The Political Economy of Intellectual Property Treaties

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Intellectual property treaties create two types of obligations: for national treatment of foreign inventors and for certain harmonized protections. I investigate both the incentive to join such treaties and the incentive to harmonize. As compared to an equilibrium in which the countries' policy makers make independent choices, harmonization will generally strengthen protections. This analysis recognizes that public sponsorship is sometimes an efficient alternative to intellectual property. However, there are no institutions to harmonize public spending, and there are no international mechanisms to repatriate the spillovers it generates. As a consequence, there may be too little public sponsorship and too much intellectual property. A country's inclination to strengthen harmonized protections will depend both on its innovativeness (positively) and on the size of its domestic market (negatively).

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.

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It has been widely argued that the recent expansion of intellectual property rights under the treaty on Trade-Related Aspects of Intellectual Property Rights (TRIPS) has extended intellectual property rights beyond what is optimal. Some commentators (e.g., Hall, 2001; Lanjouw and Cockburn, 2001) have suggested that this is because trade negotiators are "captured" by industry. Capture is undoubtedly an important phenomenon, but I argue that intellectual property policies can become overprotective even if trade policy negotiators are equally concerned with all domestic interests, those of both consumers and producers. This is because intellectual property is a tool by which cross-border externalities can be recaptured by the innovating country. McCalman (2001) estimates that the TRIPS provisions would have increased the revenues available to holders of U.S. patents issued in 1988 by $4.5 billion, in 1988 dollars. Of course, the domestic interests of countries' innovators must be balanced against the interests of domestic 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.

Two important provisions of IP treaties are "national treatment of foreign inventors" and "harmonization." "National treatment" means that within each country, foreign inventors cannot receive worse treatment than domestic inventors. In Section 2, I give a cursory overview of how national treatment and harmonization have evolved by treaty. Prior to the treaties of the 1880s, national treatment, if provided, had no requirement of reciprocity. I argue in Section 3 how this would be a serious impediment to the globalization of intellectual property rights. Without a requirement of reciprocity, there is little incentive for countries to grant national treatment to foreigners. If a country is the recipient of such a benevolent practice abroad, it may nevertheless be better off free riding on that practice, rather than reciprocating. However, if the benevolence of the foreign jurisdiction will only be extended on condition of reciprocity, there is a profit motive to grant national treatment. Small countries may join a treaty in order to gain the privilege of proprietary pricing in large foreign markets, even though they give up the privilege of free riding on foreign inventions.

But even assuming that countries participate in a global treaty for national treatment, there remains the confusing issue of what types of innovations will be protected. National treatment does not speak to the question of what will be protected, but only asserts that whatever protections are provided to domestic inventors will also be extended to foreign inventors. "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.

If we conclude that intellectual property rights chosen in an international context are more extensive or less extensive than optimal, we must be precise about what is optimal. This is discussed in Section 4. An important aspect is, IP as compared to what? There are two lines of thought

about this. The older literature, which follows Nordhaus (1969), sees the alternative to IP as a dearth of innovation. It is argued that, without sufficient IP rights, innovation will be stifled, and consumers will be deprived of innovations. The newer literature, discussed, for example, by Gallini and Scotchmer (2002) and Maurer and Scotchmer (2004), 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 Sections 5–7, 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. Among my conclusions are the following, some of which are obvious once the issues are framed, and some of which, such as the penultimate one, are more subtle:

- 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 everywhere.
- With national treatment, there will be less public funding and more intellectual property than efficient, because public sponsors (unlike private firms with IP incentives) have no means to repatriate cross-border spillovers.
- Harmonization will typically lead to more extensive intellectual property rights than independent choices do and may lead to more extensive intellectual property rights than are optimal, even in the absence of "capture."
- Holding "innovativeness" constant, small countries will favor more extensive intellectual property rights than large countries.
- Holding "market size" constant, more innovative countries will favor more extensive intellectual property rights than less innovative countries.

My focus on public sponsorship as an alternative to private incentives is a departure from the other economics literature in this area, for example, the articles cited below. I view this departure as appropriate both because it agrees with the modern economics view of incentive systems, and because public sponsorship of research and development (R&D) is, in fact, huge. The Organization for Economic Cooperation and Development (OECD) (2002) reports that in 2000, only 56% of R&D spending in the European Union was by industry. The industrial share is higher in the United States, about 68%, still a considerable departure from 100%. In Latin America, public sponsorship tends to be dominant. In 1996, industry funded only 40% of R&D in Brazil, 28% in Argentina, and less than 20% in Chile, Costa Rica, and Mexico (National Science Foundation, 2000). An area where R&D investment has been mostly public, at least prior to the era of

bioengineering, is agriculture. In his presidential address to the Australian Agricultural Economics Association, Alston (2002) summarizes evidence that more than half of international agricultural productivity growth has been generated by spillovers. Intellectual property is alluring in such a context, since it creates a mechanism by which countries can recover some of the spillover benefits as profit.

There are close parallels between treaty making for intellectual property and extraterritoriality issues in competition policy [see, in particular, Guzman (1998, 2001)]. Domestic policy makers 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 the ones that arise from independent 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 article is also the premise here: The policy of each country creates uncompensated externalities abroad, which might be remedied by treaty. 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 the TRIPS negotiations and their consequences, see, for example, Reichman (1997) and Watal (1998).

Finally, there is a literature on the "north/south" problem, which considers patent life as a regulatory instrument to encourage investment, especially in an environment with asymmetric innovative capacities. See, in particular, Chin and Grossman (1990), Diwan and Rodrik (1991), Deardorff (1992), Helpman (1993) and Lai and Qiu (forthcoming). Of particular interest is the article by Grossman and Lai (2001), who discuss length of protection rather than subject matter, and do not consider the balance between intellectual property and public funding. In their model it is also true that stronger protection is more attractive to smaller or more innovative countries. Another related article is Aoki and Prusa (1993), who discuss the profitability and efficiency of asymmetric enforcement activities against potential infringers.

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 well over 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.

