficient to ensure that there is positive demand for all variety and that prices are finite. The number of consumers (market size) in North and South are M_N and M_S respectively. Note that the number of consumers is not necessarily the same as the population, for IPR-sensitive goods are typically normal goods with high income elasticity. Accordingly, they could have higher demand in richer countries than in poorer countries.

In steady state, free entry into the innovation business implies that at each date the returns to research capital $r_j H_j$ plus those of research labor $w_j L_{Rj}$ must equal the total value ($\phi_j v$)of the patents of all goods invented at that date: $r_j H_j + w_j L_{Rj} = \phi_j v$. Here H_j, the supply of research capital. is exogenous given, while r_j, the rate of return to research capital, L_{Rj},the labor employed in research, ϕ_j,the flow of inventions from country j, and v,the value of a global patent, equal to $\pi\left(M_S\Omega_S + M_N\Omega_N\right)$, are endogenously determined.

The welfare of country i at time 0 consists of the welfare from consumption of goods that have been invented before time 0, Λ_{j0}, plus the present-discounted value of labor income, returns to capital, and consumer surplus derived from consumption of goods expected to be developed in each period in the future. This initial welfare measure for country j is then

$$W_j(0) = \Lambda_{j0} + \frac{w_j(L_j - L_{Rj})}{\rho} + \frac{M_j(\phi_S + \phi_N)}{\rho}\left[\Omega_j C_m + (\bar{T} - \Omega_j)C_c\right] + \frac{\phi_j}{\rho}\pi\left(M_S\Omega_S + M_N\Omega_N\right)$$

where L_j is supply of labor, π is the monopoly profit per consumer, C_c is consumer surplus under perfect competition, C_m is consumer surplus under monopoly, w_j is wage, and ρ is the time rate of preference, which is also equal to the interest rate as expenditure is constant over time. Of the variables in the above equation, only w_j, L_{Rj}, ϕ_S and ϕ_N are endogenously determined. The wage w_j is determined by trade and labor productivities. Stronger protection of IPR anywhere in the world would lead to increases in L_{Rj}, ϕ_S and ϕ_N, as stronger IPR protection under free trade induces more labor allocated to research in both countries and thus higher flows of innovation in both countries.

Labor is the only factor input in production of any good. Let a_j be the units of labor to produce one unit of any good in country j. Since the numeraire good is produced in both countries, and is freely traded, we have $w_N/w_S \equiv w = a_S/a_N$. Moreover, differentiated products have the same unit cost in each country. Assume for simplicity that the R&D function, $\phi_j = F\left(H_j, L_{Rj}/a_j\right)$, is Cobb-Douglas in research labor L_{Rj} and research capital H_j: $\phi_j = A\left(L_{Rj}/a_j\right)^b H_j^{1-b}$. Define γ_j to be the elasticity of the rate of innovation with respect to the value of a patent. When the R&D function is of the Cobb-Douglas type, $\gamma_j = \gamma = b/(1-b)$, which is a constant. Equilibrium in the labor market means that the value of marginal product of workers in R&D is equal to the wage, which determines the allocation of workers to R&D and manufacturing. Then an increase in patent value v leads to an increase in research labor L_{Rj}, which increases the rate of innovation ϕ_j. Under more general R&D functions, γ becomes endogenous and $\gamma'(v) \leq 0$ if there are weakly diminishing returns to innovation with respect to IPR protection. This is a more plausible scenario than a constant innovation elasticity.

Firms patent their goods separately in each country, but they all receive national treatment in each country. Countries choose their strengths of patent protection Ω_S and Ω_N. In the share of goods (ω_S, ω_N) where patents are protected, imitators cannot produce the goods locally, nor can an imitation good be imported and sold. When the patent expires, or when the patent is not protected because of lax enforcement, the good can be imitated, produced and sold freely.

Now I derive the best-response functions. To derive South's best response, note that the marginal cost (per consumer) to South consists of, first, increases in deadweight loss on goods invented in South, $C_c - (C_m + \pi)$, and, second, increases in the loss of consumer surplus on goods invented in North, $C_c - C_m$. The marginal benefit (per consumer) to South consists of, first, increases in the profits $M_S\pi$ of Southern innovators, which leads to an increase of ϕ_S, which in turn leads to greater consumer surplus for Southern consumers, and, second, increases in the profits $M_S\pi$ of Northern innovators, which leads to an increase in ϕ_N, and thus greater consumer surplus for Southern consumers. In other words, South's best response is given by

$$\phi_S(C_c - C_m - \pi) + \phi_N(C_c - C_m) = \left(\frac{d\phi_S}{dv} + \frac{d\phi_N}{dv}\right) \cdot \frac{dv}{d\Omega_S}\left[C_m\Omega_S + C_c(\bar{T} - \Omega_S)\right]$$

where the left-hand side is marginal cost and the right-hand side is marginal benefit. Define $\mu_j \equiv \phi_j/(\phi_S + \phi_N) = H_j/(H_S + H_N)$for the Cobb-Douglas research function (indeed, for all CES research functions). Then this equation can be rewritten for country $j = N, S$

$$C_c - C_m - \mu_j\pi = \frac{\gamma M_j\left[C_c\bar{T} - (C_c - C_m)\,\Omega_j\right]}{M_S\Omega_S + M_N\Omega_N} \tag{1}$$

It is clear that the best-response function is downward sloping in (Ω_S, Ω_N) space. To understand the strategic interdependence between the governments, consider the choice of patent protection by the South. Suppose the North were to strengthen its patent protection, implementing a higher Ω_N. This would shrink the fraction of total discounted profits that any innovator earns in the South and so, *ceteris paribus*, would reduce the responsiveness of global innovation to patent policy in the South. Moreover, the increase in Ω_N would draw labor into R&D in both the North and South. Since the elasticity of innovation stays constant, the South would find that its market is relatively less important to potential innovators and that these innovators are less responsive to its patent policy. For both reasons, the marginal benefit to the South of strengthening its patent protection would fall and so the government would respond to the increase in Ω_N with a reduction in patent length or an easing of enforcement. Thus, foreign and home IPR protection policies are strategic substitutes given our assumption that innovation elasticity γ is independent of patent value v.

4.3 Nash Equilibrium

The Nash equilibrium is shown in Figure 1. It is clear that the equilibrium is "stable" and unique when there is an interior solution. From equation (1), one can infer that a country with both larger M_j and μ_j has a higher equilibrium Ω_j. Thus, a country with a larger domestic market for IPR-sensitive goods and higher innovative capability protects patents more in equilibrium. Given that in practical terms the North has a larger market for IPR-sensitive goods, and higher innovative capability, it is natural to assume that $M_N > M_S$ and $\mu_N > \mu_S$. Then, it is not surprising that the North protects IPR more than the South does in equilibrium. This creates tension between the countries, as we shall discuss below.

Note that a country's equilibrium strength of protection is zero if its relative market size or relative innovativeness is small compared with the rest of the world. In other words, if either M_S/M_N or μ_S is too small, then the equilibrium Ω_S is equal to zero.[3] Similarly, there is an interior solution only when γ is sufficiently large. Otherwise, the South offers no protection in equilibrium. Since γ is the elasticity of rate of innovation with respect to the value of a patent, a large γ means that the differentiated goods are patent-sensitive. If the goods are not sufficiently patent-sensitive, the equilibrium strength of Southern protection Ω_S is zero.[4] This outcome would pertain if the set of protected subject matters include many non-patent-sensitive sectors, making γ too small.

