NBER WORKING PAPER SERIES

THE POLITICAL ECONOMY OF INTELLECTUAL PROPERTY TREATIES

Suzanne Scotchmer

Working Paper 9114
http://www.nber.org/papers/w9114

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
August 2002

I thank Stylianos Tellis and Kevin Schubert for research assistance, and Alan Deardorff, Nancy Gallini, Rich Gilbert, Gene Grossman, Jean Lanjouw, Mark Lemley, Stephen Maurer, Pam Samuelson, and seminar participants at Industry Canada and Ecole des Mines for helpful comments. I thank the National Science Foundation for financial support. This paper is a revision of IBER Working paper E01-305 (August 2001). The views expressed herein are those of the author and not necessarily those of the National Bureau of Economic Research.

The Political Economy of Intellectual Property Treaties
Suzanne Scotchmer
NBER Working Paper No. 9114
August 2002
JEL No. F1, L5

ABSTRACT

Intellectual property treaties have two main types of provisions: national treatment of foreign inventors, and harmonization of protections. I address the positive question of when countries would want to treat foreign inventors the same as domestic inventors, and how their incentive to do so depends on reciprocity. I also investigate an equilibrium in which regional policy makers choose IP policies that serve regional interests, conditional on each other's policies. I compare these policies with a notion of what is optimal, and argue that harmonization will involve stronger IP protection than independent choices. Harmonization can either enhance or reduce global welfare. 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 more extensive protection engendered by attempts at harmonization are a partial remedy.

Suzanne Scotchmer
Department of Economics and GSPP
University of California, Berkeley
Berkeley, CA 94720-7320
and NBER
scotch@socrates.berkeley.edu

1 Introduction

The economic rationale for intellectual property (IP) is that it encourages development of new products, and thus generates consumers' surplus. The net profit that accrues to inventors is also a social benefit, since it is a transfer from consumers. However profit is recognized as a necessary evil, since the flip side of profit is deadweight loss. There is no economic rationale for protecting inventors *per se.*

This reasoning gets subverted in the international arena. To a trade policy negotiator, profit earned abroad is unambiguously a good thing, and the consumers' surplus conferred on foreign consumers does not count at all. There is a domestic interest in capturing profit abroad, and symmetrically, there is a domestic interest in trying to ensure that domestic consumers get access to foreign inventions on competitive terms.

Some commentators (e.g., Hall (2001), Lanjouw and Cockburn (2000)) have suggested that intellectual property rights in the international arena will be stronger than optimal because trade negotiators are "captured" by industry. Capture is undoubtedly an important phenomenon, but I argue that intellectual property policies can be overprotective even without it. This is because intellectual property is the only available tool by which cross-border externalities can be recaptured by the innovating country. McCalman (1999) estimates that the TRIPS provisions would have increased the revenues available to holders of U.S. patents issued in 1988 by $4.5b, in 1988 dollars. Of course the domestic interests of regional innovators must be balanced against the domestic interests of regional consumers; see Maskus (2000a,b) for evidence that national differences give rise to different IP policies, and evidence on how IP policies affect trading relationships and foreign direct investment.

If we conjecture that intellectual property rights are more extensive than optimal, we must be precise about what is optimal. There are two lines of thought about this, and they differ in their assumption about the alternative to intellectual property. The older literature, which follows Nordhaus (1969), sees the alternative as a dearth of innovation. It is argued that, without sufficient intellectual property rights, innovation will be stifled, and consumers will be deprived of innovations. A newer literature, summarized, for example, by Gallini and Scotchmer (2001), sees a viable alternative in public sponsorship. Since public sponsorship can avoid proprietary pricing, there should be a strong presumption that it is a superior way to support research unless offset by some other type of inefficiency. The investigation below is mostly in that spirit.

In fact, public spending on R&D is huge. The OECD reports[1] that in 1999, only 56% of R&D spending in the European Union was by industry. The industrial share is higher in the U.S., about 66%, where public spending on R&D is crowded out by military spending. This is still a considerable departure from 100%. In Latin America, public sponsorship is dominant. In 1996 the government shares of R&D spending in Brazil, Chile, Costa Rica and Mexico were substantially over half, while the government shares in Argentia and Venezuela were respectively 46% and 32%.[2]

These numbers draw attention to an important aspect of economic efficiency in the R&D environment that is often ignored, namely, the mix of private and public spending. Most investigations of intellectual property policy are concerned solely with the the private sector.

Public spending on R&D confers externalities abroad, just as private spend-

[1] www.oecd.org/pdf/M00026000/M00026476.pdf
[2] www.nsf.gov/sbe/srs/nsf00316/secta.htm

ing does. From a global perspective, optimal public spending would account for the consumers' surplus that accrues to foreigner consumers as well as domestic consumers. However a domestic policy maker is unlikely to take such a comprehensive view. Since cross-border externalities can be partially reclaimed through intellectual property rights abroad, but not when public sponsors put their inventions in the public domain, the mix of public and private R&D spending will be be affected by intellectual property treaties. My inquiry addresses the mix of public and private spending, as well as total expenditures on R&D.[3]

Two important provisions of IP treaties are "national treatment of foreign inventors" and "harmonization." "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.

My first objective in this paper is to expose the rudimentary incentives to sign intellectual property treaties, and my second objective is to understand how intellectual property treaties affect the extent of protection. Section 2 presents a 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. In Sections 4 and 5, I investigate how domestic intellectual property choices are affected

[3]An angle studied by Spencer and Brander (1983), and by Kang (2000a,b) is that subsidy policy can be used strategically to enhance the competitive position of domestic innovators. Here the role of the public sector is the more straightforward one of substituting for private incentives, for the direct benefit of consumers.

by treaties that provide for national treatment but no harmonization, versus treaties with national treatment that also require harmonization. I take an equilibrium perspective in which each country chooses an IP policy that is a best response to the incentives provided by other countries. In Section 4, I assume that, if the private sector has no incentive to invest in a certain type of innovations, then the public sector will do so if the regional benefits outweigh the burden on taxpayers. In Section 5, I revisit the same questions under the more traditional (and easier to analyze) hypothesis that the alternative to private spending is no investment.

Among my conclusions:

- Independent choices of IP policies can lead to two coordination problems, one involving asymmetric protections and "free-riding," and the other involving too little protection.
- Harmonization on minimum protections can also lead to asymmetric protections, and these may be more efficient than universal protections, even if inequitable.
- Harmonization will typically lead to more extensive intellectual property rights than independent choices, and may lead to more extensive intellectual property rights than are optimal, even in the absence of "capture."
- The aggregate level of R&D spending will typically be too low due to uncompensated externalities across borders.
- If the alternative to private R&D spending is no investment rather than public sponsorship, then harmonized intellectual property rights will be more extensive than if both regions anticipated domestic public sponsorship.