Membership in the Berne and Paris Conventions requires that a country provide national treatment to inventors in other member countries, and permits its own inventors to receive national treatment in return. The principle of national treatment has occasionally been extended beyond the subject matters covered by the treaties, and in those cases, reciprocity has sometimes been made an explicit condition for protecting foreign inventors. When the United States enacted the Semiconductor Chip Protection Act of 1984, the protection of foreign inventors was made conditional on the passage of similar legislation in their own countries. In 1996 the European Union enacted a Directive on Databases, which instructs the member states to protect databases beyond the protection already afforded by copyright law. The directive has a preamble denying national treatment to nonmember states (presumably, the United States) unless they also enact such legislation. These conditions make it clear that reciprocity is an important provision. Without reciprocity, it will generally not be in the interest of any country to give foreign inventors the same intellectual property privileges as national inventors.

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 only weak enforcement powers. Better enforcement provisions were introduced in the Agreement on Trade-Related Aspects of Intellectual Property (TRIPS), as administered by the World Trade Organization (WTO) [see, generally, Samuelson (1999)].

The principle of national treatment specifies that foreign inventors will be protected as strongly as national inventors, but does not require that all countries have the same protections. The North American Free Trade Agreement (NAFTA), implemented in 1994, not only extended national treatment to all intellectual property on the North American continent, but goes some distance toward harmonizing protections. However, it does not go as far as TRIPS, also signed in 1994. TRIPS has specific provisions for protecting bioengineered microorganisms, pharmaceuticals, computer software, and databases, and stipulates minimum durations of protection. Disputes are brought before the WTO, which is authorized to carry out very specific enforcement actions that are widely thought to have teeth.

United States history itself is informative about the economics and politics of IP treaties. The constitutional convention of 1789 was an early instance where a fragmented 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 instead of trying to maintain autonomy. The United States did not join the Berne Convention for reciprocal copyright protection until 1989 because certain aspects of its substantive and procedural policies were in conflict

with U.S. policies. The United States joined in 1989 because it had become a major exporter of copyrighted works and wanted both protection abroad and a voice in international policy making. Before that, in the 1950s, the United States 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 United States 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 strengthening of protections abroad under NAFTA and TRIPS is aligned with American commercial interests, and largely follow the American model.

3. The Incentive to Provide National Treatment to Foreign Inventors

Suppose there are two countries, a and 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 discounted consumers' surplus per innovation, assuming perfect competition, and let $c^i m$ be the aggregate consumers' surplus per innovation, assuming that the product is sold by a monopolist for part of its life. Let $c^i \pi$ and $c^i d$ 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 will index "subject matter" by its R&D cost, say $x \in [0, \infty]$. Let x and kx be the costs if undertaken by the private and public sectors, respectively, where $k > 1$. Potential innovations are ordered so that the cost advantage of the private sector, $(k-1)x$, is increasing in x. There are many reasons why innovation may be more costly to public sponsors, including the contracting difficulties of finding the most efficient firms and ensuring that public funds are used responsibly, and the restrictions placed on public employers due to equity and other policy concerns. The cost premium also reflects the deadweight loss of taxing for general revenue. In the analysis below, the choice between intellectual property incentives and public sponsorship is largely a trade-off between the costliness of raising funds to pay for sponsored research and the deadweight loss of proprietary pricing.

The most important aspect of this setup is that both public sponsors and private investors have deficient incentives to invest, relative to what is efficient. Both confer uncompensated externalities abroad. Reciprocal national treatment, which allows inventors to earn profit abroad, causes domestic inventors and domestic policy makers to account at least partially for cross-border spillovers. There is no analogous institution for making public sponsors account for cross-border spillovers, and this

asymmetry will drive many of the conclusions below. To be more precise, reciprocal national treatment allows innovators in both countries to profit in the amount of $\pi(c^a + c^w)$ from an innovation, and thus to invest if $x < \pi(c^a + c^w)$, instead of, for example, $x < \pi c^a$. There is no analogous policy that will incite public sponsorship if $kx \leq (c^a + c^w)$ instead of $kx < c^a$.

In this environment, each country faces two decisions: whether to grant national treatment to foreign inventors, usually accomplished through membership in a treaty, and how strong its protections will be. The strength of protection may include all the usual policy levers, like length, breadth, exemptions, and the required inventive step, but here we shall focus on the aspect that was of most concern in the TRIPS negotiation, namely, which subject matters will be protected at all.

In the previous section we pointed out that intellectual property treaties entail reciprocity. Inventors in member states receive intellectual property protection abroad, but consumers in member states must pay proprietary prices for foreign inventions. A member state cannot have one without the other. We now point out why national treatment would otherwise not be very extensively provided.

If country *a* grants national treatment without reciprocity, then inventors in country *w* will take advantage of the profit opportunities in country *a*. Innovations in *w*, which would otherwise be provided in country *a* at competitive prices, will become proprietary in *a*. Country *a* will experience an outflow of profit and deadweight loss. The only reason that country *a* might grant national treatment in the face of these losses is that its own market might engender a very large increase in total innovation in country *w*, and the value of these increased innovations would outweigh the fact that each innovation is of less value to residents of *a*. It is only if country *a* has a very large market that this could possibly be the case. It will not be in the interest of a small country to grant national treatment unilaterally. Moser (2003) shows how small countries like Switzerland and Denmark built industrial strength by free-riding on foreign inventions in the nineteenth century.

However, a small country might be more receptive if national treatment will be reciprocal. With reciprocity, the small country gains the right to earn proprietary profit in a large foreign market. That opportunity may outweigh its own outflow of profit and increased deadweight loss.

A treaty for national treatment will only come into existence if it creates net benefits for all the members. These net benefits cannot be created only by profit flows, which sum to zero in aggregate. In fact, if there is no increase in innovation, a treaty for national treatment will hurt at least one member, since the net effect is only to increase aggregate deadweight loss. In order to benefit all the members, treaties for national treatment must result in a real efficiency gain, such as increased innovation. Thus the main impetus for forming IP treaties is to stimulate innovation. Treaties

will only form if the additional stimulus to innovation outweighs the increase in aggregate deadweight loss that arises when protections are extended across borders.

