The Political Economy of Intellectual Property Treaties

Suzanne Scotchmer[1]

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Abstract: Intellectual property treaties have two main types of provisions: national treatment of foreign inventors, and harmonization of protections. I characterize the circumstances in which countries would want to treat foreign inventors the same as national inventors. I then argue that national treatment of foreign inventors leads to stronger intellectual property protection than is optimal, and that this effect is exacerbated when protections must be harmonized. However levels of public and private R&D spending will be lower than if each country took account of the uncompensated externalities that its R&D spending confers on other countries. The stronger protection engendered by attempts at harmonization are a partial remedy.

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[1]NBER and Department of Economics and Goldman School of Public Policy, University of California, Berkeley, 94720-7320, scotch@socrates.berkeley.edu. I would like to thank Stylianos Tellis for research assistance, and Alan Deardorff, Rich Gilbert, Jean Lanjouw, Stephen Maurer and Pam Samuelson for helpful comments. I thank the National Science Foundation for financial support.

1 Introduction

The economic rationale for intellectual property (IP) is that it encourages invention for the benefit of consumers. There is no economic rationale for protecting inventors *per se.* Their profits count as benefits to the extent that profit exceeds R&D costs, but profits are recognized as a necessary evil, since the flip side of profit is a loss in consumers' surplus.

This reasoning gets subverted in the international arena. To a trade policy negotiator, profit earned abroad is unambiguously a good thing: the more the better. Moreover, consumers' surplus conferred on foreigners by domestic inventions does not count at all. Because of these distortions, we would expect intellectual property policies devised by trade negotiators to be nonoptimal, even if the negotiations are undertaken to satisfy some type of worldwide treaty. The objective of this paper is to try to understand what distortions will arise.

Two important provisions of treaties about intellectual property are "national treatment of foreign inventors" and "harmonization," which might also be called "globalization." "National treatment" means that within each country, foreign and domestic inventors receive identical treatment, namely, the treatment of nationals. A secondary question is whether national treatment will be granted unilaterally, or only on condition of reciprocity by the foreign country. "Harmonization" refers to provisions by which signatory states agree to a common set of protections. The first step toward harmonization is usually to state minimum standards, both in the subject matter protected, and the length of protection. Generally, intellectual property treaties set minimum protections, not maximum protections, although TRIPS (discussed below) has provisions that can be understood as constraining intellectual property. For example, it codifies the general feature of copyright laws

that expression can be protected, but not ideas.

My objective in this paper is to understand the rudimentary incentives to sign intellectual property treaties, and perhaps more importantly, to understand how intellectual property treaties affect national choices about the strength of protection. Section 2 presents a very short history of intellectual property treaties, with emphasis on national treatment, reciprocity, and harmonization. Section 3 develops a simple model to expose the incentives for national treatment, and asks when national treatment will be conditional on reciprocity. In Section 4, I investigate how domestic intellectual property choices are affected by treaties that provide for national treatment but no harmonization, versus treaties with national treatment that also require harmonization.

The premise of this inquiry is that countries can negotiate only over intellectual property rights (and not, for example, over R&D spending or tariff policy), and that each country is concerned only with the consumers' surplus received by its own consumers on domestic and foreign inventions, and with profit of its firms, earned at home and abroad. In contrast, a planner concerned with global social welfare would be concerned with consumers' surplus and profit in all countries simultaneously. As pointed out by Hall (2001), this discrepancy should lead to distortions, and certainly to international disagreements.

My main conclusion is that intellectual property rights will be stronger under a system of harmonized national treatment than is optimal. The stronger property rights address a problem that arises from international fragmentation, namely, that each country's spending on R&D will be too low. This is especially true of R&D undertaken by public sponsors. When inventions are put in the public domain, domestic taxpayers create uncompensated benefits

for foreign beneficiaries. Politically, that is a hard sell. In contrast, if R&D is supported by intellectual property rather than public sponsorship, foreign beneficiaries must reimburse at least some of the cost by paying proprietary prices. The prospect of profit earned abroad gives a natural impetus toward stronger protection. If there is a policy lesson here, it is that countries would do better to negotiate treaties for coordinated public spending, all to be put in the public domain, rather than negotiating treaties to strengthen intellectual property rights, which create an additional burden of high prices. My conclusions would be even stronger if trade policy negotiators overweighted the interests of domestic firms, as compared to the interests of domestic consumers. It is thought by many commentators that they do so, especially in the highly contested realm of pharmaceuticals (e.g., see Lanjouw and Cockburn (2000)).

There has been surprisingly little economic analysis of economic treaties. An important exception is Bagwell and Staiger (1999), who studied how the provisions in the General Agreement on Tariffs and Trade (GATT) can remedy inefficient tariff policies that arise from incentives to protect domestic interests. The premise of their paper is also the premise here: The policy of each country creates uncompensated externalities abroad, which might be remedied by treaty. In their case, the policies are tariffs, which change the terms of trade. The countries' chosen tariffs will not be optimal because countries do not account for the externalities. Negotiation under GATT empowers the countries to remedy that problem for the countries' mutual benefit. In contrast, reciprocity will not remedy the inefficiencies that arise in choosing intellectual property rights, because the countries do not negotiate over all the economic decisions that matter. In particular, they negotiate over intellectual property rights, but not over R&D spending. In addition, I assume for this first investigation that terms-of-trade issues are divorced from negotiations over intellectual property rights. In reality, small countries

may be strong-armed into signing IP treaties in order to receive favorable trading status.