There are close parallels between treaty-making for intellectual property and extraterritoriality issues in competition policy; see, in particular, Guzman (1998, 2001). Domestic policymakers have less incentive to curb collusion in an export industry than an import industry, since the burden of high prices is imposed on foreign consumers, while the profit accrues domestically. These cross-border externalities are similar to those that arise from regional intellectual property decisions.

There are also close parallels between treaty-making for intellectual property and treaty-making on tariff policy. Bagwell and Staiger (1999) have 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 public R&D spending. In order to isolate the problem of intellectual property, I assume that terms-of-trade issues are divorced from negotiations over intellectual property rights. However my conclusions shed light on why the TRIPS negotiations were linked to tariff concessions, which allowed small countries to be strong-armed into signing IP treaties that would otherwise not be in their interest. For discussions of these negotiations, see, for example, Samuelson (1999), Watal (1998) and Reichman (1997).

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. In a similar framework, Lai and Giu (forthcoming) and Grossman and Lai (2001) study harmonization on the optimal length of protection, the latter building on Helpman (1993), who introduced complexities such as differences in the efficiency of the manufacturing sector. 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.

A slightly different angle is pursued by Aoki and Prusa (1993), who consider the effect on domestic profit of discriminatory enforcement against foreign and domestic rivals. They show that asymmetric treatment is not necessarily in the interest of domestic innovators, and argue that domestic social welfare is not necessarily higher under an asymmetric policy.

2 A Short History of IP Treaties

The earliest large-scale intellectual property treaties were the Paris Convention of 1883 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, mostly at a procedural level.

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 very 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 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. Disputes are brought before 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 and incompatible system of local copyright and patent law was replaced with a federal system. Each of the 13 founding States ceded its 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 because certain aspects of its substantive and procedural policies were in conflict with U.S.

policies. It joined in 1989 because the U.S. had become a major exporter of copyrighted works, and wanted a voice in the international policy making process. In the meantime, 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 a forum for dispute resolution, 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

As a warmup, 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 mc^i be the aggregate consumers' surplus per innovation, assuming that the product is sold by a monopolist. Let πc^i and dc^i be the aggregate profit and deadweight loss per innovation, respectively. The profit and consumers' surplus are assumed to be the same whether the innovation is supplied by a domestic firm or foreign firm. By definition, $m + \pi + d = 1$. These can be interpreted as present discounted values, and therefore π, d will be larger for longer durations of protection, whereas m will be smaller,

We use a function k^i to represent the total cost of innovations by inventors 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 $\tilde{r}^w \geq \hat{r}^w$, and that is all we need to know about incentives for the moment.

Offering national treatment to foreigners would be a pure gift if its only effect were to allow foreign inventors to profit at the expense of domestic consumers. The compensation is more foreign inventions, which create benefits for domestic consumers.

Under autarky, total social surplus for country a is

$$\hat{r}^a(m+\pi)c^a + \hat{r}^w c^a - k(\hat{r}^a)$$

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

Country a would find it beneficial to grant national treatment to inventors in country w if the following holds.

$$\hat{r}^a c^a(m+\pi) + \hat{r}^w c^a - k(\hat{r}^a) < \hat{r}^a c^a(m+\pi) + \tilde{r}^w m c^a - k(\hat{r}^a) \qquad (1)$$

or

$$\tilde{r}^w/\hat{r}^w > 1/m \qquad (2)$$

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 IP privileges for

foreigners will cause domestic consumers to pay proprietary prices instead of competitive prices for foreign innovations, the increase in such inventions may outweigh the loss in consumers' surplus on each invention.

Condition (2) is the relevant one even if inventors in country a already receive rights in the rest of the world. In that case, country a will reciprocate if

$$\tilde{r}^a[c^a(m+\pi^a)+\pi c^w]+\hat{r}^w c^a - k(\tilde{r}^a) < \tilde{r}^a[c^a(m+\pi^a)+\pi c^w]+\tilde{r}^w m c^a - k(\tilde{r}^a) \tag{3}$$

which again reduces to (2) (athough the magnitudes of $\tilde{r}^w, \hat{r}^a$ will be different). Thus,

Remark 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 also provides such rights. 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 described in Section 2, most IP treaties include small, open economies. This seems to contradict part (ii) of the remark. The key is that regions do not usually grant national treatment as a unilateral gift, but rather in return for reciprocity.

If region a's choice is between reciprocal national treatment and autarky, the decision criterion is to choose reciprocal national treatment if

$$\hat{r}^a c^a m + \hat{r}^w c^a + \hat{r}^a c^a \pi - k(\hat{r}^a) < \tilde{r}^a c^a m + \tilde{r}^w c^a m + \tilde{r}^a \pi(c^a + c^w) - k(\tilde{r}^a) \tag{4}$$

A sufficient condition for this inequality is again (2), assuming that the profit available to domestic firms goes up when profit opportunities abroad are added ($\hat{r}^a c^a \pi - k(\hat{r}^a) < \tilde{r}^a \pi(c^a + c^w) - k(\tilde{r}^a)$). If the additional profit is substantial, the inequality (4) may hold even if (2) does not hold.

This argument can be expanded to shed light on why reciprocity might overturn the instability pointed to in Remark 1(ii). Instead of interpreting w as a single other country, assume that it is an amalgamation of many countries, each more or less the size of a. Consider the experiment that country a unilaterally withdraws from a multilateral reciprocal agreement for national treatment. Assuming that the agreements among all the other countries remain intact, and that a is relatively small, their R&D incentives will not change very much. That is, $\hat{r}^w \cong \tilde{r}^w$. In that case, the inequality (2) will not hold, but (4) may nevertheless hold if there is a large enough impact on domestic innovation and domestic profit in a. With reciprocity, the incentive for a small country to stay in a multilateral agreement is profit driven. In particular, if the difference between $\hat{r}^a c^a \pi - k(\hat{r}^a)$ and $\tilde{r}^a \pi(c^a + c^w) - k(\tilde{r}^a)$ is large enough, then country a will remain in the agreement despite the opportunity to free ride on foreign inventions, in order to gain access to profit in the large world market. Even this incentive may fail, and then the country must be induced to participate by granting additional concessions such as trade concessions and membership in the WTO (see Lai and Giu (forthcoming)).

It is straightforward that if the countries agree to reciprocal national treatment, then the agreement enhances social welfare. And if the agreement would decrease social welfare, at least one of the countries would oppose it.[4] Further, reciprocal national treatment can only be in the interest of all countries if it increases innovation substantially. Without an increase in inno-

[4]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.

vation, each country sees two effects: a change in profit flow among countries, and deadweight loss on foreign inventions. In aggregate, the profit flows are transfers; except in the case of complete symmetry, at least one country is a net winner and at least one other is a net loser. However the deadweight loss is "real." This implies that, without an offsetting benefit of more innovations, there must be at least one net loser.