4. Global Efficiency

My objective in the remainder of this article is to understand, within the framework of reciprocal national treatment, whether the harmonization efforts undertaken in the TRIPS negotiation were efficiency enhancing. To that end, we must first have a concept of efficiency.

Two questions addressed by the TRIPS negotiators were the appropriate length of global (harmonized) protections and the subject matters that would be protected. This article focuses on subject matter, which was more controversial and resulted in more fundamental changes than the changes to length. The analysis here focuses on general-purpose protections like patents and copyrights, for which "one size fits all" within a large class of subject matters. The strength of protection is not tailored to the average cost of innovation within each subject matter. As a consequence, the global protections that are optimal for one subject matter may not be optimal for another. The question addressed here is whether an equilibrium among nations will differentiate the treatment of subject matter in a way that is efficient, and to the extent that it does not, whether harmonization will redress the inefficiencies.[1]

The efficiency analysis has three considerations: which investments should be undertaken at all, whether they should be funded under private incentives or public sponsorship, and if private, where the subject matter should be protected. I will say that the system of intellectual property protection and public sponsorship is *efficient* if it maximizes worldwide consumers' surplus without regard to distribution. This is a definition that intentionally ignores the conflicts that arise due to uncompensated externalities. Those conflicts lead to a discrepancy between the outcome of a treaty negotiation and the system of intellectual property rights that would be efficient if nations could make side payments to internalize externalities. I have chosen a definition of efficiency that allows me to illuminate that discrepancy.

Before characterizing the efficient intellectual property regime, I point out a serious limitation of global rights. Suppose that for some subject matter, protection in any one of the large markets, the United States, Europe, or Japan, is enough to compensate an inventor, regardless of where the inventor is domiciled. Then, for such subject matter, a natural and unwasteful system would be domestic, but not foreign, protection. That is, each inventor would be protected in his own jurisdiction, but not elsewhere. Such a system would create reciprocal externalities in the sense that American consumers would get a competitive supply of European

1. A consideration avoided by this model is that the ratio of profit to deadweight loss may differ in a and w. See Scotchmer (forthcoming) chapters 4 and 11.

inventions and vice versa, but would pay proprietary prices for their own domestic inventions. Globalizing the protection of each invention would be inefficient in the sense that it would impose deadweight loss without (by hypothesis) calling forth new inventions.

Such a system of domestic rights is impossible under a treaty that provides for national treatment. If the United States protects bioengineered organisms for U.S. bioengineers, then it gives the same protection to European bioengineers. With national treatment, the only way to limit protection to a single market is for one jurisdiction, say the United States, to protect *all* bioengineering, regardless of where the bioengineer is domiciled, and for other jurisdictions to grant *no* protection. However, that system is very asymmetric. All the deadweight loss is borne by consumers in the protective jurisdiction (e.g., the United States) and none in the unprotective jurisdictions (e.g., Europe), regardless of where the inventions originate (the United States or Europe). Uncompensated externalities will lead to conflict. The United States is likely to favor a system of global protection rather than unilateral protection, because it allows repatriation of some of the external benefits.

The efficient IP regime is described in Tables 1 and 2. It is important to realize that the considerations in Tables 1 and 2 will not be reflected in any policy-maker's objective function. For example, from a global perspective, public sponsorship is more efficient than IP whenever $x < \frac{1}{k-1} d(c^a + c^w)$, which means that the cost premium of the public sponsorship is smaller than the deadweight loss of intellectual property. But this efficiency criterion will not be a decision criterion of either country.

Table 1. Global Efficiency with Equal Size Markets

Subject matter (cost)	Intellectual property?
$x \in [0, \frac{dc}{(k-1)})$	Public sponsorship in both countries
$x \in [\frac{dc}{(k-1)}, \pi c)$	IP in only one country
$x \in [\pi c, \frac{2dc}{(k-1)})$	Public sponsorship in both countries
$x \in [\frac{2dc}{(k-1)}, 2\pi c)$	IP in both countries
$x \in [2\pi c, \frac{2c}{k})$	Public sponsorship in both countries

Table 2. Global Efficiency with Unequal Markets

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*
$x \in [\pi c^a, \pi c^w)$	IP in *w*
$x \in [\pi c^w, \frac{d(c^a+c^w)}{(k-1)})$	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*

Table 1 describes the efficient regime when the two countries are symmetric, in the sense that they have the same-size markets ($c = c^a = c^w$). For the asymmetric case, we will assume without loss of generality (since the indices can be reversed) that $c^a < c^w$ (the world market is larger than country a's market), so that $\frac{dc^a}{(k-1)} < \frac{dc^w}{(k-1)}$ and $\pi c^a < \pi c^w < \pi(c^a + c^w)$.

We will say that *unilateral protection in country* a *is effective* (symmetrically for w) for a given subject matter x if $x \leq \pi c^a$. We will say that bilateral protection is effective for a given subject matter x if $x \leq \pi(c^a + c^w)$.

We say that *unilateral protection in country* a *is efficient* (symmetrically for w) for a subject matter x if (a) it is effective, (b) either $c^a < c^w$ or $c^w < c^a$ and protection in w is not effective, and (c) $\frac{1}{k-1} dc^a < x$. Condition (c) implies that the deadweight loss of proprietary pricing is less than the cost premium of public sponsorship.

We say that *bilateral protection is efficient* for a subject matter x if (a) it is effective, (b) unilateral protection is not effective in either country, and (c) $\frac{1}{k-1} d(c^a + c^w) < x$. Condition (c) again implies that the deadweight loss of proprietary pricing is less than the cost premium of public sponsorship. However, the deadweight loss is in both markets. If Condition (c) does not hold, then public sponsorship is efficient rather than IP.

To account for the fact that public sponsorship may not be provided when efficient, we define a notion of when public sponsorship will be provided, and a notion of second-best efficiency for IP. Second-best efficiency describes the regime of IP protections that are efficient in the absence of public sponsorship. It is "second best" when the first-best regime would be public sponsorship, but public sponsors will not provide funding.

We say that, in the absence of effective IP rights, *public sponsorship will be provided* in country a (symmetrically, w) for a subject matter x if $kx < c^a$. This definition recognizes that public sponsors respond only to domestic incentives and ignore cross-border spillovers. I assume that they only fund R&D if IP protection is not effective.