<Figure 1 here>

4.4 Efficiency

To find the global optimum, we choose policies Ω_S and Ω_N that maximize $W_S(0) + W_N(0)$, where

$$\rho\left[W_S(0) + W_N(0)\right] = \rho(\Lambda_{S0} + \Lambda_{N0}) + (L_S - L_{RS})w_S$$

$$+(L_N - L_{RN})w_N + (M_S + M_N)\bar{T}\left(\phi_S + \phi_N\right)C_c - Q\left(\phi_S + \phi_N\right)\left(C_c - C_m - \pi\right).$$

in which $Q = M_S\Omega_S + M_N\Omega_N$ is the aggregate global strength of IPR protection. Observe that patent value $v = \pi(M_S\Omega_S + M_N\Omega_N) = \pi Q$,while the value of marginal product in innovation, $vF_L(H_j, L_{Rj}) = w_j = 1/a_j$ is constant. So, changes in Ω_S and Ω_N that leave Q unchanged do not affect labor allocation or innovation rates in either country or global welfare. The value of Q that maximizes global welfare defines the efficient combinations of Ω_S and Ω_N. Therefore, there is an efficiency frontier instead of an efficiency point. In fact,

[3] We have not discussed the shape of the best- response functions where they hit the axes or where the constraint that $\Omega_j \leq \bar{T}$ begins to bind. The best-response curve of the South becomes vertical if it hits the vertical axis at a point below $\Omega_N = \bar{T}$. It also becomes vertical if the South's best response is $\bar{T}$ for some positive value of Ω_N. Similarly, the best-response curve for the North becomes horizontal if either it hits the horizontal axis before $\Omega_S = \bar{T}$ or if the North's best response is $\bar{T}$ for some positive value of Ω_S. Thus, the best-response curve for the South must be steeper than that for the North at any point of intersection.

[4] One can easily solve for $M_S\Omega_S$ from the best-response functions and observe that its value increases with γ. As γ becomes small, the value of $M_S\Omega_S$ becomes zero, given our assumption that $M_N > M_S$ and $\mu_N > \mu_S$.

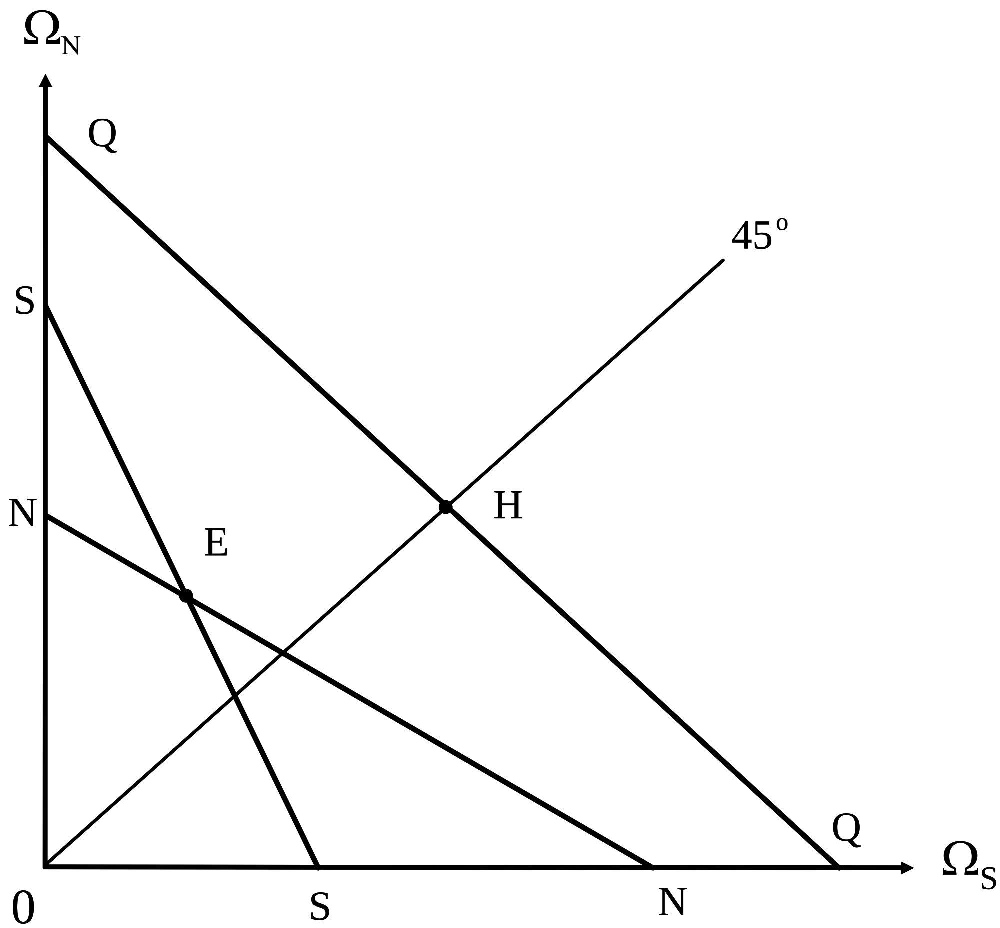

Figure 1: Comparison of Nash Equilibrium and Efficient Patent Regime

the first-order condition for maximization of $W_S(0) + W_N(0)$ is

$$C_c - C_m - \pi = \frac{\gamma (M_S + M_N)}{Q} \left[C_c \bar{T} - (C_c - C_m) \left(\frac{Q}{M_S + M_N} \right) \right], \tag{2}$$

which is linear in (Ω_S, Ω_N) space for the Cobb-Douglas research technology. If we compare equation (2) with equation (1), we see that the efficiency frontier lies outside both best-response functions, because of the externalities that we discussed before. Figure 1 shows this situation. The curve QQ is the efficiency frontier. For any given foreign strength of IPR protection, each country needs to protect more than its best-response level to achieve global efficiency.

If international transfer payments are feasible, then a globally efficient patent regime must have $M_S\Omega_S + M_N\Omega_N = Q^*$, where Q^* is the solution to equation (2). Notice that a range of efficient outcomes can be achieved without the need for any international transfers. By appropriate choice of Ω_N and Ω_S, the countries can be given any welfare levels on the efficiency frontier between that which they would achieve if $\Omega_S = 0$ and $\Omega_N = Q^*/M_N$ and that which they would achieve if $\Omega_S = Q^*/M_S$ and $\Omega_N = 0$.[5]

Although aggregate world welfare does not vary with the national policies ω_j and τ_j as long as $M_S\Omega_S + M_N\Omega_N = Q^*$, the countries fare differently under the alternative combinations of policies that can be used to achieve global efficiency unless compensating transfers take place. In particular, the welfare of the North increases, and that of the South decreases, as Ω_S is raised and Ω_N is lowered in such a way as to keep the weighted sum constant. It follows that, absent any international transfer payments, the countries have a strong conflict of interest over the terms of an international patent agreement.

4.5 Pareto-Improving Patent Agreements

The conclusion from Figure 1 is that efficiency requires strengthening patent protection in at least one country. Do all countries need to strengthen their protection under efficient harmonization? Suppose I maintain the plausible assumption that $M_N > M_S$ and $\mu_N > \mu_S$. More detailed analysis reveals that efficient harmonization must require the strengthening

[5] This statement ignores the ceiling on patent lengths imposed by the finite economic life of differentiated products. A more precise statement is that a range of distributions of maximal world welfare can be achieved by varying Ω_S between $\Omega_S = \max\{0, (Q^* - M_N\bar{T})/M_S\}$ and $\min\{Q^*/M_S, \bar{T}\}$ while varying Ω_N between $\Omega_N = \min\{Q^*/M_N, \bar{T}\}$ and $\max\{0, \left(Q^* - M_S\bar{T}\right)/M_N\}$ in such a way that $M_S\Omega_S + M_N\Omega_N = Q^*$.

of IPR protection in the South, and in the world as a whole, as long as has there are weakly diminishing returns to patent protection in terms of inducing global innovation. Indeed, when the degree of diminishing returns is sufficiently high, efficient harmonization may not require strengthening of protection in the North (Boldrin and Levine 2005; Grossman and Lai 2005). However, it will require the North's strengthening of protection if γ is constant (i.e., the research function is Cobb-Douglas).

Do both countries necessarily gain from efficient harmonization? The answer is "no". Figure 2 shows the case when the North gains from efficient harmonization but the South loses. The more asymmetric the two regions are, i.e. the higher is M_N/M_S or H_N/H_S, the more likely is this outcome. If the countries are more symmetric it is more possible for both regions to gain from efficient harmonization.