Remark 2 ***(Reciprocal National Treatment)***
(i) If a country has incentive to provide national treatment to foreign inventors in the absence of reciprocity, then it would also favor a reciprocal agreement to do so.
(ii) A country may agree to a reciprocal agreement in circumstances where the country would not unilaterally grant national treatment to foreigners.
(iii) Unless reciprocal national treatment leads to more proprietary innovations and higher social welfare than autarky, at least one country will oppose it.
(iv) A federation of "small" nations might agree to a multilateral reciprocal agreement for national treatment even if none would unilaterally grant national treatment.

Remark 1(ii) should be compared with Remark 2(iv). Remark 1(ii) implies that a small country will not want to provide national treatment if its rights abroad do not depend on it. Remark 2(iv) points out that by making the rights abroad contingent on reciprocity, the small country might be kept from defecting, despite the opportunity to free-ride on a large number of foreign inventions.

Remark 2 tells us that efficiency is enhanced by making treaties for reciprocial IP privileges. However the notion of efficiency in Remark 2 is restricted, since

it takes as given the levels of protection in each country. In the next sections I investigate how these agreements affect the extent of the protections that will be provided. The original Paris and Berne Conventions specified neither the subject matters that would be protected nor, for the most part, the policy levers that affect profitability, such as the length and breadth of rights, and exceptions for fair use or public purposes. It is possible to harmonize all these policy levers, and, indeed, TRIPS addressed the issue of length (see Grossman and Lai (2001)). However the main points of controversy in the TRIPS negotiation concerned subject matter itself, rather than the policy levers. For example, there was substantial controversy over the protection of bioengineered life forms, computer software, and data products. The model that follows is oriented toward harmonization on subject matter, assuming that the policy levers are of secondary importance, at least within the range of possibilities under discussion.

4 Global Efficiency

If there were no social advantage in delegating R&D to private firms, and if there were no uncompensated externalities across borders, the first-best policy would be public support of all R&D, which would avoid deadweight loss. However, even aside from the distributional issues that undermine the willingness to pay for public investments that benefit all consumers globally, there are at least two possible advantages to private investments. One is that public sponsors are less good at satisfying consumer preferences, and the other is that private sponsors are more efficient. In this model I shall assume the latter.

Instead of introducing heterogeneity in the value of innovations, I maintain

the market structure above for each innovation, and index "subject matter" by cost. I assume that the cost of subject matter $x \in [0, \infty]$ is x if provided by the private sector under intellectual property incentives, and is kx if provided by the public sector, where $k > 1$. Thus, the innovations are ordered so that the cost advantage of the private sector, $(k-1)x$, is increasing in x.

In this section I discuss first-best efficiency in the organization of intellectual property rights (assuming that the duration of protection is fixed). In the efficiency analysis there are two considerations: which investments should be undertaken, and how should they be funded. The two options are public sponsorship and intellectual property. I will say that the system of intellectual property protection and public sponsorship is *globally efficient* if it maximizes worldwide consumers' surplus without regard to distribution.

The efficient intellectual property regime is described in Table I below. It is important to realize that the considerations in Table 1 will not be reflected in any administrator's objective function. For example, from a global perspective, public sponsorship is more efficient than intellectual property whenever $(k-1)x$ is less than $d(c^a + c^w)$. But this will not be a decision criterion of either region.

In order to reduce the number of cases, the entries in the table reflect assumptions that $\frac{dc^a}{(k-1)} < \frac{dc^w}{(k-1)} < (\pi c^a, \pi c^w) < \frac{d(c^a+c^w)}{(k-1)} < \pi(c^a + c^w) < \frac{(c^a+c^w)}{k}$. It is clear how to modify the table if these relationships do not hold.

Table I: Global Efficiency

SUBJECT MATTER (COST)	INTELLECTUAL PROPERTY?
$x \in [0, \frac{dc^a}{(k-1)})$	public sponsorship in a and w
$x \in [\frac{dc^a}{(k-1)}, \pi c^a)$	IP in a, public sponsorship in w
$x \in [\pi c^a, \pi c^w)$	IP in w, public sponsorship in a
$x \in [\pi c^w, \frac{d(c^a+c^w)}{(k-1)})$	public sponsorship in a and w
$x \in [\frac{d(c^a+c^w)}{(k-1)}, \pi(c^a + c^w))$	IP in a and w
$x \in [\pi(c^a + c^w), \frac{(c^a+c^w)}{k})$	public sponsorship in a and w

An efficient regime may provide for intellectual property in only a single region, in particular, for the less costly innovations. Granting rights in only a single market imposes less deadweight loss. However, costly innovations may require profits in both markets.

Three types of subject matter should not be protected: (1) innovations whose cost is relatively low, so that the cost efficiency of the private sector does not outweigh the deadweight loss even in a single market, (2) high-cost subject matter for which cost cannot be covered by revenue even in both markets, and (3) innovations whose cost cannot be covered in a single market, but for which the deadweight loss in both markets would be more burdensome than the inefficiency of public sponsorship.

The distributional issues ignored in Table 1 become key in the equilibrium analysis below. Neither region wants to be the sole provider of intellectual property rights, because their consumers bear all the deadweight loss, while their innovators and public sponsors confer uncompensated externalities on the other region. A region would always want to have its own intellectual property reciprocated abroad, so that it can recoup part of the externality it confers, as profit.

5 IP and Public Sponsorship

It seems unlikely that an intellectual property policy such as the one in Table 1 would be implemented. There will be conflicts, since asymmetric protections create one-way externalities. Nevertheless, I show that certain important features of the Table, such as unilateral protection for some subject matters, may emerge.

I assume that domestic policy makers will respect a notion of social value that accounts for all the domestic interests, including those of domestic consumers and domestic inventors. Profit earned abroad enters the social calculus through the interests of domestic inventors.

If an invention (subject matter) is not supplied by the private sector, then I assume it will be supplied by the public sector if its regional social value outweighs its cost. An invention that is publicly sponsored by either region can be competitively supplied in all regions, since it enters the public domain. Thus if a subject matter is protected in one region but not another, the innovations will be public in some regions, but not in others. Whether an invention is public or private in a particular region depends on the intellectual property law in that region, and not on where the inventor is domiciled.

Let $\gamma^a, \gamma^w \in R_+$ measure the two regions' innovativeness. γ^i represents the number of innovations on a unit of the real line. Investment in jurisdiction i along an interval $[0, f^i]$ results in a total of $\gamma^i f^i$ innovations, at total cost $\gamma^i k \int_0^{f^i} x dx$ if undertaken by the public sector. Investment in the interval $[f^i, \pi(c^a + c^w)]$ results in $\gamma^i[\pi(c^a + c^w) - f^i]$ innovations, with total cost $\int_{f^i}^{\pi(c^a+c^w)} x dx$ if undertaken by the private sector.

I shall now investigate how protections are chosen in equilibrium under var-

ious treaty rules, and compare with the optimal policy described in Table 1, which accounts for all the externalities.

Consider a treaty that provides for national treatment of foreign inventors, but each region chooses the extent of its protections independently of the other, as in the original Paris Convention.