In addition, several authors have addressed the "North/South" problem, which is a stylization of asymmetric innovative capacities. One country (North) has the innovative compacity, and both countries have demand for new products. The papers have differing models, but the lessons in all of them are rooted in cross-border externalities, as in my own arguments. Inventors in the North are protected by their domestic IP laws. Through their inventions, they create benefits for the South. If the Northern inventions are not protected in the South, then the Southerners get the benefit of competitive supply. If the Southerners grant protection, then they get even more new products (since the inventors have more global protection), but at proprietary prices. Deardorff (1992) shows that protection in the South might not be optimal for either Southerners alone, or for the world as a whole, since the deadweight loss in the South might outweigh the worldwide benefits of getting more inventions. Diwan and Rodrik (1991) characterize how "strongly" the North and South will protect the Northern inventions, assuming that each country is motivated only by its domestic interests, and that the countries do not make treaties. The South may want different products than the North, for example, drugs for tropical diseases. To elicit investment in those products by Northerners, they must grant intellectual property protection in the South, even though such protection undermines the externalities they get from other inventions of Northerners. Helpman (1993) introduces other complexities that arise in general equilibrium, such as the fact that it might be cheaper to produce in one country rather than another. A distortion created by differing intellectual property laws is that production could be shifted to the less efficient, but more protective, country. Chin and Grossman (1990) studied a similar environment, but a different type of intellectual property. In their model, the invention is a cost-reducing invention, which means that

piracy reduces the global price. The inventor does not appropriate the full rewards of his invention, even in his own country, since the product can be produced with the pirated technology and imported.

In order to study whether the externalities will be internalized through treaties, I use a simpler model than in most of the cited papers. One of the questions of interest is how treaty provisions affect the extent of protected subject matter. For that purpose it is more convenient to assume that countries are alike, rather than to assume they are extremely different, as in the North/South models.

2 A Short History of IP Treaties

The earliest large-scale intellectual property treaties were the Paris Convention of 1884 on patents and other industrial property, and the Berne Convention of 1886 for literary and artistic works. Under various revisions, these treaties have remained in effect since their inception, and now have more than 100 members. Both established the idea of national treatment. The Berne Convention also made the first efforts to harmonize protections across countries.

For the most part, the principle of national treatment has been maintained since the Paris and Berne Conventions. Reciprocity is inherent in the treaties: No country provides national treatment to foreigners in a country that does not reciprocate. However, reciprocity has recently been made a *condition* for national treatment. When the U.S. enacted the Semiconductor Chip Protection Act of 1984, the protection of foreign inventors was made conditional on the passage of similar legislation in the foreign countries.

In 1996, the European Union retaliated with their Directive on Databases, which instructs the member states to enact legislation protecting databases beyond the protection already afforded by copyright law. The Directive has a preamble denying national treatment to non-member states (presumably, the U.S.) unless the nonmember states also enact such legislation. (See McManis 1996.)

A shortcoming of the Paris and Berne Conventions is that they made no provisions for enforcement. Their modern descendants are administered by the World Intellectual Property Organization (WIPO), which has very weak enforcement powers (Mossinghoff 1999, Samuelson 1999). Better enforcement provisions were introduced in the North American Free Trade Association (NAFTA) and particularly in the Agreement on Trade-Related Aspects of Intellectual Property (TRIPS), as administered by the World Trade Organization. The latter treaties provide for compulsory third-party arbitration and other binding procedures.

More importantly for this paper, NAFTA extended national treatment to all intellectual property, at least on the North American continent. It goes some distance in harmonizing protections, although not as far as TRIPS. TRIPS has specific provisions for minimum protection of bioengineered microorganisms, pharmaceuticals, computer software, and databases, and stipulates minimum durations of protection. It is administered by the World Trade Organization, which is authorized to carry out very specific enforcement actions that are widely thought to have teeth.

U.S. history is informative about the politics of IP treaties. The constitutional convention of 1789 was an early instance where a disjointed system of local rights was replaced with a federal system. Each of the 13 founding States had previously granted patents, but all ceded their authority in

this area to the newly established federal government. The U.S. did not join the Berne Convention for reciprocal copyright policy until 1989, largely because it did not want to adopt the required procedures administering copyrights. Instead, in the 1950's, the U.S. lobbied for the Universal Copyright Convention, which, like the Berne Convention, provided for national treatment, but did not have the same requirements for harmonized protections, procedures, and length of protection. In the more recent attempts at harmonization, the U.S. has been a leader. This is especially true of TRIPS, which is the most powerful harmonization treaty to date for both patentable and copyrightable subject matter, as well as providing for an effective enforcement regime through the WTO. The U.S. was also very much in favor of NAFTA. The strengthening of protections abroad under NAFTA and TRIPS are aligned with American commercial interests.

3 National Treatment

I first take the protected intellectual property as given in each country, and consider the incentives to offer national treatment to foreigners. Suppose there are two countries, a, w. We shall focus on country a, and sometimes interpret w as "the rest of the world." For $i = a, w$, let c^i be the aggregate consumers' surplus per innovation, assuming perfect competition, and let C^i be the aggregate consumers' surplus per innovation, assuming that the product is sold by a monopolist. Thus we assume that $C^i < c^i$. Let π^i be the aggregate profit per innovation, for each country $i = a, w$. In each country, the consumers' surpluses and profits depend on the size of the market, which will be large or small, depending on the population. The difference $c^i - C^i - \pi^i$ represents the deadweight loss when a competitively supplied product becomes proprietary in country i.