<Figure 2 here>

4.6 Many Countries

With many countries in the world the flavor of this analysis still holds. Specifically, a sufficiently small country (in a world with some large countries) will set its patent protection to zero in Nash equilibrium. Interestingly, the Nash-equilibrium global strength of patent protection is a declining function of the number of countries. The reason is that the greater the number of countries, the more serious is the free-rider problem. As a result global incentives for innovation are weaker in a noncooperative equilibrium. The efficiency frontier may be used to show that the greater the number of nations, the larger is the departure of global protection from the coordinated efficient level. It follows that a multi-country world would find it particularly hard to reach an agreement on efficient patent policies.

4.7 Main Results

I summarize the main results of the model as follows. First, a country with a larger domestic market and higher innovative capability tends to protect IPR more in Nash equilibrium. Second, to achieve global efficiency, an international agreement must strengthen the aggregate world patent protection relative to the Nash equilibrium. Third, the problem of too-weak protection of IPR becomes more serious with an increase in the number of independent sovereign decision makers. Finally, harmonization is neither necessary nor sufficient

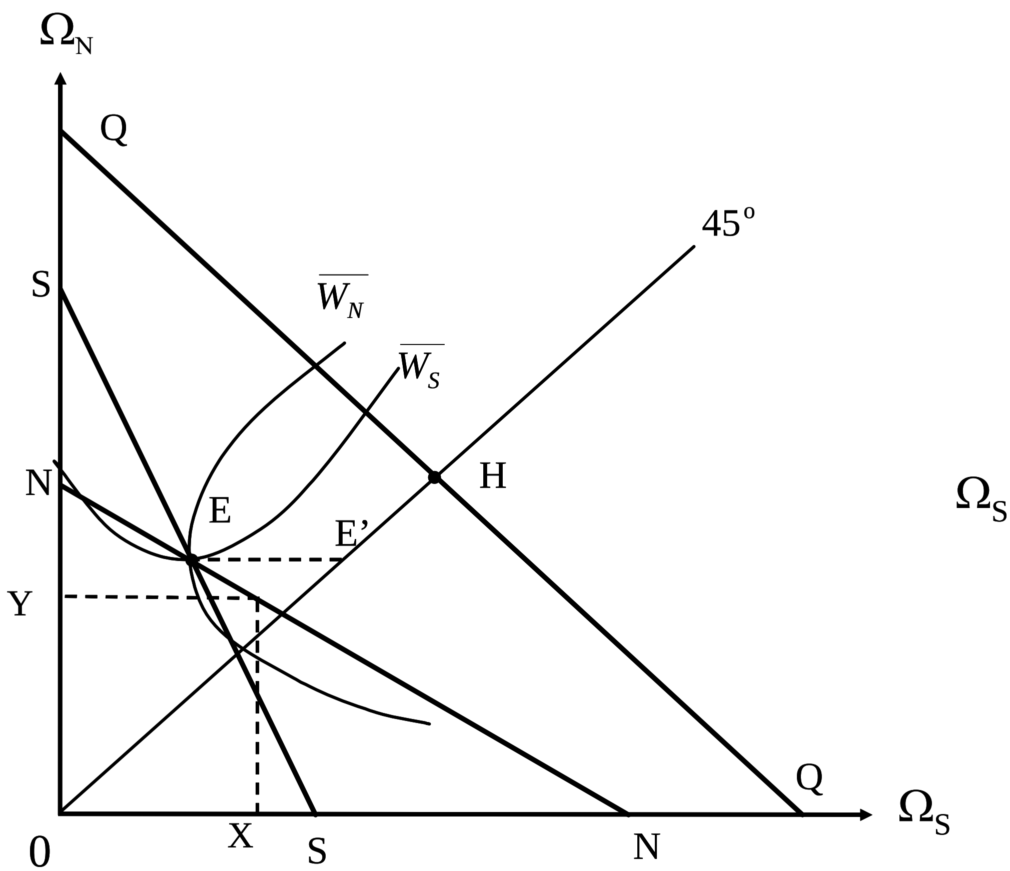

Figure 2: Who gains and who loses from harmonization of IPR protection?

for maximization of joint surplus of the world.

5 Empirical Studies on the Determinants of IPR Protection

With this analysis it becomes interesting to investigate how different patent rights are in the global economy. A number of empirical studies have been undertaken of this question, though most are *ad hoc* and reduced-form in nature, as I discuss next.

Ginarte and Park (1997) constructed an index of patent rights for 110 countries based on the laws and memberships in international agreements in each country for the years 1960 through 1990 at five-year intervals.[6] The authors then went on to analyze empirically the determinants of patent rights in 1965 through 1990 for 48 countries. When they put only GDP per capita on the right hand side, they found it to be a highly significant explanatory variable. However, when they additionally put in R&D/GDP and measures of schooling, political freedom, openness, and market freedom, they found GDP per capita to be insignificant, while R&D/GDP, openness and market freedom became significant. Interestingly, they did not include a domestic market-size variable as a determinant. Grossman and Lai's model suggests that this variable is an important determinant of patent rights.

Using an index constructed by Rapp and Rozek (1990), Maskus and Penubarti (1995) found that patent rights are positively related to GDP per capita and schooling. Later, using the index constructed by Ginarte and Park (1997), Maskus (2000, pp.102-109) uncovered that GDP per capita (a proxy for the stage of economic development) affects patent rights in a non-monotonic manner — there is a U-shaped relationship between the two variables. In addition, scientists and engineers working in R&D as a percentage of labor force (a proxy for innovative capability or human capital) has a significantly positive effect. Maskus argued, consistent with the theory above, that market size should matter for the strength of patents but did not find GDP to be significant.

The above empirical studies are not guided by any rigorous theory. With Grossman and Lai's game-theoretic model in hand, Lai and Yan (2006) test its empirical implications directly. The model predicts that in non-cooperative equilibrium, a country's IPR protec-

[6]Park later added the data for 1995 and 2000. See, for example, Park and Wagh (2002).

tion increases with its domestic market size and innovative capability. Assuming that the world was essentially in non-cooperative equilibrium in 1980, 1985 and 1990 (i.e., before TRIPS), they test these predictions using Ginarte and Park's index. They use the dollar value of domestic consumption of patent-sensitive goods as the proxy for domestic market size. More precisely, they use GDP per capita and GDP as instruments to estimate domestic consumption of patent-sensitive goods (since they have consumption data for some but not all countries), then use the estimated value to proxy for market size. For innovative capability, they use scientists and engineers working in R&D as a fraction of the labor force. To take into account the interdependence in the determination of strengths of patent protection between countries, they adopt a spatial econometrics approach. They find that the pattern of patent protection around the globe before the implementation of TRIPS in 1995 was broadly consistent with the model's predictions.

It is interesting to compare Lai and Yan's (2006) result with that of Maskus (2000). While Maskus found that GDP has negative but insignificant impact on patent rights, Lai and Yan found that it has significant positive impact when used as an instrument for domestic market size of patent-sensitive goods. The two studies use about the same data for about the same years and about the same number of countries. What give rise to the different conclusions? This question is left for future research.

What is the evidence for the existence of positive externalities in strengthening IPR protection? Externalities are difficult to pin down, since they do not leave any trace in the market, but the fact that the developed countries were willing to give market-access concessions to developing countries in the Uruguay Round in order for the latter to increase their IPR standards is consistent with the idea that such externalities exist.

6 What has TRIPS Done?

It is possible to interpret TRIPS based on the above theoretical model. A number of views can be offered.