Equilibrium with independent choices may be asymmetric in its intellectual property regimes, even if the regions are identical. To see why this is true, suppose instead that both protect the same subject matters. Suppose, however, that a single market, say a, is lucrative enough to cover R&D costs for inventions in either region. Then the rest of the world, w, can weaken its protection without jeopardizing innovation, even by its own innovators. Its own innovators can still get protection in the lucrative market a, but consumers in w get these innovations at competitive prices.

The argument relies on national treatment, by which each jurisdiction grants the same rights to all firms, regardless of where they are domiciled. With national treatment, a firm's incentive to invent does not depend on where it is domiciled, even if regions have different intellectual property regimes. A firm in a region with low protection can patent in the region with high protection. Thus, if one of the regions has relatively high protections, the other region can exploit that fact by granting low protection. Low protection allows its own consumers to benefit from competitive supply, and national treatment allows its firms to profit from their inventions by marketing them abroad. As a consequence, for some parameter values, there is an equilibrium with high protection in one region and low protection in the other. In fact, this may be the only equilibrium.

In order to study the equilibria, we must specify the regions' payoff functions.

A simplifying aspect is that a region's choice whether to protect a given subject matter x can be cleaved off from its choices about other subject matters. Thus, we can think of each region's strategy in terms of individual decisions about individual subject matters. The strategies shall be functions $P_i : [0, \infty] \rightarrow \{0, 1\}$, where $P_i(x) = 1$ means that subject matter with cost x is protected in region i.

The following functions, each on $[0, \pi(c^a + c^w)]$, are useful in defining the regions' objective functions. D_a (symmetrically, D_w) is the amount by which region a would be better off providing unilateral intellectual property rather than relying on public sponsorship. The regional social benefit with unilateral IP is $(1 - d - \pi)c^a(\gamma^a + \gamma^w) + \pi c^a \gamma^a - \gamma^a x$. The regional social benefit with public sponsorship is $c^a(\gamma^a + \gamma^w) - k\gamma^a x$. The difference is $D_a(x)$. $\tilde{D}_a$ (symmetrically, $\tilde{D}_w$) is the amount by which region a would be better off with bilateral intellectual property rather than public sponsorship in both regions. With bilateral intellectual property, region a's net benefit is $(1 - d - \pi)c^a(\gamma^a + \gamma^w) + \pi(c^a + c^w)\gamma^a - \gamma^a x$. With public sponsorship, the net regional benefit is $c^a(\gamma^a + \gamma^w) - k\gamma^a x$. The difference is $\tilde{D}_a(x)$.

$$\begin{aligned}
D_a(x) &= -c^a\gamma^w(d + \pi) - c^a\gamma^a d + (k - 1)\gamma^a x \\
\tilde{D}_a(x) &= -c^a\gamma^w(d + \pi) - c^a\gamma^a d + \pi\gamma^a c^w + (k - 1)\gamma^a x \\
D_w(x) &= -c^w\gamma^a(d + \pi) - c^w\gamma^w d + (k - 1)\gamma^w x \\
\tilde{D}_w(x) &= -c^w\gamma^a(d + \pi) - c^w\gamma^w d + \pi\gamma^w c^a + (k - 1)\gamma^w x
\end{aligned}$$

A subject matter x will be publicly supported instead of abandoned in the absence of intellectual property right if

$$c^a \geq kx$$

We will assume for simplicity that this condition holds whenever $x \leq \pi c^a$, and symmetrically for w.

Because of the binary nature of strategies, it is easiest to define the objec-

tive function Π_a (symmetrically, Π_w) as the difference in payoff to region a between providing protection and not providing it, times the value of the strategy. Thus $P_a(x) = 1$ maximizes the payoff difference if the difference is nonnegative, and $P_a(x) = 0$ is optimal otherwise. The payoff function of a (symmetrically, w) is as follows.

$$\Pi_a(P_a(x); P_w(x)) = \begin{array}{ll} P_a(x) \times D_a(x) & \text{if } P_w(x) = 0,\ x \leq \pi c^a \\ P_a(x) \times 0 & \text{if } P_w(x) = 0,\ x > \pi c^a \\ P_a(x) & \text{if } P_w(x) = 1,\ x \leq \pi c^w \\ \times\ [-c^a \gamma^a d - c^a \gamma^w (d + \pi)] & \\ P_a(x) \times \tilde{D}_a(x) & \text{if } P_w(x) = 1, \\ & \pi(c^a + c^w) \geq x > \pi c^w \end{array}$$

An *equilibrium with independent choices* is a pair (P_a, P_w) such that at each $x \in [0, \infty]$, $P_a(x) \in \arg\max\{\Pi_a(P_a; P_w(x)) | P_a \in \{0, 1\}\}$ and $P_w(x) \in \arg\max\{\Pi_w(P_w; P_a(x)) | P_w \in \{0, 1\}\}$. We adopt the convention that if the region is indifferent between providing protection or not, it chooses $P_i(x) = 0$ (does not provide protection).

Let

$$\begin{aligned} \underline{x}^a &= \max\{x \in R_+ \mid D_a(x) \leq 0\} \\ \underline{x}^w &= \max\{x \in R_+ \mid D_w(x) \leq 0\} \end{aligned} \tag{5}$$

$$f = \frac{1}{(k-1)} \quad \max\{c^a \frac{\gamma^w}{\gamma^a}(d + \pi) + c^a d - \pi c^w,\ c^w \frac{\gamma^a}{\gamma^w}(d + \pi) + \ c^w d - \pi c^a\} \tag{6}$$

A characterization of equilibrium follows. For a clean statement of the proposition, I assume that $\pi c^a \leq \pi c^w$ and $\underline{x}^a \leq \underline{x}^w$. It should be clear how to revise the conclusions for the other cases, by substituting $\min\{\underline{x}^a, \underline{x}^w\}$ for $\underline{x}^a$, $\max\{\underline{x}^a, \underline{x}^w\}$ for $\underline{x}^w$, $\min\{\pi c^a, \pi c^w\}$ for πc^a, $\max\{\pi c^a, \pi c^w\}$ for πc^w.

Proposition 3 (Independent Choices: Existence and Characterization) *An equilibrium with independent choices exists, and must have the following properties: For* $\underline{x}^a, \underline{x}^w$ *and* f *defined in (5) and (6), the following is a complete characterization of equilibrium.*

(a) For each $x \in [0, \underline{x}^a)$, $P_a(x) = P_w(x) = 0$.

(b) For each $x \in [\underline{x}^a, \underline{x}^w)$, $P_a(x) = 1$, $P_w(x) = 0$.

(c) For each $x \in [\underline{x}^w, \pi c^a)$, *either* $(P_a(x) = 1, P_w(x) = 0)$ *or vice versa.*

(d) For each $x \in [\pi c^a, \pi c^w)$, $P_w(x) = 1$, $P_a(x) = 0$.

(e) For each $x \in [\pi c^w, f)$, $P_a(x) = P_w(x) = 0$.