We will say that *unilateral protection in country* a *is second-best efficient* (symmetrically for w) for a subject matter x if (a) it is effective, (b) it is not efficient (public sponsorship would be better), and (c) either $c^a < c^w$ or protection in w is not effective. We say that *bilateral protection is second-best efficient* for a subject matter x if (a) it is effective, (b) it is not efficient (public sponsorship would be better), and (c) unilateral protection is not effective in either country.

As in the symmetric case, an efficient regime may entail IP in only a single country, in particular, for the less costly innovations. If so, IP should be granted in the smallest market where protection is effective. Innovations that are more costly may require bilateral protection.

In Table 1, we assume that $\frac{1}{k-1} dc^a$, $\frac{1}{k-1} dc^w < \pi c^a < \pi c^w$, and $\frac{1}{k-1} d(c^a + c^w) < \pi(c^a + c^w)$. The latter implies, for example, that there are subject matters x for which bilateral protection rather than sponsorship is efficient, namely, those for which $\frac{1}{k-1} d(c^a + c^w) < x < \pi(c^a + c^w)$.

If $\pi(c^a + c^w) < \frac{1}{k-1} d(c^a + c^w)$, then there are no subject matters for which bilateral protection is efficient. If the efficiency criterion $\frac{1}{k-1} d(c^a + c^w) < x$ is satisfied, then costs are so high that proprietary pricing cannot cover costs, even in both countries.

Both tables show that three types of subject matter should be publicly sponsored: (1) innovations whose cost is relatively low, so that the cost efficiency of the private sector does not outweigh the deadweight loss even in the smallest 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. See Figure 1, where the shaded areas of the top panel represent the subject matters that should be publicly sponsored. The

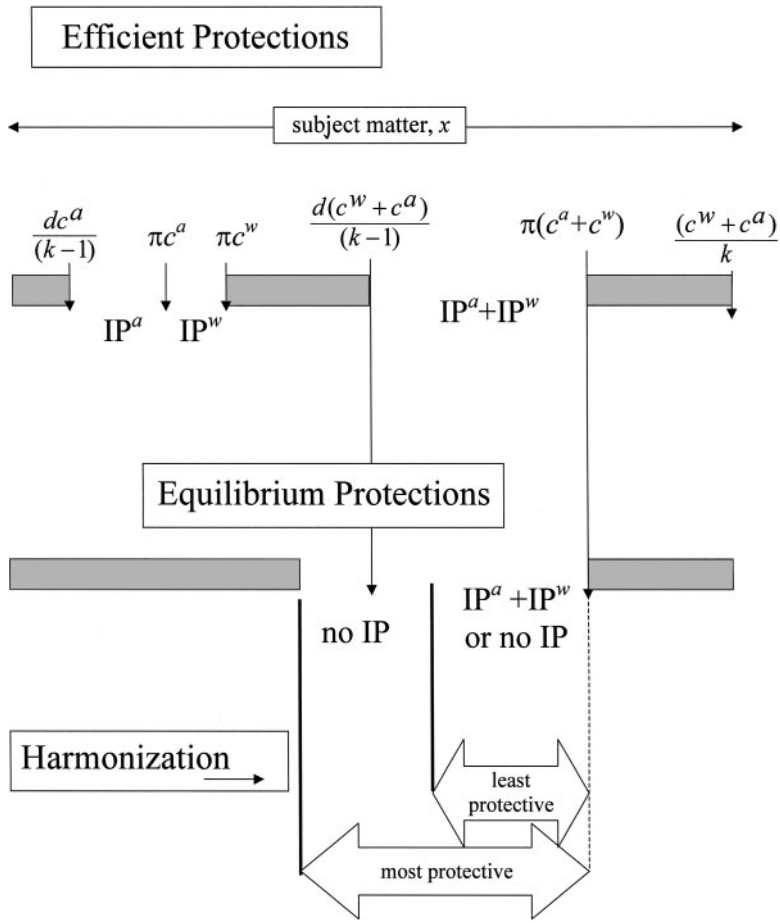

Figure 1. Different market sizes: efficiency, equilibrium and harmonization.

horizontal dimension indexes the cost, x. The subject matters x that are not shaded should be protected with IP, either in country a, designated IP^a, or country w, designated IP^w, or in both, designated $IP^a + IP^w$.

Two issues that are ignored in Tables 1 and 2 become key in the equilibrium analysis below. First is the problem that public sponsorship may not be provided, even if efficient, due to the fact that public sponsors are only concerned with domestic welfare. Second is the distributional issue. Neither country is keen to be the sole provider of intellectual property rights, because their consumers bear all the deadweight loss, as well as an outflow of profit, while their innovators and public sponsors confer uncompensated externalities on the other country. A country would always want to have its own IP reciprocated abroad, so that it can recoup as profit part of the externality it confers. In fact, if $k < 2$, there is no equilibrium in which a single country protects any subject matter. (That is the case depicted in Figure 1.)

5. Equilibrium Choices of IP: The Symmetric Case

We now investigate whether an IP policy such as the one in Table 1 will be implemented. We use the symmetric case, $c^a = c^w$, to reveal several of the reasons that equilibrium will not generally be efficient. First, for subject matters that could efficiently be protected in a single country, the country may not provide protection due to asymmetric profit flows. Second, when public sponsorship is efficient, it may not be provided because public sponsors do not take account of cross-border externalities. Since bilateral IP partly internalizes the cross-border externalities, IP may be used instead. Third, there is a coordination problem. For subject matters that require bilateral protection, there are two equilibria, one in which the subject matter is protected, and another in which it is not.

Country a's willingness to provide IP rights for a given subject matter with cost x will depend on whether country w also provides such rights. If it does, then rights in w may be sufficient to cover the costs of innovation in country a as well as w, and country a has no incentive to increase the incentive still further. This is the best possible situation for a. When the country w offers IP rights for a given subject matter, country a would only offer such rights if

1. protection in both markets is necessary to cover the costs of innovation, and
2. country a is better off with IP than public sponsorship, when it takes account of the cost efficiency as well as profit flows and local deadweight loss.