First, suppose we take the view of Reichman (1995) and others that TRIPS is backward-looking, in that it basically requires the South to adopt the pre-TRIPS standards of the North, without requiring much of an increase in standards in the latter. In other words, TRIPS requires harmonization of world IPR standards at the North's pre-TRIPS level. If we assume that the pre-TRIPS world is represented by the Nash equilibrium point E in Figure 2, then the effect of TRIPS is to move the world from point E to point E'. By comparing the latter point to the iso-welfare contours through the original point, it is clear that North gains and South loses, but global welfare improves.[7]

Second, suppose one takes the different view that TRIPS in fact required the South to harmonize with the North at the global efficiency frontier starting from the Nash equilibrium. Then the effect of TRIPS is to move the world from point E to H. In Figure 2, we have shown the case when the North gains and the South loses from such a global treaty. It is possible, however, that both the North and South gain from efficient harmonization. In that case, point H lies to the right of the $\overline{W_N}$ curve and above the $\overline{W_S}$ curve. By inspection, one can easily see that the more asymmetric are the two regions, the more likely it is that the South loses from efficient harmonization. Given the large differences in market sizes and innovative capabilities of the two regions, my considered conclusion is that the South likely loses from efficient harmonization. Even if this is true, it is still the case that the North's gains outweigh the South's losses and global welfare increases as a result of this agreement.

Yet a third view of what TRIPS has done is that it requires the South to undertake partial harmonization and set IPR protection at a level such as X in Figure 2. Given that the South protects at level X, it is optimal for the North to protect at level Y, which remains stronger than the new South level. However, given that the North protects at Y, the South actually wants to protect at a lower level than X. But South is bound by TRIPS to maintain its protection at least at X. Therefore, TRIPS puts the world at $(\Omega_S, \Omega_N) = (X, Y)$. This view is consistent with the fact that TRIPS only sets minimum standards, which are binding for the South and not binding for the North. That is why in equilibrium some Northern countries choose to protect more than the minimum standard, while many Southern countries actually prefer to adopt lower standards than that required by TRIPS, though they cannot do so legally. Note that, compared with no agreement, it is still true that the North gains, the South loses, and global welfare increases.

It is important to emphasize that the best-response functions shown correspond to the post-TRIPS world. The analysis has been based on the assumption that these functions are the same both before and after TRIPS. However, it could be that the best-response functions of both regions in the post-TRIPS world have shifted from their earlier positions. One may

[7] South's consumers lose by paying higher prices, the North's producers gain higher profits, but all consumers gain from a larger variety of goods.

suppose that at the time TRIPS was signed, governments actually anticipated the shifting of these curves in view of the continuous technological progress of the world and changes in the sizes of markets.

The second interpretation above is theoretically appealing, but unlikely to be true in practice. Unlike free trade, which is an easily located benchmark of economic optimality, the global efficiency frontier in IPR is not easily identifiable in practice. It is hard to argue that TRIPS is an economic optimizer. As the first and third interpretations demonstrate, it is possible to argue that TRIPS is globally welfare-improving without assuming that TRIPS actually achieves a global optimum.

If we adopt any of the above interpretations of TRIPS, its effect is to raise prices in South (and maybe also in North, to a lesser extent), raise profits of both Northern and Southern firms (with the majority being Northern ones), and increase the rate of innovation all over the world. Moreover, it increases trade in IPR-sensitive goods between countries. Suppose innovators respond to the increased incentives with a long time lag. Then, in the short-run the price hikes are the dominant effect. Southern consumers are the major losers while Northern firms are the major winners, as McCalman's (2001) results indicate. In the long run, it is predicted by the model that the increased rate of innovation will kick in and this effect will dominate the deadweight loss, an effect not captured by McCalman's study. The effect would hold as long as TRIPS put the world on or inside the efficiency frontier shown in Figure 2. That is, the dynamic gains will dominate as long as TRIPS does not result in over-protection of IPR in the world.

Scotchmer (2004b, pp.334-336) offers an interesting alternative interpretation of what TRIPS has done. Because countries realize the inefficiency of individually choosing their own strengths of IPR protection, they decide to harmonize their standards. The question she asks is: "At what level do they harmonize?" Given the constraint $\Omega_S = \Omega_N = \overline{\Omega}$, she finds that a country prefers a higher harmonized $\overline{\Omega}$ the smaller and more innovative it is. Therefore, small and innovative countries such as Switzerland should be most enthusiastic about strengthening global IPR protection. The final outcome is a compromise among all countries.[8]

Is it possible to conceive of a Pareto-efficient agreement that is mutually beneficial to all countries? In fact, there is no reason why such an agreement cannot be reached, at least in

[8] In the context of my multi-country model, the country with higher μ_j/M_j prefers a higher $\overline{\Omega}$. This is the same conclusion as Scotchmer's.

principle. In Figure 2, we can always find a point on the efficiency frontier that lies above the South's iso-welfare line $\overline{W_S}$ and to the right of the North's iso-welfare line $\overline{W_N}$. At that point, the welfare of both South and North will be greater than in Nash equilibrium.[9] However, the real world consists of more than two countries, and in a multi-country world the Pareto-optimal set of strengths of IPR protection across countries contains combinations with very different degrees of protection among them. Such a Pareto-optimal agreement is complicated to write and hard to enforce.

7 Extension with Multi-issue Negotiations

If a region's action confers positive externalities on another region, then the role of international policy coordination is to create a win-win situation so that both regions can be made better off by moving from the non-cooperative equilibrium to the cooperative outcome. Furthermore, if one accepts the presumption that TRIPS hurts the South and benefits the North, but the latter's gains outweighs the former's losses, then, in principle, one can imagine the North giving a lump-sum transfer to the South in exchange for its cooperation. In reality, however, rather than a transfer it is more feasible for the two regions to trade concessions with each other in multisectoral negotiations, such as in the WTO. It is widely believed that the South agreed to sign on to TRIPS only because the North offered additional market access for textiles, apparel and agricultural products (Reichman 1995 and Maskus 2000). This shows the merits of multisectoral negotiations, in which all countries may benefit from the deal.

This possibility can be easily demonstrated with an extension of the basic model, as shown in Lai and Qiu (2003). In that paper, it is assumed that the North loses from a lowering of tariff t it imposes on imports from the South, but the South gains from the tariff reduction. This case can be motivated by assuming that each country has an endowment of some traditional good and that the autarky price of the good is lower in the South. Thus, that region has the comparative advantage in this sector. Since the North is large, its incentive is to drive down the price it pays for the good by setting a positive optimum tariff.

Suppose the two regions bargain simultaneously over whether the South adopts the North's pre-TRIPS patent policy and over the value of t. Then, adopting the Nash bar-

[9] Note that the segment of the efficiency frontier enveloped between the iso-welfare line $\overline{W_S}$ and iso-welfare line $\overline{W_N}$ represent a "contract curve" of sorts.

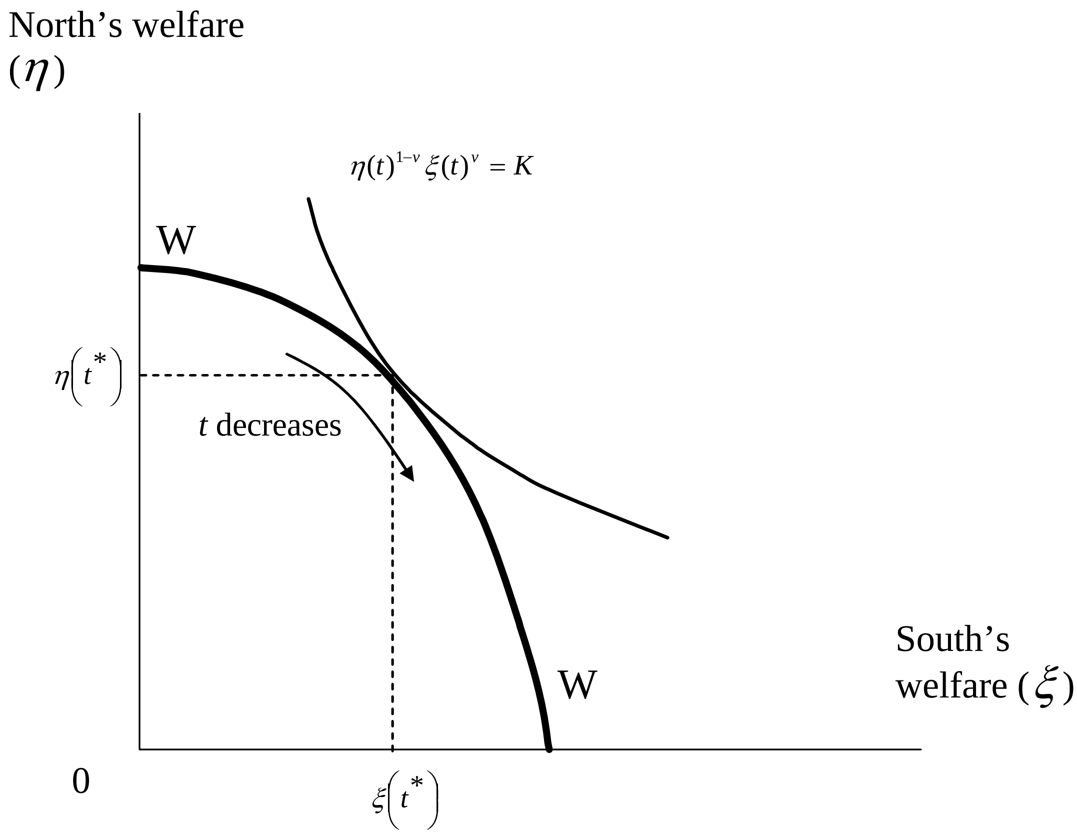

Figure 3: Nash Bargaining over t. The origin is the point with no agreement.