(f) If $f \leq \pi(c^a + c^w)$, *for each* $x \in [f, \pi(c^a + c^w))$, *either* $P_a(x) = P_w(x) = 0$ *or* $P_a(x) = P_w(x) = 1$.

(g) For each $x > \pi(c^a + c^w)$, $P_a(x) = P_w(x) = 0$.

Public sponsors will provide the very low-cost subject matters described in part (a), since public expenditure is not very inefficient. Investments that are too costly to be protected by a single jurisdiction, but not costly enough to justify deadweight loss in two regions, will also be publicly sponsored (part (e)). And innovations with cost so high that not even protection in two regions can cover it will also be publicly sponsored (part (g)), provided the subject matter satisfies $x \leq \frac{c^i}{k}$.

Parts (b), (c) and (d) describe subject matters for which, in equilibrium, inventions might be protected in only one region, which is sufficient to cover the costs of invention. The other region can free-ride, benefitting from competitive supply of the innovations, and allowing its own innovators to cover their cost by selling at proprietary prices abroad. It is important to notice that there can be multiple equilibria in the region described by (c), where either region can be the one that unilaterally provides protection. There is no reason to think that, in equilibrium, the region providing unilateral protection will be the one that minimizes deadeweight loss. In (b) and (d), only

one region has an incentive to do so.

Proposition 3 points to multiple equilibria in at least two ways, resulting from coordination problems. First, for low-cost subject matters which only warrant protection in a single region, there may be an indeterminacy as to which region protects it. In the domain described by (c), either region may protect the subject matter, and the other has incentive not to. Further, for subject matters with cost large enough that unilateral protection is ineffective, there is a different coordination problem. If neither region is protecting the subject matter, unilateral action cannot break the impasse. The regions can get stuck in a situation where neither protects it, even though they might both be better off providing protection.

Before considering harmonization, I point out the ways in which indendent choices depart from the optimal choices described in Table I.

Proposition 4 [(In)efficiency of Equilibrium with Independent Choices] *An equilibrium with independent choices* (P_a, P_w) *has the following properties:*

(a) (Efficiency of unilateral protection) *If either region grants unilateral protection (e.g.,* $P_a(x) = 1, P_w(x) = 0$*), then unilateral protection is more efficient than public sponsorship. However it may hold that* $P_a(x) = 1, P_w(x) = 0$ *when* $P_a(x) = 0, P_w(x) = 1$ *would be more efficient.*

(b) (Efficiency of bilateral protection) *If both regions grant simultaneous protection* $(P_a(x) = P_w(x) = 1)$*, then bilateral protection is more efficient than public sponsorship, and unilateral protection would be ineffective.*

(c) (Too little protection) *If neither region grants protection* $(P_a(x) = P_w(x) = 0)$ *then it could nevertheless hold that either unilateral protection or bilateral protection would be more efficient than public sponsorship.*

Proof: (a) $P_a(x) = 1, P_w(x) = 0$ imply $D_a(x) \geq 0$, which implies $dc^a < (k-1)x$. However, by Proposition 3(c), if $x \leq \max\{\pi c^a, \pi c^w\}$, nothing guarantees that it is the market with smaller deadweight loss where protection is provided. (b) $P_a(x) = P_w(x) = 1$ imply that $\tilde{D}_a(x), \tilde{D}_w(x) \geq 0$, which jointly imply that $d(c^a + c^w) < (k-1)x$. By Proposition 3(a)-(d), if $x \leq \max\{\pi c^a, \pi c^w\}$, only one region will protect the subject matter, hence the hypothesis $P_a(x) = P_w(x) = 1$ implies that $x > \max\{\pi c^a, \pi c^w\}$, so that unilateral protection would be ineffective. (c) Nothing in Proposition 3 excludes that $x \leq \max\{\pi c^a, \pi c^w\}$, $D_a(x), D_w(x) < 0$ (so $P_a(x) = P_w(x) = 0$) and $dc^a < kx$. Nothing excludes that $x > \pi c^a, \pi c^w$, $\tilde{D}_a(x) < 0 < \tilde{D}_w(x)$, and $d(c^a + c^w) < (k-1)x$. $\square$

Regarding part (c), a region will resist unilateral protection, even when it would be efficient, because unilateral protection creates an outflow of profit from domestic consumers to foreign inventors. The outflow of profit is a transfer, which nets to zero in the global efficiency calculation, but is one of the regional policy maker's decision criteria.

Bilateral protection might also be stymied due to the transfers of profit. Each region both gives and receives transfers that, in aggregate, sum to zero. The domestic region pays profits to foreign inventors, and receives profits from foreign consumers. If bilateral protection is stymied, it is because one region would be a large net payer of profits, and the other would be a large net receiver of profits, and the discrepancy is large enough to overcome the cost advantages of private investment. Whether a region is a net payer or net receiver depends on the relative sizes of the markets, and on the regions' relative productivity, as remarked below.

We now turn to harmonization. Under a system of harmonized national treatment, the regions must agree on a common set of minimum protections.

Regions can increase their protections, but cannot reduce them. The regions' preferred harmonized policies – the ones they would lobby for – are not the same as the ones they would choose in an equilibrium with independent choices. This is because an increase in harmonized protection has a benefit for the region that a unilateral strengthening of protection does not; it supposes a reciprocal strengthening of protections abroad, which allows the region to collect additional profit.

In order to have a preference on whether the regions should harmonize on protecting a given subject matter, each region must have a prediction as to what would happen otherwise. What would happen is described in Proposition 3, since the independent choices for each x are independent of the choices for any other subject matter. Since, by Proposition 3, there can be multiple equilibria, the preferences about harmonization will reflect a specific anticipated alternative, say (P_a, P_w).

Again, to avoid notation, I will assume that $\pi c^a \leq \pi c^w$. Recall that we have assumed $\frac{c^a}{k}, \frac{c^w}{k} \geq \max\{\pi c^a, \pi c^w\}$.

Lemma 5 *Assume that $\pi c^a \leq \pi c^w$, and let (P_a, P_w) be an anticipated equilibrium with independent choices. Region a (symmetrically, w) prefers to harmonize on subject matter x if and only if $\tilde{D}_a(x) \geq 0$ and one of the following holds:*

(a) $x \geq \pi c^w$
(b) $x \in [0, \pi c^w)$ *and* $P_a(x) = 1$, $P_w(x) = 0$.
(c) $x \in [0, \pi c^w)$, $P_a(x) = P_w(x) = 0$.

Proof: (If) For any subject matter for which $\tilde{D}_a(x) \geq 0$, it may or may not be the case that $x \geq \frac{c^a}{k}$; that is, it may or may not be the case that the

alternative to harmonization is public sponsorship rather than no investment. However $\tilde{D}_a(x) \geq 0$ implies that region a prefers harmonized protection to either, provided the alternative is not unilateral protection by region w. The three circumstances (a), (b) and (c) eliminate that possibility.