But this observation suggests a second type of coordination problem. If the revenue in either market would be sufficient to cover cost, there are two equilibria. In one equilibrium, country a protects the subject matter, but country w does not, and in the other equilibrium, it is the other way

around. In the asymmetric case discussed below, there is no guarantee that the efficient outcome will be implemented. It may be in the larger market where the subject matter receives protection, even though the smaller market would suffice.

Of course, each country would like to be in the favored position of not protecting the subject matter. Which country achieves that status depends on history, but however it arises, the equilibrium can become self-reinforcing and unalterable.

To understand equilibrium behavior, we also have to understand the equilibrium response of country a when a subject matter is not protected in country w. Country a will symmetrically choose not to protect the subject matter if either

1. unilateral protection would not be effective; or
2. public sponsors would provide the R&D, and country a prefers public sponsorship to being the sole provider of IP rights.

We will now investigate more systematically what happens in equilibrium. A country's strategy is a decision whether to protect each subject matter, x. An equilibrium is a strategy for each country which is optimal given the strategy of the other country.

By symmetry we mean that the countries are identical in both the sizes of their markets and their innovative capacities. Each country has the same number of potential innovations, assumed to be one in each country, and the market sizes are measured by c^a and c^w. Where "2" appears in the countries' payoffs, it represents two innovations, one from each country. For each subject matter, x, the payoff to country a is written in Tables 3 and 4, as it depends on the two countries' strategies. The payoff also

Table 3. Payoffs to Region a

	IP in w	No IP in w
IP in a	$2c(1-d)-x$	$c(2m+\pi)-x$
No IP in a	$c(2+\pi)-x$ (best response of a)	$2c-kx$ (best response of a iff $(k-1)x<c(2d+\pi)$)

Assume the markets are equal, that unilateral protection in each country is effective, and that, absent IP, public sponsorship will be provided.

Table 4. Payoffs to Region a

	IP in w	No IP in w
IP in a	$2c(1-d)-x$	$2c-kx$
No IP in a	$2c-kx$ (best response of a iff $2dc>(k-1)x$)	$2c-kx$ (best response of a)

Assume symmetric markets, that bilateral protection is effective, but not unilateral protection, and that, absent IP, public sponsorship will be provided.

depends on whether unilateral protection would be effective (Table 3) or not (Table 4). The payoffs to country w can be ascertained by reversing a and w in the tables. The payoffs in these tables reflect an assumption that public sponsorship will be provided whenever the equilibrium IP protections are not effective. However, this will not always be the case.

Table 3 shows in the left column that country a's best strategy is not to protect the subject matter if it can free ride on country w. The right column gives the condition under which country a will step into the breach if country w does not protect the subject matter, namely, if the cost, x, is relatively high. The lefthand column of Table 4 gives the condition under which country a will match the protection in country w by also providing protection, assuming that protection in country w alone is not effective. The right column, where country w is assumed not to provide protection, shows that country a's payoff is the same whether it provides protection or not; namely, the payoffs from public sponsorship in both countries. Since unilateral protection is not effective, we assume that country a will not provide it. (Country a may fear, for example, that the public sponsors in w will patent in country a, and that would reduce its payoff.)

Tables 3 and 4 assume that in the absence of effective IP rights, public sponsorship will be provided. Whether that is so depends on the parameter values d, π, k, as well as x. I have not presented tables for the case that public sponsorship would not be provided, because the analysis is much simpler. For example, if $\pi k < 1$ as assumed in Figure 1, public sponsorship will always be provided when unilateral IP protection is effective but not provided ($x < \pi c$ implies $kx < c$).

If $\frac{c}{k} < \frac{2dc}{k-1} < x < 2c\pi$, then bilateral IP would be effective and efficient, and there are two equilibria, one with bilateral protection, and one with no protection and no sponsorship, hence no R&D. If $\frac{c}{k} < x < \frac{2dc}{k-1} < 2c\pi$, then public sponsorship would be efficient, but still not provided. Bilateral IP is second-best efficient, but there are again two equilibria. One equilibrium has bilateral protection, and the other has no R&D.

These considerations, together with Tables 1, 3, and 4, lead to the following remark:

Remark 1 (The Symmetric Case: Inefficiencies). Suppose the two countries, a and w, have identical markets and are equally innovative. Then there are parameters d, π, k and subject matter x for which, in equilibrium, (a) unilateral protection is efficient but R&D is publicly sponsored; (b) bilateral protection is efficient but R&D is publicly sponsored; (c) public sponsorship is efficient but both countries provide intellectual property protection; and (d) R&D investments are not made because neither country protects the subject matter or provides public sponsorship.

(a) As can be seen in Table 3, a country will only provide unilateral protection if $\frac{1}{k-1}c(2d + \pi) < x < \pi c$. However, unilateral protection

is also efficient for lower-cost subject matters x for which $\frac{cd}{k-1} < x < \frac{1}{k-1}c(2d+\pi) < \pi c$. R&D in those subject matters will be publicly provided if $kx < c$.

(b) As can be seen in Table 4, there can be an inefficient equilibrium in which neither country protects the subject matter, even though bilateral protection is efficient ($\frac{2dc}{k-1} \leq x \leq 2\pi c$). If public sponsorship will be provided, this shows problem (b), and otherwise shows problem (d).

Problem (c) arises because public sponsorship is only provided when domestic benefits outweigh costs ($kx < c$), not when global benefits outweigh costs ($kx < 2c$). If $\frac{c}{k} < x < \frac{2dc}{k-1} < 2\pi c$, public sponsorship is efficient, but will not be provided in either country. It is then an equilibrium for the two countries to protect the subject matter instead of foregoing the innovations entirely.

We now ask whether harmonization can overcome these problems. Harmonization can cure the coordination impasse in which bilateral protection is not provided, even though efficient and preferred by both countries, but cannot cure the reluctance of each country to be the sole provider of IP incentives. Harmonization also cannot overcome the problem that public sponsors only take account of domestic benefits, and thus may not invest even when public sponsorship is efficient.