gaining framework of analysis, the equilibrium is as shown in Figure 3. The function $\eta(t)$ is Northern welfare with TRIPS in place and with the Northern tariff set at t. The function $\xi(t)$ is the corresponding Southern welfare. The parameter v is South's bargaining power, K is a constant, and the curve WW is the welfare frontier. The outcome of Nash bargaining is a point on the welfare frontier such that $\eta(t)^{1-v}\xi(t)^{v}$ is maximized. This corresponds to the point $(\xi(t^*), \eta(t^*))$ in Figure 3. If the two countries fail to reach an agreement on t, then the South does not accept TRIPS. Since there is neither agreement in IPR nor in the tariff, this is the threat point of the bargaining game, corresponding to the origin of the graph. As shown in Figure 3, clearly both regions gain in equilibrium. The bargaining outcome is mutually beneficial since the total change in global welfare, taking into account both the IPR agreement and the trade agreement, is positive. The stronger the bargaining power of the South, v, the deeper is the reduction in t, and the greater is the gain in global welfare.

<Figure 3 here>

Thus, there is a synergy between international policy coordination in technology protection and coordination in trade liberalization. This is reminiscent of the point made in Krugman and Obstfeld (2006, p.237) that multisectoral trade negotiations help trade liberalization by playing the lobby supporting free trade, the exporting firms, against the lobby opposing free trade, the import-competing firms. In this case, multi-issue negotiations help trade liberalization by playing the North's protectionist import-competing firms against the exporters of intellectual property. It is precisely the possibility of engaging in such negotiations that makes the WTO an effective body in facilitating global trade liberalization.

8 Relationship with the Literature on Coordination of Trade Policy

Bagwell and Staiger (1999, 2002) hold the view that terms of trade externalities are the core reason for the WTO because Nash equilibrium tariffs are suboptimal from the global welfare point of view. According to Bagwell and Staiger (2002, p.3), "...the purpose of a trade agreement [such as the GATT or WTO] is to offer a means for governments to escape from a terms-of-trade-driven Prisoners' Dilemma". The reason is that "...a government (of a large country) is assumed to set its import tariff in order to maximize national welfare, while recognizing that some of the cost of the tariff falls upon foreign exporters whose products sell at a lower world price (i.e., at a diminished terms of trade). This 'terms of trade externality' naturally leads governments to set unilateral tariffs that are higher than would be efficient." (Bagwell and Staiger 2002, p.3.) In the case of IPR protection, we also have a Prisoners' Dilemma game, but the externality is positive. The TRIPS agreement, together with the agreement to lower trade barriers in the North's traditional goods sector, allows the governments to escape both forms of the Prisoners' Dilemma.

In fact, unlike Bagwell and Staiger, I do not need to assume that countries are large in the analysis of IPR protection, which makes the patent story more compelling. Bagwell and Staiger and others develop a dynamic version of this line of analysis. They conclude that, in a repeated game, the trade agreement is self-enforcing since the cooperative outcome can be supported as a subgame perfect equilibrium of the dynamic tariff-setting game as long as the discount factor is sufficiently large (see, for example, Staiger 1995, Bagwell and Staiger 1997, and Furusawa and Lai 1999). There is no reason why the basic IPR model cannot also be analyzed from the perspective of a repeated game. Similar conclusion would be drawn, namely that the cooperative outcome is self-enforcing when the discount factor is sufficiently large.

9 Extension with Firm-Bias and Trade Barriers

The conclusion that global IPR protection is too weak in the absence of international agreement can be met with skepticism. Many people point to the strong pharmaceutical lobbies in Washington to justify why they think global patent protection before TRIPS must have been already too strong rather than too weak. Moreover, the existence of trade barriers weakens the international spillovers that one nation confers on foreign countries when it strengthens domestic IPR protection. Therefore, I address here two key simplifications of the basic model: that governments put equal weights on consumer welfare and firm profits and that there are no trade barriers. In reality, governments are often biased in favor of domestic firms and trade barriers are non-trivial. Omitting these factors can bias the conclusion that global IPR protection is too weak in the non-cooperative equilibrium. Obviously, whether the conclusion of the basic model can be overturned depends on how large are the magnitudes of these two effects. The analytical task is to find out what values of firm-biasedness and trade barriers can sustain the original conclusion that there is under-protection of IPR in Nash equilibrium, and then judge whether these values are plausible. This analysis is done by Lai (2005), which I explain briefly next.

Let y be the probability that an invention by a domestic firm is sold in a foreign market (call it the "import penetration rate"). This is an inverse measure of foreign trade barriers. In fact, if I assume that there is an iceberg trade cost equal to a fraction t of the production cost, then this formulation is equivalent to having $y = (1+t)^{-\epsilon+1}$, where ϵ is the price elasticity of demand for each differentiated good. So assume that there is a constant-elasticity demand curve faced by each consumer. Let $1+a$ be the weight a government puts on domestic profits when a weight of one is put on domestic consumer surplus in its objective function. The parameter a measures the firm-bias of governments. Note that this approach of assigning additional exogenous weight to firms as opposed to consumers is similar to what is done by Bagwell and Staiger (2002). They essentially put a weight of $1+a$ on firms in the government's objective function, which they treat as a reduced form derived from the analysis of a political-economy equilibrium a la Grossman and Helpman (1994). Let v_i be the expected value of a patent of an invention by a firm in country i. Therefore, $v_i = \pi\left[\sum_{k\neq i}(yM_k\Omega_k) + M_i\Omega_i\right]$.

It is useful to consider a multi-country setting, as the number of independent decision-making governments plays a crucial role in whether there is under-protection of IP in Nash equilibrium. Let there be J countries in the set $\mathcal{N}$ of countries in the world. In a multi-country setting, the best-response function of country i is

$$\begin{aligned} & y\left(\sum_{j\neq i}\phi_j\right)(C_c - C_m) + \phi_i(C_c - C_m) - \phi_i(1+a)\pi \\ = & \left(\sum_{j\neq i}\gamma\frac{\phi_j}{v_j}\right)y^2\pi M_i f_i + \gamma\frac{\phi_i}{v_i}\pi M_i f_i \end{aligned} \tag{3}$$

where $f_i \equiv C_c\overline{T} - (C_c - C_m)\Omega_i$ is the present discounted value of per-person consumer surplus derived from a differentiated good over its product life. The left-hand side of the above equation is, in fact, the marginal cost per consumer in country i of strengthening IPR there. The first term is the loss in consumer surplus attributed to inventions from firms outside country i; the second term is the loss of consumer surplus attributed to inventions from country i; and the third term is the offsetting of the losses of consumer surplus by gains in profits of firms in country i. The right-hand side is the marginal benefit per consumer in country i. The first term is the increase in consumer welfare in country i due to increases in flows of innovations from firms outside country i; the second term is the increase in consumer welfare in country i due to the increase in flow of innovation from country i. If I define the left-hand side as $MC_i(a)$ and the right-hand side as MB_i, then $\frac{1}{M_i}\frac{\partial W_i(a)}{\partial\Omega_i} = MB_i - MC_i(a)$, where $W_i(a)$ is the Government i's objective function. (Hereinafter, I put an argument 'a' after the name of a function if firm-bias affects the value of the function.)