(Only if) Region a prefers harmonization only if bilateral protection is better than public sponsorship ($\tilde{D}_a(x) \geq 0$) and unilateral protection in region w is not a viable alternative. These circumstances are eliminated by (a), (b), (c). □

Remark 6 *Assume that bilateral protection for subject matter x is efficient. If region a is sufficiently more innovative than w, or if the market in w is large enough (that is, if $\frac{\gamma^a}{\gamma^w}$ or c^w is sufficiently large), region a will favor harmonization on x, and region w will oppose it.*

The remark follows by considering

$$\begin{aligned} \frac{\tilde{D}_a(x)}{c^a\gamma^a} &= -(\frac{\gamma^w}{\gamma^a}+1)c^a d + \pi(c^w - c^a\frac{\gamma^w}{\gamma^a}) + (k-1)x \\ \frac{\tilde{D}_w(x)}{\gamma^a} &= -(\frac{\gamma^w}{\gamma^a}+1)c^w d - \pi(c^w - \frac{\gamma^w}{\gamma^a}c^a) + (k-1)\frac{\gamma^w}{\gamma^a}x. \end{aligned}$$

The efficiency of bilateral protection is equivalent to $\tilde{D}_a(x) + \tilde{D}_w(x) \geq 0$. But for either $\frac{\gamma^w}{\gamma^a}$ sufficiently small or c^w sufficiently large, $\tilde{D}_w(x) < 0$, which means that region w will oppose bilateral protection. It must therefore hold that $\tilde{D}_a(x) > 0$, which means that region a will favor it.

We now come to the question of whether harmonization strengthens protections over what would happen otherwise. An important implication of Lemma 5 is that the two regions will disagree sharply on subject matters which would otherwise be protected in only one region. Region a wants

to harmonize on subject matter that would otherwise only be protected in region a, and region w wants to harmonize on subject matter that would otherwise only be protected in region w. In general they will also disagree on some subject matters that require joint protection in order to be effective. But for many such subject matters, they will agree, in particular for any subject matter with cost greater than f defined in (6), since $x \geq f$ holds if and only if both $\tilde{D}_a(x) \geq 0$ and $\tilde{D}_w(f) \geq 0$.

We shall define a *most protective equilibrium* as one in which every subject matter $x \geq f$ is protected in an equilibrium with independent choices, and each subject matter with $x \leq \max\{\pi c^a, \pi c^w\}$ is protected by a single jurisdiction. In Proposition 7, when we say that the regions anticipate a particular equilibrium with independent choices, we mean with respect to those subject matters for which there has been no agreement to harmonize.

We can consider various rules for resolving disputes, each with the property that, if the regions agree on harmonization, they will implement their agreement.

(i) Nonprotectionist Rule: If the regions disagree on a particular subject matter, there will be no agreement to jointly protect it.

(ii) Protectionist Rule: If the regions disagree on a particular subject matter, there will be an agreement to jointly protect it.

(iii) Bargaining Solution: If the regions disagree on a particular subject matter it will be jointly protected with positive probability.

Proposition 7 (Comparison of Harmonization and Independent Choices) *If the regions anticipate any equilibrium other than the most protective one, then*

harmonization will lead to stronger intellectual property protection than an equilibrium with independent choices, under any of the disagreement rules (i), (ii) or (iii). The most protective equilibrium may have the same protections.

Proof: Consider first the Nonprotectionist Rule. Since subject matters with cost less than $\max\{\pi c^a, \pi c^w\}$ are never protected bilaterally in the equilibrium with independent choices, harmonization can only strengthen protections there. If there is no agreement to harmonize, then the same protections will arise as in the alternative equilibrium. However if the conditions of Lemma 5(c) hold and $\tilde{D}_a(x), \tilde{D}_w(x) \geq 0$ even though $P_a(x) = P_w(x) = 0$, harmonization may strengthen protections for such subject matters. Subject matters with cost greater than $\max\{\pi c^a, \pi c^w\}$ are either protected bilaterally or not at all in the alternative equilibrium. Referring to Proposition 3(f), if $P_a(x) = P_w(x) = 1$ for such a subject matter, then harmonization has no effect. But if $P_a(x) = P_w(x) = 0$, then harmonization strengthens protections. Under this rule, harmonization can increase protections because it can solve a coordination problem between the regions.

Since there can only be more protection under the Protectionist Rule and Bargaining Rule than under the Nonprotectionist Rule, harmonization can only increase protections. □

Proposition 8 (Welfare Effects of Harmonization) *When the alternative to intellectual property is public sponsorship, the welfare effects of harmonization are ambiguous:*
(a) Under the Nonprotectionist rule, the regions will never harmonize on a subject matter for which bilateral public sponsorship would be more efficient. Under the Protectionist rule and Bargaining Solution they may do so.
(b) Under any of the disagreement rules, harmonization can lead to bilateral protection where unilateral protection would be more efficient.

Proof: (a) If $\tilde{D}_a(x) \geq 0, \tilde{D}_w(x) \geq 0$, then $\frac{d(c^a+c^w)}{(k-1)} \leq x$, which means that bilateral protection is more efficient than bilateral public sponsorship. However the regions may disagree on harmonization where it would not be efficient, and then rules (ii) and (iii) may lead to inefficient harmonization.

(b) For subject matters in the domain $[0, \max\{\pi c^a, \pi c^w\}]$ harmonization is less efficient than unilateral protection, but may nevertheless occur if $\tilde{D}_a(x) \geq 0, \tilde{D}_w(x) \geq 0$, and $D_a(x) < 0, D_w(x) < 0$. $\square$

6 IP without Public Sponsorship

As mentioned in the introduction, most of the economics literature on patent incentives assumes that the alternative to private investment in R&D is no investment at all. This assumption may be wrong for two reasons: it does not reflect institutions, and it does not assume a benevolent government acting on behalf of its citizens. However, since it is the premise of most other investigations of intellectual property rights, I revisit the questions above, assuming there is no public sector for R&D.

The analysis of efficiency is much simpler when there are no public sponsors, since the only alternative to intellectual property is no investment in R&D. As to intellectual property, since profit is only part of the social benefit of invention, it is never efficient to stop firms from investing. At best they will invest up to cost $\pi(c^a + c^w)$ (since that is the maximum profit available in the global economy). Without a benevolent public sector, the main problem is that there will be too little investment, not that it will be funded in the wrong way. An inefficiency might also arise through bilateral protection where unilateral protection would suffice, as above.