We will refer to the *least protective* harmonization as the one that arises when disagreements are resolved in favor of no protection. We will refer to the *most protective* harmonization as the one that will arise when disagreements are resolved in favor of protection. In cases of agreement, there is no difference.

Remark 2 (The Symmetric Case: Harmonization). Suppose the two countries, a and w, have identical markets and are equally innovative. Each of the following holds for some parameters d, π, k and subject matter x: (a) in both the least protective and most protective harmonizations, R&D is publicly sponsored even though unilateral protection in one of the countries would be efficient; (b) in the most protective harmonization, countries harmonize on subject matters for which unilateral protection would be efficient; and (c) in the least and most protective harmonizations, the countries harmonize on subject matters for which public sponsorship is efficient but would not be provided.

Remark 2(a) refers to subject matters such that $\frac{dc}{k-1} < x < \frac{1}{k-1}c(2d+\pi)$, $x < \pi c$, and $x < c/k$, which imply that unilateral protection would be efficient, but will not be provided, and that public sponsors will provide funding instead.

Remark 2(b) refers to the countries' disagreement about subject matters such that $\frac{1}{k-1}(2dc+\pi) < x < \pi c$, which would be protected in a single jurisdiction without harmonization. In the most protective harmonization, the nonprotective jurisdiction is forced also to protect the subject matter, and that is inefficient.

Table 5. Payoffs to Region a

	IP in *w*	No IP in *w*
IP in *a*	$2c^a(1-d)+\pi(c^w-c^a)-x$	$2c^a m+c^a\pi-x$
No IP in *a*	$2c^a+c^w\pi-x$ (best response of *a*)	$2c^a-kx$ (best response of *a* iff or $(k-1)x<c^a(2d+\pi)$)

Assume that unilateral protection in *a* *w* is effective, and that, if IP is not provided, public sponsors in *a* and *w* will provide funding.

Table 6. Payoffs to Region a

	IP in *w*	No IP in *w*
IP in *a*	$2c^a(1-d)+\pi(c^w-c^a)-x$	$2c^a-kx$
No IP in *a*	$2c^a-kx$ (best response of *a* iff $2dc^a-\pi(c^w-c^a)>(k-1)x$)	$2c^a-kx$ (best response of *a*)

Assume that bilateral protection is effective, but not unilateral protection, and that, absent effective IP, public sponsors in *a* and *w* will provide funding.

Remark 2(c) refers to subject matter x such that $\pi c<\frac{c}{k}<x<\frac{2dc}{k-1}<2\pi c$. Bilateral protection is second-best efficient, and better for the countries than no R&D at all. Public sponsorship will not be provided, even though it would be efficient, so the regions will harmonize.

6. Asymmetric Market Sizes

Tables 5 and 6 show country a's best response to country w's policy, assuming that the regional markets differ in size ($c^a<c^w$), but that their innovative capacities are the same for each subject matter. Each country again has one unit of innovative capacity.

The middle panel of Figure 1 shows how equilibrium protections may diverge from efficient, in particular, illustrating two types of coordination problems. The shaded areas represent subject matters that will not be protected with IP in equilibrium if the countries believe that public sponsorship will be provided. (Whether this is true depends on where the parameters $\frac{c^a}{k}$ and $\frac{c^w}{k}$ lie.) Under the assumption that $1<k<2$, there are no subject matters for which a single country would provide protection.

With Figure 1 as an aid, we now show:

Remark 3 (Asymmetric Markets: Inefficiencies). When the sizes of the regional markets are different, but the countries have the same innovative capacities, then each of the following holds for some parameter values π, d, k and subject matter x: (a) unilateral protection is efficient but R&D is publicly sponsored; (b) unilateral protection in the smaller country is efficient, but the larger country provides it; (c) bilateral protection is

efficient, but R&D is publicly sponsored; (d) public sponsorship is efficient, but both countries protect the subject matter; and (e) R&D investments are not made because neither country protects the subject matter or provides public sponsorship.

(a) Suppose that unilateral protection would be effective in either a or w, and that the subject matter satisfies $\frac{1}{k-1}dc^a < x < \frac{1}{k-1}c^a(2d+\pi)$ and $kx < c^a < c^w$. Then, referring to the efficiency criteria in Table 2, and the equilibrium behavior in Table 5, unilateral protection by country a (the smaller market) is efficient, but neither country will provide unilateral protection because both prefer to avoid the one-way flow of profit that comes with unilateral protection.

(b) If the larger country, w, protects the subject matter effectively, then there is no reason for country a to protect it as well. Region a prefers to free ride.

For (c) and (d), consider subject matters that satisfy

$$\frac{1}{k-1}[2dc^a - \pi(c^w - c^a)] < x < \frac{1}{k-1}[2dc^w - \pi(c^a - c^w)]. \tag{1}$$

These are the subject matters, x, between the darker vertical lines in Figure 1. Referring to Table 6, the maximum x such that country a prefers public sponsorship to bilateral protection is the expression on the left of Expression (1), and the maximum for country w is the expression on the right. The two countries thus disagree on bilateral protection for subject matters that satisfy Expression (1). The larger country, w, prefers public sponsorship, while the smaller country, a, prefers bilateral protection. This accounts for Remark 4, that the smaller country wants more harmonized protections.

Bilateral protection for a subject matter that satisfies Expression (1) may or may not be efficient, depending on whether x is smaller or larger than $\frac{1}{k-1}d(c^a + c^w)$, represented by the arrow between the dark lines in Figure 1. This follows from Table 2, which tells us that bilateral protection is efficient for a subject matter, x, that satisfies

$$\frac{2dc^a - \pi(c^w - c^a)}{k-1} < \frac{d(c^a + c^w)}{k-1} < x < \frac{2dc^w - \pi(c^a - c^w)}{k-1} \tag{2}$$

and public sponsorship is efficient for a subject matter, x, that satisfies

$$\frac{2dc^a - \pi(c^w - c^a)}{k-1} < x < \frac{d(c^a + c^w)}{k-1} < \frac{2dc^w - \pi(c^a - c^w)}{k-1}, \tag{3}$$

provided, in both cases, that unilateral protection would not be effective. But for all of the subject matters between the dark lines in Figure 1, which satisfy Equation (1), and assuming $kx < c^a < c^w$, there is only one equilibrium, namely, with public sponsorship and no intellectual property protection. This proves (c).