Let $(\hat{r}^a, \hat{r}^w)$ be the numbers of proprietary innovations in the two countries respectively under "autarky", namely, when intellectual property rights are only available to domestic firms in each country. Let $(\tilde{r}^a, \tilde{r}^w)$ be the numbers of innovations when each country grants rights to foreign firms as well as to domestic firms ("national treatment"). Since national treatment creates additional incentives for inventors, $\tilde{r}^a \geq \hat{r}^a$ and $\tilde{r}^w \geq \hat{r}^w$. [2]

We first investigate whether it would be in the interest of any country to offer national treatment to foreigners even when the foreign country does not reciprocate. By doing so, the country would generate profit for foreign inventors at the expense of its own consumers, who could otherwise use the proprietary foreign technologies without paying proprietary prices. On the other hand, there could be more foreign invention, which would create benefits for domestic consumers.

Under "autarky", total social surplus for country a is

$$\hat{r}^a(C^a + \pi^a) + \hat{r}^w c^a$$

which includes profit and (monopoly) consumers' surplus plus the consumers' surplus generated by a competitive supply of the other country's inventions. The last term should be understood as an uncompensated externality from the rest of the world to country a.

Country a would find it profitable to grant national treatment to inventors in country w if

$$\hat{r}^a(C^a + \pi^a) + \hat{r}^w c^a < \hat{r}^a(C^a + \pi^a) + \tilde{r}^w C^a \tag{1}$$

[2] I implicitly assume that each inventor's incentive to invent only depends on the extent of his own property rights. This is a reasonable approximation for my purposes here, but in fact, incentives also depend on the property rights available to competitors in other countries.

or

$$\tilde{r}^w/\hat{r}^w > c^a/C^a \tag{2}$$

If $\tilde{r}^w$ is sufficiently large, or if $\hat{r}^w$ is sufficiently small, national treatment of foreigners will benefit consumers in country a. Even though the national rights will cause them to pay proprietary prices instead of competitive prices for the innovations made in the other country, the increase in such inventions may outweigh the loss in consumers' surplus on each invention

It is reasonable to think that the lefthand side, but not the righthand side, of (2) reflects the size of county a. Suppose, for example, that every resident of a receives the same consumer's surplus under competitive supply and with proprietary prices, respectively. Then the righthand side is the ratio of consumer's surpluses for every individual consumer per innovation as well as for the country as a whole, and it is bounded above 1. But the lefthand side is larger than 1 by the fractional increase in innovation abroad if country a grants property rights. It is reasonable to think that the increase will be greater if country a is large, and that the lefthand side ratio will be close to 1 if country a is small. Thus, a small, open economy will be reluctant to provide national treatment to foreign inventors, although a large country might do so unilaterally. Since this should be clear, I have not written down a formal assumption in stating the proposition below. The terms "large" and "small" in Proposition 1(ii) must be interpreted such that the inequality (2) does and does not hold, respectively.

It is easy to verify that (2) is the condition for country a to grant national treatment even if country a is already favored with rights in the rest of the world, rather than being autarkic. In that case, country a will reciprocate if

$$\tilde{r}^a(C^a + \pi^a + \pi^w) + \hat{r}^w c^a < \tilde{r}^a(C^a + \pi^a + \pi^w) + \tilde{r}^w C^a$$

which again reduces to (2). Thus,

Proposition 1 ***(Independent choices about National Treatment)*** *(i) A country's incentive to grant national treatment to foreign firms does not depend directly on whether the foreign country is reciprocating. It depends only on the amount of research that would thus be engendered, compared to the loss in consumers' surplus on each invention.*
(ii) A small open economy will typically not find it advantageous to grant national treatment to foreign inventors, although a large economy would do so.

As documented in Section 2, most IP treaties include small, open economies. This seems to contradict part (ii) of the proposition. The reason is illuminated in the next section. Although small open economies would not unilaterally decide to grant national treatment to foreigners, they may do so in return for reciprocity. Reciprocity is a powerful motivating force.

A second reason, not discussed here, is that small open economies are often strong-armed into granting IP rights by the threat of trade sanctions from their larger trading partners. I have left trade sanctions out of this paper in order to assess what can be said about negotiations on intellectual property rights alone. However, an interpretation of Proposition 1(ii) is that trade sanctions might have to be invoked if large countries want national rights in small countries.

3.1 Reciprocity

According to the above argument, it could easily happen that the large country finds it advantageous to grant national treatment, but a small country does not. Of course the large country would be even better off if the small country reciprocated, since that would increase the profit of its own firms marketing abroad. We now turn to the question of whether there is any power in the threat to withold national treatment of foreign inventors in the absence of reciprocity.

Above I answered the question: Given that a large economy has made a unilateral decision to grant national rights to foreign inventors, does a small foreign country have an incentive to reciprocate? We now ask: Supposing that a large economy will only grant national rights under a reciprocal arrangement, will a small foreign country agree to a reciprocal arrangement rather than autarky?

I again assume that the protected intellectual property in each country is given. I again use $(\hat{r}^a, \hat{r}^w)$ to represent the amount of innovation under autarky, and use $(\bar{r}^a, \bar{r}^w)$ to represent the amount of innovation with a reciprocal agreement. If there are only two nations, $(\bar{r}^a, \bar{r}^w) = (\tilde{r}^a, \tilde{r}^w)$. If w represents many nations, then the reciprocal agreement involves reciprocity among those nations as well as between those nations and a . Consequently there will be more stimulus to innovation. Reciprocal national treatment is better than autarky for countries a, w, respectively, if:

$$\hat{r}^a(C^a + \pi^a) + \hat{r}^w c^a < \bar{r}^a(C^a + \pi^a + \pi^w) + \bar{r}^w C^a \tag{3}$$

$$\hat{r}^w(C^w + \pi^w) + \hat{r}^a c^w < \bar{r}^w(C^w + \pi^a + \pi^w) + \bar{r}^a C^w$$

where the righthand side of (3) is the welfare of country a with reciprocal national treatment and the lefthand side is the welfare of country a under

an autarkic system. In the two-country case, where $(\bar{r}^a, \bar{r}^w) = (\tilde{r}^a, \tilde{r}^w)$, the righthand side of (3) is larger than the righthand side of (1) by amount $\bar{r}^a \pi^w$. This is the profit that can be earned abroad if national treatment comes with reciprocity. Thus, in the two-country case, reciprocity will never discourage country a from granting national treatment, and it may tip the balance so that country a prefers national treatment.