We shall again consider strategies $P_a, P_w : R_+ \to \{0,1\}$. In order to analyize equilibrium, I will use functions W_a, W_w to represent the value to regions a and w respectively of providing unilateral protection as opposed to no protection, and $\tilde{W}_a, \tilde{W}_w$ to represent the value to regions a and w respectively of providing bilateral protection as opposed to no protection. If, for example, $W_a(x) > 0$, then region a as a whole would benefit from unilaterally providing intellectual property protection, but this is only true if, in fact, innovators can cover the cost x by patenting in region a, which requires in addition that $x \leq \pi c^a$.

$$\begin{array}{rcl} W_a(x) & = & mc^a(\gamma^a + \gamma^w) + \pi\gamma^a c^a - \gamma^a x \\ \tilde{W}_a(x) & = & mc^a(\gamma^a + \gamma^w) + \pi\gamma^a(c^a + c^w) - \gamma^a x \\ W_w(x) & = & mc^w(\gamma^w + \gamma^a) + \pi\gamma^w c^w - \gamma^w x \\ \tilde{W}_w(x) & = & mc^w(\gamma^w + \gamma^a) + \pi\gamma^w(c^w + c^a) - \gamma^w x \end{array}$$

First, consider independent choices. The objective function of region a (symmetrically, w) will be

$$\Omega_a(P_a(x); P_w(x)) = \begin{array}{ll} P_a(x) \times W_a(x) & \text{if } P_w(x) = 0,\ x \leq \pi c^a \\ P_a(x) \times 0 & \text{if } P_w(x) = 0,\ x > \pi c^a \\ P_a(x) & \text{if } P_w(x) = 1,\ x \leq \pi c^w \\ \times\ [-c^a\gamma^a d - c^a\gamma^w(d+\pi)] & \\ P_a(x) \times \tilde{W}_a(x) & \text{if } P_w(x) = 1, \\ & \pi(c^a + c^w) \geq x > \pi c^w \end{array}$$

An *equilibrium with independent choices* (in the absence of public sponsors) is a pair (P_a, P_w) such that at each $x \in [0, \infty]$, $P_a(x) \in \arg\max\{\Omega_a(P_a; P_w(x)) | P_a \in \{0,1\}\}$ and $P_w(x) \in \arg\max\{\Omega_w(P_w; P_a(x)) | P_w \in \{0,1\}\}$. We again adopt the convention that if the region is indifferent between providing protection or not, it chooses $P_i(x) = 0$ (does not provide protection).

Equilibrium strategies have some obvious features. For any subject matter with $x \in [0, \min\{\pi c^a, \pi c^w\})$, the best response of either region to protec-

tion by the other region is not to protect it. This is because protection in a single region is enough to ensure innovation. The nonprotective region prefers to free-ride, and avoid the deadweight loss of providing additional protection. On the other hand, the best response to the absence of protection by the other region is protection, in order to ensure that the innovation is undertaken. Thus, one region will protect each subject matter $x \in [0, \min\{\pi c^a, \pi c^w\})$, but not both, and it may be indeterminate which region it will be. Subject matter in the interval $[\min\{\pi c^a, \pi c^w\}, \max\{\pi c^a, \pi c^w\})$ will be protected by the region that provides the maximum profit. (In the domain $x \in [0, \max\{\pi c^a, \pi c^w\})$, either $W_a(x) \geq 0$ or $W_w(x) \geq 0$ or both.)

Second, $\tilde{W}_a(x), \tilde{W}_w(x) \geq 0$ for every subject matter $x \in [\max\{\pi c^a, \pi c^w\}, \pi(c^a + c^w))$. There are two equilibria for each subject matter in this domain: $P_a(x) = P_w(x) = 0$ and $P_a(x) = P_w(x) = 1$. If the other region does not protect, then there is no incentive to protect. Unilateral protection is ineffective, since inventors could not cover their costs. However, if either region protects the subject matter, then the protection will be reciprocated. Reciprocity is required for innovation, and innovation enhances welfare in each region.

Proposition 9 (Independent Choices: Existence and Characterization of Equilibrium) *If public sponsorship is impossible, so that the alternative to intellectual property is no innovation, then an equilibrium with independent choices exists and must have the following properties:*

(a) For every subject matter $x \in [0, \min\{\pi c^a, \pi c^w\})$ *either* $P_a(x) = 1$, $P^w(x) = 0$ *or vice versa.*

(b) For every subject matter $x \in [\min\{\pi c^a, \pi c^w\}, \max\{\pi c^a, \pi c^w\})$, $P_a(x) = 1, P_w(x) = 0$ *if* $\pi c^a > \pi c^w$ *and vice versa otherwise.*

(c) For every subject matter $x \in [\max\{\pi c^a, \pi c^w\}, \pi(c^a + c^w)]$, *either* $P_a(x) = P_w(x) = 0$ *or* $P_a(x) = P_w(x) = 1$.

(d) For every subject matter $x > \pi(c^a + c^w)$, $P_a(x) = P_w(x) = 0$.

This shows that, again, the regions' preferences for harmonization will depend on the alternative equilibrium (P_a, P_w).

Proposition 10 [Harmonization] *Let* (P_a, P_w) *be an anticipated equilibrium with independent choices, assuming that the alternative to intellectual property is no innovation. Region a (symmetrically, w) prefers to harmonize on subject matter* x *if and only if one of the following holds:*
(a) $x \in [\max\{\pi c^a, \pi c^w\}), \pi(c^a + c^w\}))$.
(b) $x \in [0, \max\{\pi c^a, \pi c^w\}))$ *and* $P_a(x) = 1$, $P_w(x) = 0$.

Proof: (If) In case (a), harmonized protection is required for investment, and $\tilde{W}_a(x) \geq 0$. In case (b), the alternative to harmonized protection is unilateral protection by one region or the other. If region w provides the protection, region a can free-ride and does not want to harmonize. If the protection will be provided by region a, then a would prefer bilateral protection in order to recoup some of its costs by earning proprietary profit abroad $(\tilde{W}_a(x) > W_a(x))$.

(Only If) If (a) does not hold and (b) does not hold, then $x \in [0, \max\{\pi c^a, \pi c^w\}))$ and $P_a(x) = 0$, $P_w(x) = 1$ (since the other cases are excluded by Proposition 9). But then a does not prefer harmonization, since it can free ride on w. □

As when the alternative to intellectual property is public sponsorship, at most one region will protect the relatively low-cost inventions, and the regions

will have opposed incentives as to harmonization on those subject matters. Their incentives are more aligned for high-cost inventions, for which bilateral protection is necessary to be effective.

As before, define a *most protective equilibrium* as one, without public sponsors, in which every subject matter $x \in [\max\{\pi c^a, \pi c^w\}, \pi(c^a + c^w)]$ is protected in both jurisdictions, and each subject matter with $x \in [0, \max\{\pi c^a, \pi c^w\}]$ is protected by a single jurisdiction. In Proposition 11, when we say that the regions anticipate a particular equilibrium with independent choices, we again mean with respect to those subject matters for which there has been no agreement to harmonize.

We can consider the same three rules for resolving disputes that are mentioned above: the Nonprotectionist Rule, the Protectionist Rule and the Bargaining Solution. The following proposition is again somewhat obvious, but I record it for completeness.