It can be easily shown that the first-order condition for global welfare maximization with respect to the choice of Ω_i is given by

$$\begin{aligned} & MC_i(a) + \pi a\phi_i - y\pi\left(\sum_{j\neq i}\phi_j\right) = \\ & MB_i + \sum_{k\neq i}\left(\sum_{j\neq k}\gamma\frac{\phi_j}{v_j}\right)y^2\pi M_k f_k + \sum_{k\neq i}\gamma\frac{\phi_k}{v_k}y\pi M_k f_k \end{aligned} \tag{4}$$

The left-hand side of this equation is the marginal global cost borne by each consumer in country i of strengthening IPR protection in that country. The second term is the welfare that will not be taken into account when IPR protection in country i is chosen to maximize global welfare instead of to maximize government i's firm-biased objective (therefore it is an addition to marginal cost); the third term is the offsetting of the loss in welfare of country i due to increases in profits of firms outside of country i. The right-hand side is the marginal global benefit attributed to each consumer in country i of strengthening IPR there. The second term plus the third term is the increase in welfare of consumers outside of country i due to faster innovation outside of country i plus the increase due to faster innovation from country i. The cross-border externalities of IPR protection are captured by the third term on the left hand side plus the second and third terms on the right hand side. It is apparent that since an increase in trade barriers (a decrease in y) leads to less international spillovers, the likelihood of under-protection of IPR in equilibrium is lower. Likewise, an increase in firm-bias (an increase in a) reduces the gap between marginal global benefit and marginal national benefit, making under-protection of IPR less likely.

Let us define the left hand side of the first order condition above as MC_i^w and the right hand side of the equation as MB_i^w. It follows that $\frac{1}{M_i}\frac{\partial W^w}{\partial \Omega_i} = MB_i^w - MC_i^w$, where W^w is world welfare (without bias towards firm profits).

I define under-protection as a situation when, starting from Nash equilibrium, global welfare increases as a result of some positive changes in all $\{\Omega_i\}_{i\in\mathcal{N}}$ (where the magnitudes of increase are not necessarily equal). The point of the analysis is to come up with a sufficient condition under which, starting from Nash equilibrium $\left\{\Omega_i^E\right\}_{i\in\mathcal{N}}$, some coordinated increases in IPR protection of all countries is globally welfare-improving. Note that an increase in the strength of protection in all countries raises the values of all patents. This increases the global deadweight losses, but gives a boost to the rate of innovation. To simplify the analysis, I focus on changes in $\{\Omega_i\}_{i\in\mathcal{N}}$ such that $M_i d\Omega_i = d\overline{\Omega}$ for all i. I want to find a sufficient condition under which such changes lead to an increase in global welfare. In other words, I seek a condition under which the marginal global benefit outweighs the marginal global cost.

Bear in mind that equation (3) is equivalent to $\frac{1}{M_i}\frac{\partial W_i(a)}{\partial \Omega_i} = 0$, and equation (4) is equivalent to $\frac{1}{M_i}\frac{\partial W^w}{\partial \Omega_i} = 0$. Summing the left-hand side and the right-hand side of equations (3) over all i as well as both sides of (4) over all i, and comparing the two ensuing equations, it can be shown that

$$(J-1)\, y > a$$

is a sufficient condition under which, starting from Nash equilibrium, small increases in Ω_i such that $d\Omega_i = \frac{d\overline{\Omega}}{M_i}$ is globally welfare-improving, i.e. $\frac{dW^w}{d\overline{\Omega}} > 0$. A detailed proof of this result can be found in Lai (2005).

This last statement says that starting from each Ω_i being at the Nash equilibrium level, small increases in $\{\Omega_i\}_{i \in \mathcal{N}}$ such that $\frac{d\Omega_i}{d\Omega_j} = \frac{M_j}{M_i}$ for all $i \neq j$ leads to an increase in global welfare. Therefore, $(J-1)\, y > a$ is exactly the condition we are looking for. To check that this is a reasonable condition, note that in the special case of the basic model, when there are two countries ($J = 2$), $y = 1$ and $a = 0$, the condition is satisfied. Moreover, it accords with the intuition that the free-rider problem gets more serious when there are more countries playing the patent-setting game, for a larger J leads to more under-protection. It also is consistent with the notions that trade barriers weaken the cross-border externality of IPR protection, because a smaller y leads to less under-protection, and that stronger government bias towards patent-holding firms tends to strengthen patents, for a larger a leads to less under-protection.

What is a reasonable value for a? In the political-economy literature (Grossman and Helpman 1994; Maggi and Goldberg 1999), researchers have tried to estimate the weight the U.S. government puts on campaign contributions when it puts a weight of unity on welfare. They rarely come up with a number more than 0.5. Since this is a preference parameter, it should be the same in the context of patent protection. Suppose there is a patent lobby, and suppose there is no consumer lobby, nor is there lobbying from other sectors of the economy. Then I can show that the value the government puts on contributions is exactly the same as a in our model (Lai 2005).

What is a reasonable value for J? This is the number of independent government decision-makers in the patent-setting game. Thus, it is the number of countries in the world that consume and trade patent-sensitive goods, and that adopt neither zero nor full patent protection. To be conservative, let $J = 5$.

When $a = 0.5$ and $J = 5$, a sufficient condition for the Nash equilibrium to be under-protecting patents is $y > 0.1$. As stated earlier, y can be interpreted as a parameter derived from iceberg trade costs, such that $y = (1+t)^{-\epsilon+1}$. If the price elasticity of demand for a differentiated good ϵ is equal to 4, then $y > 0.1$ is equivalent to an iceberg trade cost t of less than or equal to 78 percent of the cost of production. This condition is likely to be satisfied for most products. So, based on this rough calculation, I conclude that global patent protection in the absence of international coordination is probably too weak.

10 Extension with Relaxation of National Treatment

One may argue that in a non-cooperative equilibrium, there is no incentive for a country to offer national treatment. One response to this criticism is that, before the TRIPS Agreement was signed and implemented, many countries were already members of WIPO and the Berne and Paris Conventions. These treaties required their members to adopt national treatment. A critique of this response is that these treaties were so loosely enforced that countries did not really abide by that commitment. Do the main conclusions of the basic model continue to hold if I relax the assumption of national treatment? It turns out that the answer is, for the most part, "yes". Specifically, a larger country has incentives to offer more IPR protection, the positive cross-border externalities of strengthening domestic IPR protection continue to exist, and harmonization is neither necessary nor sufficient for global efficiency. I briefly explain the analysis below.

I first compute the Nash equilibrium. Let Ω_{ij} be the strength of protection offered by country i on goods invented by country j, where $i, j = \{N, S\}$. The value of a patent of a good invented in country j is therefore given by $v_j = \pi (M_j \Omega_{jj} + M_i \Omega_{ij})$, where $i \neq j$. Focusing on the protection of goods invented by country j, the best-response function of that country gives the optimal choice of Ω_{jj} given that country i chooses Ω_{ij}. That function is

$$C_c - C_m - \pi = \frac{\gamma}{M_j \Omega_{jj} + M_i \Omega_{ij}} M_j \left[\Omega_{jj} C_m + \left(\bar{T} - \Omega_{jj} \right) C_c \right]; \tag{5}$$

while the best-response function of country i, selecting its best choice of Ω_{ij} given that country j chooses Ω_{jj}, is

$$C_c - C_m = \frac{\gamma}{M_j \Omega_{jj} + M_i \Omega_{ij}} M_i \left[\Omega_{ij} C_m + \left(\bar{T} - \Omega_{ij} \right) C_c \right]. \tag{6}$$

Note that the innovative capability of a country does not affect its equilibrium strength of IPR protection when countries can optimally choose to offer differential treatments to domestic and foreign firms. If one adds equations (5) and (6), it is not hard to show that v_j is the same for all countries in equilibrium. That is, the equilibrium value of a patent is independent of where the good is invented. Since $M_j \Omega_{jj} + M_i \Omega_{ij} = M_i \Omega_{ii} + M_j \Omega_{ji}$ where $i \neq j$, we can infer from (5) that a country with a larger domestic market tends to protect the IPR of domestically-invented goods more than one with a smaller domestic market. Moreover, (6) implies that a country with a larger domestic market tends to protect the IPR of foreign-invented goods more than one with a smaller domestic market.