By adding the two inequalities (3), we see that, if the two countries agree to reciprocal national treatment, then the agreement enhances social welfare. They cannot have "too strong" an incentive to make such an agreement; if the agreement would decrease social welfare, at least one of the countries would oppose it.[3]

I now show that reciprocal national treatment can only be in the interest of both parties if it increases incentives to innovate substantially. Assume to the contrary that the amount of innovation is not very responsive to national treatment, that is, $(\hat{r}^a, \hat{r}^w) \tilde{=} (\bar{r}^a, \bar{r}^w)$. Then reciprocal national treatment improves the welfare of a and w respectively if

$$\hat{r}^a \pi^w > \hat{r}^w (c^a - C^a) \tag{4}$$

$$\hat{r}^w \pi^a > \hat{r}^a (c^w - C^w)$$

For country a, the variables $\hat{r}^a, \bar{r}^a$ are a measure of its innovative sector, and c^a, C^a are a measure of its consumption sector. Reciprocity benefits local innovators by allowing them to collect profit π^w in country w, but burdens local consumers, who will have to pay proprietary prices for inventions made abroad. This imposes deadweight loss in amount $(c^a - C^a)$. Thus, unless

[3]Compare with the conclusions of Deardorff (1992). Deardorff showed that reciprocity can decrease social welfare, but did not ask whether the countries would agree to it.

national treatment increases the incentive to innovate by a great deal, it will reduce social welfare, and at least one of the countries will oppose it. By adding (4) and the next inequality, it is clear that the two inequalities contradict the fact that $0 < c^i - C^i - \pi^i$, $i = a, w$ (deadweight loss is positive).

For example, suppose that the two countries have the same size markets $(c^a, C^a, \pi^a) = (c^w, C^w, \pi^w)$, and the same responsiveness to increased R&D incentives, $\bar{r}^a = m\hat{r}^a$ and $\bar{r}^w = m\hat{r}^w$, $m > 1$, and that one country is more innovative than the other, e.g., $\hat{r}^a > \hat{r}^w$. Then it follows from (3) that if only one country favors reciprocal national treatment to autarky, it will be the more innovative country. The profit that the innovative country can earn abroad on its many innovations will outweigh the deadweight loss that arises by making the other country's innovations proprietary. The less innovative country will reason that if it agrees to reciprocal national treatment, it loses the competitive supply of the innovative country's innovations, a valuable externality. The relatively modest proprietary rights it can obtain through national treatment will not outweigh this loss to its own consumers.

It is also easy to see that intellectual property treaties are likely to arise among federations of relatively small countries. Condition (3) will hold if

$$\bar{r}^w/\hat{r}^w > c^a/C^a \tag{5}$$

We argued that the analogous condition (2) for unilateral choices will typically *not* hold for a small country. In contrast, (5) is likely to hold because the alternative to autarky is reciprocal national treatment rather than unilateral national treatment. The reason for this discrepancy is that $\bar{r}^w$ is much larger than $\tilde{r}^w$. Recall that $\tilde{r}^w$ is the amount of innovation promoted abroad if country a *unilaterally* decides to grant national treatment to foreigners. But $\bar{r}^w$ is the amount of innovation abroad if country a, together will all the other small countries, reciprocally and jointly decide to grant national

treatment. The latter will obviously generate a much larger stimulus to innovation, as each innovator in each country suddenly gets proprietary rights in the joint markets of all the small countries, not just in country a. Part (iii) of the following Proposition can be argued formally by observing that for a federation of many small countries, each country's rate of innovation $\hat{r}$ will be close to zero under autarkic rights, and and positive under reciprocal national treatment. If the number of such countries is large, condition (5) will hold.

Proposition 2 ***(Reciprocal National Treatment)***
(i) If a country has incentive to provide national treatment to foreign inventors without reciprocity, then it would also favor a reciprocal agreement to do so.
(ii) Unless reciprocal national treatment leads to more proprietary innovations and higher social welfare than autarky, at least one country will oppose it.
(iii) Reciprocal national treatment of foreign inventors will be favored by every member of a federation of "small" nations that are commensurately innovative, even though none would unilaterally grant such treatment.

As mentioned in the introduction, an early example of small states combining their intellectual property regimes was the U.S. Constitution. In stitching together the States to form a federal government, the founding fathers had to resolve which level of government would have the power to grant intellectual property rights. All of the States had already exercised this power. Presumably for the reasons given here, the issue was resolved in favor of the federal government. A system of autarkic rights devised by the States would either have given deficient incentives, or the deficient incentives would have had to be resolved by "treaty" among the states. Another example with the same flavor is the Paris Convention.

4 Harmonization of Protection

Above I assumed that the extent of intellectual property rights in each country was given, and asked whether countries have an incentive (i) to provide national rights to foreign inventors, and (ii) whether the answer is different if national rights are conditional on reciprocity. But even within the framework of reciprocal rights, countries argue about what should be protected. For many years Canada did not grant intellectual property protection for pharmaceuticals. Instead they had a compulsory licensing law which regulated the price at which pharmaceuticals in Canada could be sold. The standard explanation is that Canada did not have a pharmaceutical industry, and hence had no national interest in protecting pharmaceuticals. Lobbying of Congress and international bodies by the international drug companies eventually convinced the Canadians to rescind this policy, especially since their participation in NAFTA would depend on it (see Maskus (2001)).