Remark 3(d) refers to the problem that countries may choose bilateral protection even if sponsorship would be efficient (Expression (3) holds), but absent protection, public sponsors will not provide funding ($kx > c^w > c^a$).

The problem that arises in Remark 3(e) is that the countries can get stuck in an equilibrium impasse with no protection, and public sponsors will not provide funding. In particular, consider subject matters to the right of the rightmost dark line in Figure 1, where $\frac{1}{k-1}[2dc^w - \pi(c^a - c^w)] < x < \pi(c^a + c^w)$, and suppose that public sponsorship would not be provided ($kx > c^w > c^a$). For such subject matters there are two equilibria: one with bilateral protection and another with no protection, even though protection would be efficient. This is clearly a problem that harmonization can overcome.

To overcome the inefficiencies that may arise in equilibrium, the countries may undertake a harmonization effort. The third panel of Figure 1 illustrates how the countries will harmonize. In the least protective harmonization, they will only solve the coordination problem of having no protection when both prefer it. Which subject matters this includes depends, for example, on whether $c^a < c^w < kx$. The efficiency criterion for public sponsorship, $x < \frac{1}{k-1}d(c^a + c^w)$, is then irrelevant, as public sponsorship will not be provided. The countries will have to enact second-best intellectual property policies.

In the most protective harmonization, the countries will resolve all disagreements in favor of the country that favors bilateral protection. Not shown in Figure 1 is that this may include subject matters that would otherwise be protected unilaterally.

Harmonization will lead to the following:

Remark 4 (Asymmetric Markets: Harmonization). Suppose that the sizes of the regional markets are different, but the countries have the same innovative capacities. Then the country with the smaller market prefers more extensive harmonized protections than the country with the larger market. Further, each of the following holds for some parameters d, π, k and subject matter x: (a) in both the least protective and most protective harmonizations, R&D is publicly sponsored even though unilateral protection in one of the countries would be efficient; (b) in the most protective harmonization, countries harmonize on subject matters for which unilateral protection would be efficient; (c) in the least protective harmonization, R&D is publicly sponsored even though harmonized protection would be efficient; (d) in the most protective harmonization, bilateral protection is provided even though public sponsorship is efficient and would otherwise be provided; and (e) in the least and most protective harmonizations, bilateral protection is provided even though public sponsorship is efficient, because public sponsorship would not alternatively be provided.

Remark 4(a) says that harmonization cannot redress the problem in Remark 3(a). If $\frac{1}{k-1}dc^a < x < \frac{1}{k-1}[2dc^a - \pi(c^w - c^a)] < \frac{1}{k-1}c^a(2d + \pi)$, and symmetrically for country w, and $kx < c^a < c^w$, then neither country will provide unilateral protection, even though protection in the smaller market is efficient. Further, both countries prefer public sponsorship to the duplicated costs of bilateral protection, and therefore will not harmonize on it.

(b) Suppose $\frac{1}{k-1}c^a(2d + \pi) < x < \pi c^a$. Then it is an equilibrium for a to protect the subject matter unilaterally. But country a would be better off with harmonization so that it could reciprocally earn profit in w. In the most protective harmonization, country a is assumed to prevail, even though w disagrees.

Remark 4(c) arises for subject matters that satisfy Expression (2), under parameters such that public sponsorship will be provided in the absence of bilateral IP. The countries will not harmonize on these subject matters in the least protective harmonization, because country w opposes it.

Remark 4(d) arises for subject matters that satisfy Expression (3), under parameters such that public sponsorship is efficient and will be provided in the absence of bilateral IP. Bilateral protection is preferred by a but not w, and will be achieved in the most protective harmonization.

Remark 4(e) points out that harmonization cannot overcome the problem pointed to in Remark 3(e), namely, that bilateral protection is the second-best option when public sponsors will not provide funding, even though that is efficient.

The conclusion that smaller countries will favor expansions in intellectual property rights more than large countries is only partly consistent with what we observed in the TRIPS negotiation. The strengthening was favored by small countries such as Switzerland and Finland, but also by large countries such as the United States. This shows that there is more at work than the mere size of the market. The United States is not only large, but also very innovative. The incentive to strengthen protections is driven not only by market size (inversely), but also by innovative capacity, which changes the importance of the profit flow in the social calculus. We now turn to asymmetries in innovative capacity.

7. Asymmetric Innovative Capacity

Let γ^a, $\gamma^w \in R_{++}$ measure the number of potential innovations of each subject matter that countries *a, w* can make. For the conclusions below, it is only the ratio γ^a/γ^w that is relevant. In the previous section, $\gamma^a = \gamma^w = 1$, and here we shall assume that $\gamma^a > \gamma^w$.

I will not make the argument for the following remark, as the argument is the same as Remark 1.

Remark 5 (Asymmetric Innovative Capacities: Inefficiencies). Suppose the two countries a and w have identical markets but one is more innovative than the other. Then there are parameters d, π, k and subject matter x for which, in equilibrium, (a) unilateral protection is efficient, but R&D is publicly sponsored; (b) bilateral protection is efficient, but R&D is publicly sponsored; (c) public sponsorship is efficient, but both countries provide IP protection; and (d) R&D investments are not made because neither country protects the subject matter or provides public sponsorship.

Remarks 5(a), (b), and (c) of the following harmonization remark are the same as for Remark 2, and I will not repeat the arguments.