Proposition 11 (Comparison of Independent and Harmonized Choices) *Suppose that there is no public R&D sector. Then harmonized protections will extend to more subject matter than independently chosen protections, except possibly in the most protective equilibrium.*

7 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, and (in this paper) against alternative ways to fund R&D, such as public sponsorship. 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 uncompensated externalities among countries.

In a purely domestic calculation, introducing public sponsorship as a viable alternative to intellectual property would reduce reliance on private incentives as a source of R&D. This effect is muted in the international arena, where the benefits to foreigners of domestically sponsored R&D cannot be recouped through proprietary pricing. In contrast, intellectual property allows some of the benefits to be repatriated.

These arguments suggest that policy makers in a trade context will be more in favor of intellectual property than domestic interests would otherwise warrant. However there is an offsetting difficulty. There is a coordination problem in setting intellectual property policy. Some subject matters are costly enough, especially in a trading context with many small nations, that only multilateral protection of the subject matter is effective. A situation could arise where no country protects a subject matter because no other country protects it. Such subject matters would therefore have to be supported by public sponsors, whether or not that public sponsorship is more efficient than private incentives. Negotiations to harmonize intellectual property protection can solve this coordination problem.

On the other hand, harmonization can lead to multilateral protections where unilateral protections would suffice. For some subject matters, costs are low enough that protection in a single country, usually a large market, is enough to support private innovations, including private innovation in countries that do not protect the subject matter. Even though it may be efficient, the asymmetry creates international tension.

One of the main points illuminated here is that, although harmonization can increase private investment in R&D in order to collect profit in foreign markets, it does not similarly stimulate the public sector. For subject matters not entrusted to the private sector, there may be too little R&D investment. If the only remedy is harmonization on intellectual property rights, then we would expect to see an expansion in intellectual property rights. However a better remedy might be international agreements on public spending. But although there are institutions to negotiate and implement harmonized intellectual property policies, there are no institutions to coordinate public spending to be put in the public domain.

References

[1] Aoki, R. and T. J. Prusa (1993), "International Standards for Intellectual Property Rights and R&D Incentives", *Journal of International Economics* 35, 251-273.

[2] Deardorff, Alan (1992), "Welfare Effects of Global Patent Protection," *Economica* 59, 35-51.

[3] Bagwell, Kyle and Robert W. Staiger, (1999), "An Economic Theory of GATT", *American Economic Review* 89, 215-248.

[4] Chin, Judith and GEne Grossman (1990),m "Intellectual Property Rights and North-South Trade", in Ronald W. Jones and Anne O. Krueger (eds.) *The Political Economy of International Trade: Essays in Honor Robert E. Baldwin*, 90-107, Cambridge, MA: Basil Blackwell.

[5] Dixit, Avinash, Gene M. Grossman and Elhanan Helpman, (1997), "Common Agency and Coordination: General Theory and Application to Government Policy Making", *Journal of Political Economy* 105, 752-69.

[6] Gallini, Nancy and Suzanne Scotchmer (2001), "Intellectual Property: When is it the Best Incentive Mechanism?", *Innovation Policy and the Economy*, Vol 2, Adam Jaffe, Joshua Lerner and Scott Stern, MIT Press, 51-78

[7] Grossman, G. and E. Lai (2001), "International Protection of Intellectual Property", October 2001, mimeograph (Princeton University and City University of Hong Kong).

[8] Guzman, Andrew T. (2001), "Antitrust and International Regulatory Federalism", *New York University Law Review* 76(4), 1142-1163.

[9] Guzman, Andrew T. (1998), "Is International Antitrust Possible?", *New York University Law Review* 73(5), 1501-1548.

[10] Hall, Bronwyn H., (2001), "The Global Nature of Intellectual Property: Discussion", conference paper, "Intellectual Property and Innovation in the Knowledge Based Economy", Industry Canada, May 2001.

[11] Helpman, Elhanan, (1993), "Innovation, Imitation and Intellectual Property Rights", *Econometrica* 30, 27-47.

[12] Krueger, Anne O. (2000), "NAFTA's Effects: A Preliminary Assessment," *The World Economy: The Americas Edition 2000* 23: 761-776.

[13] Lai, Edwin L.-C. and Larry D. Qiu, (2001) "The North's Intellectual Property Standard for the South?" forthcoming *Journal of International Economics.*

[14] Lanjouw, Jean O. and Iain M. Cockburn, (2000) "New Pills for Poor People? Evidence After GATT", mimeograph, Yale University, Department of Economics

[15] Maskus, Keith (1998), "The International Regulation of Intellectual Property," *Weltwirtschaftliches Archiv* 134: 186-208.

[16] Maskus, Keith, (2001) "Canadian Patent Policy in the North American Context", conference paper, "Intellectual Property and Innovation in the Knowledge Based Economy", Industry Canada, May 2001.

[17] Maskus, Keith (2001), "Lessons from Studying the International Economics of Intellectual Property Rights", Vanderbilt Law Review.

[18] Maskus, Keith, (2000a), *Intellectual Property Rights in the Global Economy*, (Washington, DC: Institute for International Economics).

[19] Maskus, Keith, (2000b) "Lessons from Studying the International Economics of Intellectual Property Rights," *Vanderbilt University Law Review*, Vol. 53, no. 6, 2219-2240.

[20] Merges, Robert, (1992), *Patent Law and Policy: Cases and Materials*, The Michie Company, Law Publishers (Charlottesville, VA).

[21] Kang, Moonsung, (2000), "Patent Protection and Strategic Trade Policy," KIEP Working Paper 00-07, Korea Institute for International Economic Policy

[22] Kang, Moonsung, (2000), "Patent Infringement and Strategic Trade Policies: R&D and Export Subsidies", KIEP Working Paper 00-09, Korea Institute for International Economic Policy

[23] Mossinghoff, Gerald J., "National Obligations under Intellectual Property Treaties: The Beginning of a True International Regime", conference paper, *International Judges Conferences,* U.S. Court of Appeals for the Federal Circuit, Washington, D.C., October 1999.

[24] National Science Foundation, Science and Engineering Indicators 2000, ww.nsf.gov/sbe/srs/seind00/frames.htm

[25] Reichman, J. H. (1997), "From Free Riders to Fair Folowers: Global Competition under the Trips Agreement", *International Law and Politics* 29, 11-93.

[26] Samuelson, Pamela, (1999), "Challenges for the World Intellectual Property Organization and the Trade-related Aspects of Intellectual Property Rights Council in Regulating Intellectual Property Rights in the Information Age", E.I.P.R. 11, 578-591.

[27] Scotchmer, Suzanne (2001), "The Political Economy of Intellectual Property Treaties", IBER Working Paper E01-305 (August), U.C., Berkeley.

[28] Spencer, B. J. and J. B. Brander (1983), "International R&D rivalry and industrial strategy", *Review of Economic Studies* 50, 707-722.

[29] Watal, Jayashree (1998), "The Trips Agreement and Developing Countries–Strong, Weak or Balanced Protection", *The Journal of World Intellectual Property* 1, 281-307.