I now address the trend toward harmonization, to see how harmonization affects the strength of intellectual property rights that will arise. I assume that countries have signed treaties that specify reciprocal national treatment. However reciprocal national treatment does not specify what will be protected. I introduce a variable f in the model below, which represents what percentage of subject matter will be embraced by various forms of intellectual property. I investigate the levels of protection that will arise when countries choose this variable independently, and when their choices must be harmonized. In order to avoid bargaining problems in the case of harmonization, and to illustrate most convincingly that these two regimes give truly different national incentives, I will mostly assume for the comparison that the two countries are symmetric.

The main endogenous variable in each country will be f, the fraction

of subject matter that is protected by intellectual property. An important secondary variable is the level of R&D spending in each country, which depends on the property rights both domestically and abroad. Let $\{f^i \in [0,1], i = a, w\}$ represent the fractions of the subject matter in countries i=a,w that will be protected intellectual property. As before, w can be interpreted as the rest of the world. For each of $i = a, w$, the complement $1 - f^i$ is sponsored research, which is funded out of general revenue and put in the public domain. Any invention in the public domain is available to be competitively supplied. I let s^i, $i = a, w$, represent the total numbers innovations.

The variable s^i represents both public and private innovation. When focussing on private incentives provided through intellectual property rights, it is easy to forget the large role of the public in sponsoring R&D, and that public sponsorship is an alternative to private investment in R&D. According to the National Science Foundation (2000), in 1998 about 30% of U.S. research was funded by the federal government alone. This raises the question of why and when R&D should be funded publicly and put in the public domain, rather than made proprietary under intellectual property rights. The rationale is asymmetric information; see Gallini and Scotchmer (2001) for a summary of arguments to this effect.

If firms and sponsors have the same information about which investments should be supported, then public sponsorship dominates intellectual property as an incentive mechanism, because innovations can be put in the public domain, and avoid deadweight loss. However, when firms have better information about the value of investments, public sponsorship can lead to bad decisions about what to invest in, and sometimes to inefficiency in investment activities. There are two natural ways to model this tradeoff. One is to recognize that public sponsorship is less good at satisfying consumer preferences than private sponsorhip. The other is to assume that investment

by public sponsors is more expensive. In this model I shall assume the latter. In order to have a tractable model, I shall assume that the total cost of all innovations in country i is given by a function k^i whose arguments are (f^i, s^i). The cost functions k^i, $i = a, w$, are assumed convex. Letting $\frac{\partial k^a(\cdot)}{\partial f^a}, \frac{\partial k^a(\cdot)}{\partial s^a}$ represent the partial derivatives with respect to the first and second arguments, I assume that $\frac{\partial k^a(\cdot)}{\partial f^a} < 0$, $\frac{\partial k^a(\cdot)}{\partial s^a} > 0$. The total cost of R&D investment decreases with the fraction that is private, and increases with total investment. It is also natural to assume that the marginal cost of innovation, $\frac{\partial k^a(\cdot)}{\partial s^a}$, is nonincreasing with the fraction that is private, $\frac{\partial^2 k^a(\cdot)}{\partial s^a \partial f^a} < 0$. In order to solve a Nash equilibrium below, I will refer to the special case that $k^i(f, s) = \frac{s^2}{2f}$, $i = a, w$.

I shall investigate the preferred extent of protection f^a for country a (symmetrically for other countries) under three hypotheses about the international treaty. As a benchmark, the first is "autarky": protection is available in a given country only if the firm is domiciled in that country. The second is a treaty stipulating national rights to foreign innovators, but allowing that the levels of protection can be chosen independently. Thus the profit π^a is available to any protected invention in country a, whether by a foreign or domestic inventor. The third hypothesis is that, in addition to providing foreign rights, the countries must harmonize on a common level of protection f.

My objective will be to compare the R&D spending and levels of protection that arise under the three regimes with that which is optimal. In order to define what is optimal, I define a "global" welfare function, accounting for the externalities that each country confers on the other, and assuming reciprocal intellectual property rights:

$$G((f^a, f^w), s^a, s^w) =$$

$$(s^a + s^w) \sum_{i=a,w} (c^i - f^i(c^i - C^i - \pi^i)) - \sum_{i=a,w} k^i(f^i, s^i) \tag{6}$$

The optimal level of R&D spending for $i = a, w$ are $\bar{s}^a(f^a, f^w), \bar{s}^w(f^a, f^w)$ that maximize G conditional on (f^a, f^w). The optimal rates of spending are

$$\bar{s}^i(f^a, f^w): \qquad \sum_{j=a,w} (c^j - \bar{f}^j(c^j - C^j - \pi^j)) - k_s^i(\bar{f}^i, \bar{s}^i) = 0 \tag{7}$$

Taking these levels of spending into account, the optimal (f^a, f^w) must optimize $G((f^a, f^w), \bar{s}^a(f^a, f^w), \bar{s}^w(f^a, f^w))$. Then the optimal f^a solves the following, and the global optimum is (f^a,f^w), where f^w solves the symmetric equation for w.

$$\bar{f}^a: \qquad -(\bar{s}^a(\cdot) + \bar{s}^w(\cdot))(c^i - C^i - \pi^i) - k_f^i(\bar{f}^i, \bar{s}^i(\cdot)) = 0 \tag{8}$$

I describe what happens under autarky, national rights with independent choices of protection, and national rights with harmonized protections. I will then compare them with what is optimal.