Remark 6 (Asymmetric Markets: Harmonization). Suppose that the sizes of the regional markets are the same, but the countries have different innovative capacities. Then the country with more innovative capacity prefers more extensive harmonized protections than the country with less capacity. Further, each of the following holds for some parameters d, π, k and subject matter x: (a) in both the least protective and most protective harmonizations, R&D is publicly sponsored even though unilateral protection in one of the countries would be efficient; (b) in the most protective harmonization, countries harmonize on subject matters for which unilateral protection would be efficient; (c) in the least and most protective harmonizations, both countries will protect subject matters for which public sponsorship is efficient but would not be provided; (d) in the least protective harmonization, R&D is publicly sponsored even though harmonized protection would be efficient; and (e) in the

Table 7. Payoffs to Region a

	IP in *w*	No IP in *w*
IP in *a*	$c(\gamma^a+\gamma^w)(1-d)+\pi c(\gamma^a-\gamma^w)-\gamma^a x$	$(\gamma^a+\gamma^w)cm+\gamma^a c\pi-\gamma^a x$
No IP in *a*	$(\gamma^a+\gamma^w)c+\gamma^a c\pi-\gamma^a x$ (best response of *a*)	$(\gamma^a+\gamma^w)c-\gamma^a kx$ (best response iff $\gamma^a(k-1)x<c\gamma^w(d+\pi)+c\gamma^a d$)

Assume that unilateral protection in either country is effective. but that, absent effective IP, public sponsors will provide funding.

Table 8. Payoffs to Region a

	IP in *w*	No IP in *w*
IP in *a*	$(\gamma^a+\gamma^w)c(1-d)+\pi\, c(\gamma^a-\gamma^w)-\gamma^a x$	$(\gamma^a+\gamma^w)c-\gamma^a kx$
No IP in *a*	$(\gamma^a+\gamma^w)c-\gamma^a kx$ (best response of *a* iff $(\gamma^a+\gamma^w)dc-\pi c(\gamma^a-\gamma^w)>\gamma^a(k-1)x$)	$(\gamma^a+\gamma^w)c-\gamma^a kx$ (best response of *a*)

Assume that bilateral protection is effective, but not unilateral protection, and that absent effective IP, public sponsors will provide funding.

most protective harmonization, bilateral protection is provided even though public sponsorship is efficient and would otherwise be provided.

Remarks 5(d) and (e) refer to subject matters x for which public sponsorship would be provided, and bilateral protection is efficient, but the countries disagree on whether it should be protected (Tables 7 and 8). Consider subject matters that satisfy

$$\frac{1}{k-1}\left[\left(1+\frac{\gamma^w}{\gamma^a}\right)dc-\pi c\left(1-\frac{\gamma^w}{\gamma^a}\right)\right]<x$$
$$<\frac{1}{k-1}\left[\left(1+\frac{\gamma^a}{\gamma^w}\right)dc-\pi c\left(1-\frac{\gamma^a}{\gamma^w}\right)\right]. \tag{4}$$

Referring to Table 8, the maximum x such that country a prefers public sponsorship to bilateral protection is the expression on the left side of Expression (4), and the maximum for country w is the expression on the right. The less innovative country, w, prefers public sponsorship, while the more innovative country, a, prefers bilateral protection. This accounts for our remark that the more innovative country wants more harmonized protections.

Bilateral protection of a subject matter that satisfies Expression (4) may or may not be efficient, depending on whether x is smaller or larger than $\frac{2dc}{k-1}$. This follows from Table 1, which tells us that bilateral protection is efficient for a subject matter that satisfies

$$\frac{1}{k-1}\left[\left(1+\frac{\gamma^w}{\gamma^a}\right)dc-\pi c\left(1-\frac{\gamma^w}{\gamma^a}\right)\right]<\frac{2dc}{k-1}<x$$
$$<\frac{1}{k-1}\left[\left(1+\frac{\gamma^a}{\gamma^w}\right)dc-\pi c\left(1-\frac{\gamma^a}{\gamma^w}\right)\right], \tag{5}$$

and public sponsorship is efficient for a subject matter that satisfies

$$\frac{1}{k-1}\left[\left(1+\frac{\gamma^w}{\gamma^a}\right)dc-\pi c\left(1-\frac{\gamma^w}{\gamma^a}\right)\right]<x$$
$$<\frac{2dc}{k-1}<\frac{1}{k-1}\left[\left(1+\frac{\gamma^a}{\gamma^w}\right)dc-\pi c\left(1-\frac{\gamma^a}{\gamma^w}\right)\right], \tag{6}$$

provided that unilateral protection would not be effective. But for all of the subject matters that satisfy Expression (4), there is only one equilibrium, namely, with public sponsorship and no intellectual property protection. This is because country w will not protect the subject matter. This proves Remark 5(b) and Remark 6(d) and (e).

8. Conclusion

National treatment increases incentives to innovate, especially in an environment where local markets are not large enough to support invention. However, national treatment also creates problems.

First, it can lead to an asymmetry where, for a particular subject matter, one country protects all innovation that takes place in the member states, and consumers in the other member states free ride. But for subject matters that do not require extensive protection, there is a more natural and more equitable asymmetry, which national treatment does not permit. The more natural solution would be for each country to protect its own innovators, and for countries to exchange spillover benefits.

Second, the asymmetric solution may not be implemented, even if efficient. Each country may refuse to be the sole provider of intellectual property rights, since that entails an outflow of profit to other member states as well as deadweight loss. The reluctance to provide unilateral protection will lead to a harmonization effort. If the harmonization effort is successful, it may result in more extensive intellectual property than is necessary to protect innovators, and unnecessary deadweight loss. Harmonization is not a good solution to the asymmetries that may result when protection in a single country is sufficient for incentives, even though inequitable.

Third, countries can arrive at an inefficient equilibrium where no country protects a subject matter because no other country does, and because unilateral protection is ineffective or because the country will not tolerate a one-way outflow of profit. This is a problem that harmonization can cure.

Thus harmonization will not solve all the efficiency problems that arise from independent policy making. Perhaps the most important problem arises when we recognize that for some investments, public spending is the most efficient way to fund R&D. If publicly funded R&D outputs are put in the public domain, they create spillover benefits across borders. These spillover benefits cannot be recouped as profit, as that would reinstate the deadweight loss that public sponsorship is designed to avoid. But since public funding agencies will not be inclined to take account of benefits generated abroad, the incentives to provide public spending will be deficient. In contrast, harmonized intellectual property protections allow countries to recoup some of the benefits they confer on foreign consumers. This may lead to an international system that relies more heavily on intellectual property than is efficient, especially when it is recognized that public spending on R&D is an extensive and efficient practice.

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