The globally efficient combinations of Ω_{jj} and Ω_{ij}, on the other hand, are determined by

$$\begin{aligned} C_c - C_m - \pi &= \frac{\gamma}{M_j\Omega_{jj} + M_i\Omega_{ij}} \times \left\{ M_j \left[\Omega_{jj} C_m + \left(\bar{T} - \Omega_{jj} \right) C_c \right] + M_i \left[\Omega_{ij} C_m + \left(\bar{T} - \Omega_{ij} \right) C_c \right] \right\} \\ &= \frac{\gamma}{Q_j} \times \left[\bar{T} C_c \left(M_i + M_j \right) - \left(C_c - C_m \right) Q_j \right] \end{aligned} \tag{7}$$

where $Q_j \equiv M_j\Omega_{jj} + M_i\Omega_{ij}$. Again, rather than being unique, there exists a continuum of efficient combinations, given by setting $M_j\Omega_{jj} + M_i\Omega_{ij}$ equal to the solution of Q_j in (7). In Figure 4, we plot the best-response functions and efficiency frontier in $(\Omega_{jj}, \Omega_{ij})$ space, where $j = N$ and $i = S$. The curve $NN - NN$ is North's best-response function while $SN - SN$ is that of South. The curve $Q_N - Q_N$ is the efficiency frontier. Considering the first line of equation (7), it is obvious that the continuum of globally efficient combinations of Ω_{jj} and Ω_{ij} lies outside each of the best-response functions, which is remarkably similar to what is shown in Figure 1. The interpretation is that, given Ω_{ij}, country j's best response Ω_{jj} falls short of the global optimum and vice-versa. This situation is caused by cross-border positive externalities as a country strengthens IPR protection of a good invented either by the domestic firms or foreign firms. Therefore, there is under-protection of IPR in Nash equilibrium for each differentiated good.

<Figure 4 here>

Harmonization (in the sense that $\Omega_{ii} = \Omega_{jj}$) is certainly not sufficient for global efficiency. Neither is it necessary, since Q_j can be at the efficiency level with Ω_{ij} small and Ω_{jj} large, or with Ω_{ij} large but Ω_{jj} small. Similarly, Ω_{ii} can be either large or small to attain global efficiency. Therefore, there is no need for $\Omega_{ii} = \Omega_{jj}$ to reach global efficiency. Along similar lines, it is easy to see that national treatment is neither necessary nor sufficient for global efficiency.

Left as an exercise for the reader is to prove that a country always protects domestically invented goods more than it does foreign-invented ones (i.e., $\Omega_{ii} > \Omega_{ij}$ for $i \neq j$). In fact, this result reflects an interesting history about copyrights in the United States. In the 18th century, American authors were not popular in the English-speaking world, including in the United States itself. In order to allow cheap reproduction of books by English authors, U.S. policy basically did not offer copyright protection to their works. Even when the first copyright statute was enacted in 1790, no protection was offered to foreigners. It was not until American authors became internationally popular that the U.S. government signed an agreement with Britain in 1890 to offer reciprocal granting of copyrights to each other with national treatment in both countries. As Scotchmer (2004a) argues convincingly, countries

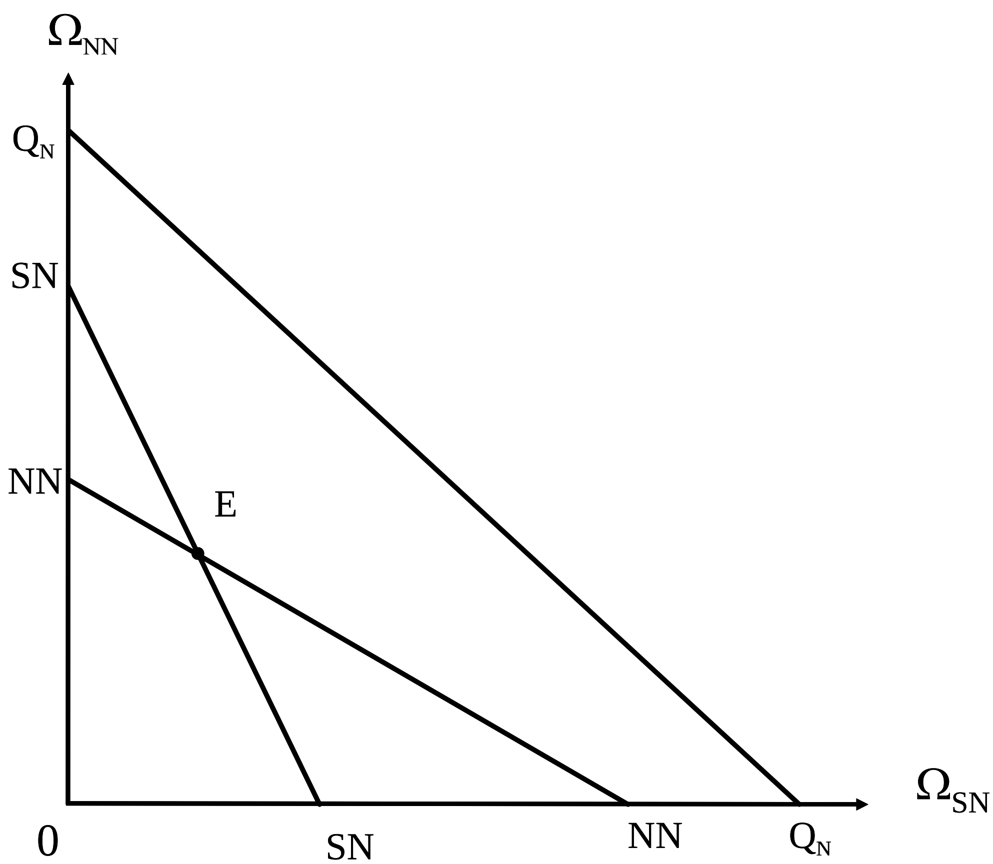

Figure 4: Best response functions and efficiency frontier corresponding to Northern goods

do not have incentives to offer national treatment when there is no reciprocity. Again, we can view the agreement between two countries of simultaneously offering national treatment and reciprocity to each other as one that facilitates escape from a Prisoners' Dilemma. In Nash equilibrium, countries tend to discriminate against foreign IPR holders and offer lower protection to them. This, however, is suboptimal and a Pareto improvement can be achieved by forcing each country to offer national treatment to the other.

11 Other Possible Extensions of the Basic Model

FDI or licensing. Imagine modifying the basic model above to allow for the effects of IPR on FDI or licensing. Suppose that in serving a foreign country's market, each innovator firm has two choices: exporting or producing the good there in a wholly-owned subsidiary. For simplicity, I assume that the firm can make the same profits from licensing the technology to an arm's-length partner. Thus, the effects of IPR on FDI and licensing are the same. The advantage of using FDI to serve a foreign market is that trade costs (including trade barriers and transportation cost) are saved. The disadvantage is that local firms can more easily invent around the patent, as proximity to information about manufacturing the good helps local firms develop commercially viable substitutes. In contrast, suppose that local firms cannot invent around a patent when the good is imported. For simplicity, assume that once a substitute is developed, the local market for the good turns from monopolistic to perfectly competitive. Suppose further that as a country strengthens IPR, the hazard rate at which local firms can successfully invent around the multinational firm's patent decreases. In equilibrium, foreign firms are indifferent between exporting to the local market and serving it through FDI. Moreover, the lower the hazard rate, the higher the equilibrium fraction of foreign goods serving the local market through FDI rather than exporting. Therefore, as a country strengthens IPR, not only does it induce more innovation from firms all over the world, it also increases FDI inflows.[10] It should be straightforward to figure out the best-response functions as well as the global efficiency frontier in this setting.