4.1 Autarky

Under autarky, the consumers in each country receive a large externality from both public sponsors and private inventors in other countries, since all other countries' innovations can be adopted at competitive prices. The uncompensated externality from each country to the others will undermine the incentives to invest of both public sponsors and private inventors, but will not necessarily bias a country's preferred IP policy in either direction. Country a's objective function W_a^A ("A" for "autarky") is given as:

$$W_a^A(f^a, s^a) \equiv (1 - f^a)\ s^a\ c^a + f^a\ s^a\ (C^a + \pi^a) \text{ - } k^a(f^a, s^a) \tag{9}$$

Under autarky, country a will prefer the mix of public and private sponsorship and level of spending, $(\hat{f}^a, \hat{s}^a)$,that satisfy

$$\hat{s}(f^a): \qquad c^a - f^a[c^a - C^a - \pi^a] - \frac{\partial k^a(f^a, \hat{s}^a)}{\partial s} = 0 \tag{10}$$

$$\hat{f}^a: \qquad -\hat{s}^a(\hat{f}^a)\ [c^a - C^a - \pi^a] - \frac{\partial k^a(\hat{f}^a, \hat{s}^a(\hat{f}^a))}{\partial f} = 0 \tag{11}$$

By the first condition, the level of R&D spending will be increased to the point that the social value, which is consumers' surplus less deadweight loss for the fraction that are proprietary, is just balanced by the cost of the marginal innovation. By the second condition, there will be enough private invention so that the reduction in cost that would be afforded by making the marginal invention private rather than publicly sponsored is just balanced by the deadweight loss that would accrue.

As will be clear when I specialize to the symmetric case below, the main problem with autarky is that it gives deficient incentives to spend on R&D, relative to the global optimum. There will be deficient spending because neither country accounts for the benefits it's own spending confers on foreign consumers.

4.2 Reciprocity with Independent Choices

Now consider a treaty that provides for national treatment of foreign inventors, but each country chooses its level of protection independently of the other, as in the original Paris Convention. Reciprocity should increase the overall incentive to invest in R&D, but how will it affect the amount of protected subject matter?

Country a's objective function is now W^I ("I" for "independent" choices), given as follows:

$$W_a^I(f^a, f^w, s^a, s^w) \equiv$$

$$(1-f^a)\ (s^a+s^w)\ c^a\ \ + f^a s^a[C^a+\pi^a] + f^a s^w\ C^a + f^w s^a\ \pi^w - \ k^a(f^a, s^a) \tag{12}$$

The inventions that go into the public domain for competitive supply, yielding consumers' surplus c^a are the $(1-f^a)s^a$ publicly sponsored inventions made in country a and the $(1-f^a)s^w$ publicly sponsored inventions made in the rest of the world. This is the first term. There are $f^a\ s^a$ inventions in country a which are proprietary, yielding consumers' surplus C^a plus profit π^a. This is the second term. The third term represents the $f^a s^w$ inventions from the rest of the world which are proprietary in country a, yielding consumers' surplus C^a. The fourth term represents the profit collected by country a's inventors from the rest of the world.

Under national treatment with independent choices, the countries will choose the levels of protection (f^a, f^w) in a Nash equilibrium, knowing that both will then choose their R&D spending, $\tilde{s}^a(f^a, f^w)$, $\tilde{s}^w(f^a, f^w)$. For country a (symmetrically for w), the optimal choice $\tilde{s}^a(f^a, f^w)$ maximizes (12), and satisfies

$$\tilde{s}^a(f^a, f^w): \qquad c^a - f^a(c^a - C^a - \pi^a)\ + f^w\ \pi^w - \ k_s^a(f^a, \tilde{s}^a) = 0 \tag{13}$$

Thus

$$\begin{aligned} \frac{\partial \tilde{s}^a(f^a, f^w)}{\partial f^a} &= \frac{-(c^a - C^a - \pi^a) - k_{sf}^a(f^a, \tilde{s}^a(\cdot))}{k_{ss}^a(f^a, \tilde{s}^a(\cdot))} \\ \frac{\partial \tilde{s}^a(f^a, f^w)}{\partial f^w} &= \frac{\pi^w}{k_{ss}^a(f^a, \tilde{s}^a(\cdot))} \end{aligned} \tag{14}$$

and similarly for w.

The optimal f^a, conditional on f^w, maximizes $W_a^I(f^a, f^w, \tilde{s}^a(f^a, f^w), \tilde{s}^w(f^a, f^w))$, and solves

$$-(\tilde{s}^a(\cdot) + \tilde{s}^w(\cdot))\ (c^a - C^a - \pi^a) - \tilde{s}^w(\cdot)\pi^a \tag{15}$$

$$+(c^a - \tilde{f}^a(c^a - C^a))\frac{\partial \tilde{s}^w(f^a, f^w)}{\partial f^a} - k_f^a(\tilde{f}^a, \tilde{s}^a(\cdot)) = 0$$

Since $\frac{\partial W_a^I(f^a, f^w, s^a(f^a, f^w), s^w(f^a, f^w))}{\partial s^a} = 0$, the derivative $\frac{\partial \tilde{s}^a(f^a, f^w)}{\partial f^a}$ does not appear in this equation .

Comparing (13) with (7), it is indeterminate whether, conditional on (f^a, f^w), country a will overspend or underspend on R&D, relative to the global optimum. Country a does not take account of the externalities it confers on consumers abroad, but on the other hand, it takes account of profit earned abroad on its own inventions (the term $f^w\ \pi^w$ in (13)). Whether spending is too high or too low depends on how these compare.

Comparing (8) with (15), it is also indeterminate whether country a will have stronger or weaker protection f^a than is optimal. The two extra terms in (15) represent, first, the fact that stronger domestic protection lets profit leak out to foreigners, due to national treatment, and, second, the stimulus for spending abroad which creates positive externalities for country a's consumers (the third term in (15)).

In the example below with symmetric countries, these indeterminacies are resolved in the direction of too little spending and too much protection. However that is a feature of the example.

4.3 Reciprocity with Harmonization

Under a system of harmonized national treatment, both countries must adopt the same level of protection, f. Each country's preferred level of protection is the one it would lobby for, but it must, in the end, implement a level of protection that is the outcome of a negotiation. Under this hypothesis, country a's welfare function is W^H ("H" for "harmonized"), is defined by

$$W_a^H(f, s^a; s^w) \equiv$$

$$(1-f)\ (s^a + s^w)\ c^a + f(s^a + s^w)C^a\ + fs^a(\pi^w + \pi^a) -\ k^a(f, s^a) \qquad (16)$$

and symmetrically for w. The first term represents the consumers' surplus in country a available from publicly sponsored innovations in both countries. The second term represents the consumers' surplus in country a on proprietary innovations supplied by both countries and protected in country a. The third term is the profit earned by inventors in a in both countries.

Under national treatment with harmonization at level f, the country a (symmetrically, w) will invest at the rate $\dot{s}^a(f)$ that maximizes W_a^H and satisfies

$$\dot{s}^a(f): \qquad c^a - f(\ c^a - C^a - \pi^a)\ + f\pi^w\ - \frac{\partial k^a(f, s^a)}{\partial s} = 0 \quad (17)$$

Thus

$$\begin{aligned} \frac{\partial \dot{s}^a(f)}{\partial f} &= \frac{-(c^a - C^a - \pi^a) + \pi^w - k^a_{sf}(f, s^a)}{k^a_{ss}(f, s^a)} \\ \frac{\partial \dot{s}^w(f)}{\partial f} &= \frac{-(c^w - C^w - \pi^w) + \pi^a - k^w_{sf}(f, s^w)}{k^w_{ss}(f, s^w)} \end{aligned} \qquad (18)$$

Since the two countries do not choose their levels of protection independently, it does not make sense to consider a Nash equilibrium, but instead to

assume that the countries will negotiate a solution, each having a first-best preference. Country a's preferred f (the one that country a would lobby for) maximizes $W_a^H(f, \dot{s}^a(f), \dot{s}^w(f))$:

$$-(\dot{s}^a(f) + \dot{s}^w(f))\ [c^a - C^a - \pi^a] - [s^w(f)\pi^a - \dot{s}^a(f)\pi^w] \tag{19}$$

$$+(c^a - f(c^a - C^a))\frac{\partial \dot{s}^w(f)}{\partial f} - k_f^a(f, \dot{s}^a(f)) = 0$$

Comparing (15) and (19), country a has incentive to choose stronger intellectual property rights under harmonization than with independent choices. This is for two reasons. First, since rights will be harmonized, domestic firms can recoup more of their costs by charging proprietary prices abroad (this is the term $\dot{s}^a(f)\pi^w$ in (19)). This offsets the fact that foreigners are recouping part of their costs by charging proprietary prices in country a under the national treatment provision, whether or not the rights are harmonized. Second, an increase in harmonized rights stimulates foreign R&D spending more than a unilateral strengthening of rights. The increased R&D generates positive externalities for country a.

The two countries will generally prefer different common levels of protection. The common level of protection preferred by w will satisfy condition (19) with the superscripts reversed. The second term in (19) is positive or negative according as $\pi^a/s^a > \pi^w/s^w$ or vice versa. Thus the second term will have opposite sign for the two countries. If the deadweight loss, cost structures, and impacts on foreign investments are the same in each country, then the two countries have different preferences for the common level of protection, depending on the profit available to them in their respective foreign markets.

It is also of interest to compare the optimal levels of protection, described in (8), with the harmonized levels that the countries would lobby

for, described in (19). If the countries did not anticipate the effects on foreign spending (i.e., ignoring the term $\frac{\partial s^w}{\partial f}$ in (19)), then their incentives to strengthen protection would be similar to the optimum, except to the extent that their foreign profit opportunities differ, as explained in the previous paragraph. However, there will be further impetus to strengthening property rights if there are positive effects on foreign R&D spending. Thus it will generally be the case that harmonized protections are stronger than optimal. This point is made more reliably in the next section, where I specialize to the symmetric case with a specific cost function.[4]

4.4 The symmetric Case

The easiest way to sort out the biases that come from harmonization and independent choices is to study the symmetric case where countries a and w are exactly alike, $c^a = c^w = c$, $C^a = C^b = C$, $\pi^a = \pi^b = \pi$, $k^a = k^w = k$. Further we will choose a cost function such that the Nash equilibrium with independent choices is unique and symmetric, namely

$$k(f, s) = \frac{s^2}{2f}$$

For each f, let

$$s^G(f) \equiv \bar{s}^a(f, f) = \bar{s}^w(f, f) = 2f(c - f(c - C) + f\pi)$$

$$s^A(f) \equiv \hat{s}^a(f, f) = \hat{s}^w(f, f) = f(c - f(c - C) + f\pi)$$

[4]The result is hard to prove generally, since the incentive to strengthen protection depends on the level of R&D spending, which is also endogenous. There will generally be less spending than is optimal, and this changes the incentives to strengthen protection, due to the negative cross-partial of the cost function.

$$s^{IH}(f) \equiv \tilde{s}^a(f,f) = \tilde{s}^w(f,f) = \dot{s}^a(f,f) = \dot{s}^w(f,f) = f(c - f(c-C) + 2f\pi) \tag{20}$$

That is, $s^G(f)$ is the level of spending in each country that would be globally optimal, taking account of global externalities, if both countries chose a protection level f. It solves (7) at $f = f^a = f^w$. $s^A(f)$ is the level of spending that each country would choose if both have the level of protection f, and neither receives intellectual property rights in the other country. It solves (10) at $f = f^a = f^w$. $s^{IH}(f)$ is the level of spending that each country would choose if both have the level of protection f, and each receives reciprocal rights in the other country. This level is the same, regardless of how the level f is chosen, e.g., independently by the two countries, or under a harmonized regime. $s^{IH}(f)$ solves (13) and (17) at $f = f^a = f^w$.