Strengthening IPR should give additional benefits to the domestic country because the increases in FDI inflows generates a saving in trade costs, which trickles down to lower prices paid by domestic consumers. Further, introduction of FDI into the basic model does

[10]This way of modeling the effects of IPR on FDI is borrowed from Lai (1998).

not change the conclusion that there is under-protection of IPR in Nash equilibrium. The positive cross-border externalities of strengthening IPR continue to exist: As a country strengthens patents, foreign imports enjoy monopoly profits in more occasions. In addition, the expected duration of monopoly of an international firm is longer as the hazard rate of having the patent circumvented is lower. Lastly, as before, foreign consumers benefit from having more varieties to consume.

Parallel Imports. Parallel imports (PI) are goods imported into a country without the authorization of the holder of intellectual property rights after the goods were legitimately sold outside the country.[11] Prohibition of PI by a country takes the form of denying "international exhaustion" of IPR. That is to say, the IP rights do not exhaust after first sale in the international market and any cross-border resale must be authorized by the rights holder. Clearly, denying international exhaustion allows the IPR holders to segment the foreign market from the domestic market, thus benefitting innovators. In short, a tighter PI policy can serve as a substitute for strengthening IPR protection. Interestingly, the TRIPS agreement does not harmonize PI policy at all. Article 6 states that "For the purposes of dispute settlement, nothing in the Agreement shall be used to address the issue of the exhaustion of IPRs, provided there is compliance with national treatment and most-favored nation treatment." (UNCTAD 1996). One can view this omission as a loophole of the TRIPS Agreement. A country that prefers to have weak IPR protection can abide by the minimum patent and copyright standards stipulated by TRIPS while undermining that protection by permitting parallel imports.

Since tight PI policy is a substitute for strong IPR protection, one would expect there to be over-provision of international exhaustion in the world as some countries tend to free-ride on other countries. The globally optimal degree of regulation of PI should therefore presumably be tighter than the Nash-equilibrium degree of regulation.

Cumulative innovation and breadth of patent. In the basic model, a crucial assumption was that innovation is not cumulative. In reality, however, development of new products often requires the inputs of the ideas embodied in patented goods. In that case, strengthening patent protection of goods with ideas used as inputs into other innovations increases the costs of future product development and could slow down the long-run rate of innovation. Here I consider one particular example to illustrate the economics of cumulative innovation, namely quality improvement on a "quality ladder". In the basic model, where inventions of

[11] The chapter by Ganslandt and Maskus in this volume deals comprehensively with parallel trade.

completely new products are not substitutable with each other, the only relevant aspects of IPR protection are length and enforcement. In the quality-ladder model, innovations improve the quality of existing products. Here, two more aspects of IPR protection are important, namely the "minimum patentable inventive step" (MPIS) and the "leading breadth" (LB; Scotchmer 2004b, pp.84-88). The former is related to the concept of non-obviousness, and the latter to the concept of novelty. A higher MPIS means that an invention has to be more non-obvious (or more different from the state of the art) to be patentable. A higher LB means that an invention has to be more novel (again, more different from the prior art) for there to be non-infringement of the patent.

In the quality-ladder model, both aspects are measured by the size of the inventive step from the position of the latest art on the ladder. Further, they may be construed as two independent concepts. If the MPIS is higher than the LB, then all patents are non-infringing. If the LB is higher than the MPIS, then some patents may be infringing.[12] Consider, however, the simple case that MPIS is restricted to be always equal to LB, so that a patent never infringes on another patent. Then, an increase in LB in one country can confer a negative externality on foreign countries as it makes future quality-improvement innovations more costly to foreign firms. As the long-run rate of innovation is reduced, foreign consumers are worse off. Another possible source of negative externality of an increase in LB is that it can increase the duration of monopoly power enjoyed by each patent, which makes goods more expensive to foreign consumers, a deadweight loss. This can happen when the length of patent is longer than the time it takes for the next patentable product to appear in the market. As a result, the patent length is rather irrelevant in determining the duration of monopoly power. If these negative externalities dominate, then in Nash equilibrium the leading breadths in each country would tend to be too large compared with the global optimum, and international coordination should narrow them.

Subject matters. The analysis of the individual country's choice of subject matter to be protected is similar to that of patent length and of national treatment. An enlargement of the set of patentable subject matters induces more innovation (for patent-sensitive sectors), but it also gives monopoly powers to additional patent-holders for a certain duration of

[12] There are many examples where, after a patent had been granted, it was successfully sued for infringement of another patent. Typically, the infringing patent-holder was ordered to pay a royalty to the patent-holder of the infringed patent, through bargaining, to compensate for the licensing of the technology from the latter to the former. In this case, the patentees are said to be holding 'blocking patents' (Scotchmer 2004b, p.86)

time. There are also positive cross-border externalities as foreign firms are given patent-protected monopoly power, and foreign consumers enjoy a larger variety of differentiated goods. Thus, the equilibrium set of protected subject matters would tend to be too small compared with the global optimum. Moreover, since countries differ in the their ability to innovate in different areas of technology, each would tend to restrict the set of patentable subject matters to include only those in which it possesses high innovativeness. By doing so, the country effectively discriminates in favor of domestic firms. This is similar to the analysis of the extent of national treatment granted to foreign firms presented above. While it narrowed this possibility considerably from the prior condition, TRIPS still allows for some national autonomy in the choice of certain subject matters. This not only allows some countries to soften the negative welfare impact from the common patent length mandated by TRIPS, but also enables them to use the choice of protected subject matters to diminish the impact of the national-treatment requirement.

Costs of implementation. The costs of implementing stronger IPR per domestic consumer can depend on many things. If there are economies of scale in implementation, then the marginal cost is lower for a larger country. This reinforces the result of the basic model that larger countries tend to have incentives to protect IPR more. If the marginal costs of implementation are lower for countries that have a longer history of rule of law, such as the former colonies of Britain or France, they would have incentives to protect more. However, the costs of implementation have no effect on the positive externalities conferred on foreigners as a country strengthens its IPR protection. Therefore, the introduction of implementation costs does not alter the basic result that countries under-protect IPR in Nash equilibrium.

12 Conclusion

A good economic reason for international coordination of IPR protection is the existence of positive cross-border externalities, leading to under-protection in the global economy. This is true regardless of whether national treatment is required. However, the conclusion that uncoordinated levels of IPR are too low has to be tempered by the presence of trade barriers and lobbying by innovating firms, though a rough calibration exercise demonstrated that these factors are probably not enough to overturn it. The central conclusion of too-limited protection should be further tempered by the fact that many innovations are cumulative in nature.

The existence of cross-border positive externalities in IPR protection finds its parallel in the existence of cross-border negative externalities in tariff protection. While the former calls for cooperative strengthening of IPR, the latter calls for cooperative reduction in tariffs. One key difference between international coordination in trade policy and patent policy is that it is easy to identify and observe the efficiency benchmark of zero tariffs in the former area but difficult to identify in practice the efficiency benchmark in IPR policy coordination.

Ideally, international coordination should bring the world to the global efficiency point or frontier. Supposing one can identify the efficiency set in practice, efficient harmonization may very well benefit the North but hurt the South. A Pareto improvement can be reached in principle if the North makes a transfer to the South. In fact, the current practice in international coordination, implemented through TRIPS, can best be interpreted as requiring the South to harmonize with the pre-TRIPS standards of the North. This is probably not globally optimal, but perhaps is globally welfare-improving in the sense that the North's gains outweigh the South's losses. This possibility justifies multi-issue negotiations, whereby the South increases its IPR protection in exchange for the North opening its markets for agriculture and labor-intensive goods. This is a fair characterization of what was achieved in the Uruguay Round.

Coordination is more than harmonization (or establishing universal minimum IPR standards). It also includes non-discrimination through national treatment and the most-favored nation principle. Moreover, coordination includes enforcement, but since that is hard to monitor, full harmonization is harder to attain in practice than national treatment and MFN.

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