The following is immediate:

Proposition 3 *With symmetric economies and the same intellectual property regimes f, each country will spend less under either autarky or national treatment than is optimal. Each country will spend less under autarky than under a system of national treatment. That is, $s^A(f) < s^{IH}(f) < s^G(f)$.*

But this proposition does not speak to the question of most interest, namely, the effect of autarky and national treatment on the levels of IP that will be chosen.

Let f^G be the optimal level of protection in each country, when the global externalities are accounted for, and the level of spending will be $s^G(f^G)$. The level of protection f^G solves (8). Let f^A be each country's preferred level of protection under autarky. It solves (11). Let f^I be each country's optimal level of protection under a system of reciprocal rights where each country

chooses its level of protection independently. It solves (15). Finally, let f^H be each country's optimal level of protection under the system of reciprocal rights when both must choose the same level. It solves (19).

In the following proposition the condition $c < 3(c - C - \pi)$ ensures that $f^G < 1$. It is not optimal for all types of inventions to receive intellectual property.

Proposition 4 *Assume $c < 3(c - C - \pi)$. The preferred levels of protection f satisfy $f^G = f^A < f^I < f^H$. That is, the system of national treatment will give countries an incentive toward overprotection, and the overprotection is exacerbated under harmonization.*

Proof: Simultaneously solving (7),(8) and then (10),(11),

$$f^A = \frac{c}{3(c - C - \pi)} = f^G.$$

With the cost function chosen, the symmetric Nash equilibrium for independent choices is unique, and the firms' objective functions are concave. At the symmetric equilibrium, each firm's independent choice satisfies (15), evaluated at (f^I, f^I). Nash equilibrium satisfies the following if there is a solution $f^I \in (0, 1)$.

$$0 = -2s^{IH}(f^I)(c - C - \pi) - \pi s^{IH}(f^I) + \pi f^I(c - f^I(c - C)) + \frac{s^{IH}(f^I)^2}{2(f^I)^2} \tag{21}$$

The value of the righthand side is positive at $f^I = 0$, hence there is no Nash equilibrium at $f^I = 0$. In fact the value is positive for all $f^I \in [0, c/3d]$; hence there is no Nash equilibrium such that $f^I \leq f^G$. Further, there is

at least one symmetric Nash equilibrium. There is either a solution to the above equation, or the value is positive at all f^I; hence the symmetric Nash equilibrium is $f^I = 1$ for both firms.

It remains to show that $f^I \leq f^H$. If $f^H = 1$, this is immediate, so we suppose there is an interior solution to (19), evaluated at (f^H, f^H) :

$$0 = -2s^{IH}(f^H)(c - C - \pi) - \pi s^H(f^H) + \pi f^H(c - f^H(c - C)) + \frac{s^{IH}(f^H)^2}{2(f^H)^2}$$

$$+f^H(c - f^H(c - C))(-(c - C - \pi) + \frac{s^{IH}(f^H)}{(f^H)^2}) + \pi s^{IH}(f^H) \qquad (22)$$

At each f^H, the value of the righthand side of (22) differs from the righthand side of (21) by the bottom line of (22). Using (20), the bottom line is positive; hence at $f^H = f^I$, each firm has an incentive to lobby for more property protection. $\square$

Thus, treaties that require national treatment of foreign inventors can encourage stronger protection than is optimal, and this effect is greatest when protection regimes must be harmonized. We should keep in mind, however, that the overall level of spending is too low under any regime in which countries do not account for the external benefits of their inventions. This is shown in Proposition 3. Expanding the subject matter that is protected will generally stimulate R&D spending. With more subject matter protected, more costs can be exported by charging proprietary prices abroad, and therefore the nation as a whole should be willing to spend more on R&D, especially if some of the output is protected. Hence the overprotection pointed to in Proposition 4 has a justification.

5 Conclusion

Economic theories about the optimal design of intellectual property involve a balancing of consumer losses due to proprietary pricing against firms' incentives to invent. The balancing is not because inventors *per se* should be weighed in the social calculus, but because inventors must be protected in order to create benefits for consumers.

The policy prescriptions suggested by such a calculus are not implemented in a fragmented world connected by trade. National policies in a fragmented world create externalities that are not accounted for. These externalities cause trade negotiators to weigh the interests of inventors directly in their welfare calculations, since inventors can become the recipients of cash transfers from abroad. But the value created for consumers abroad is not counted at all, since consumers abroad are not part of the constituency. Thus, we would not expect the intellectual property prescriptions of trade negotiators to accord with those indicated by considering a more comprehensive notion of social welfare. This raises the question of what biases are introduced.

The main consequence of a fragmented world is that the system of rights can be skewed toward more intellectual property than would be optimal if the world were integrated. The expanded property rights will encourage private firms to undertake R&D in order to earn profit abroad. In contrast, there will be too little public spending, since public sponsors are only interested in domestic consumers' surplus. Since private, but not public, spending can be encouraged through intellectual property rights, the expanded rights are a partial remedy to the fact that R&D spending is suboptimal in a fragmented world. A better remedy might be international agreements on public spending for R&D, rather than negotiating treaties to strengthen intellectual property rights.

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