

**Strengthening Worldwide Patent Protection
(revised version)**

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Abstract

This paper develops a locational model of global patent protection. Countries are distributed on a line which represents the world from North to South. The Northern region of this world provides effective protection, contrary to the Southern region. Innovators reside in the North. Southern countries are not able to imitate the Northern innovations perfectly. If the imitation capability in the South is poor, the optimal extent of intellectual property protection, from a global dynamic welfare point of view, is the whole world. However, if Southern imitations are better, it is optimal to have a Southern region without effective intellectual property rights. This conclusion is robust against various extensions of the basic model. (*JEL Code: O34; Key words: North-South relations, patents, imperfect imitation, transport costs*)

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1. Introduction

At a special ministerial session in September 1986 in Punta del Este, Uruguay, the GATT countries agreed to put the issue of Trade Related Intellectual Property Rights on the agenda for the Uruguay Round of Multilateral Trade Negotiations. Especially the US, with support of the EC and Japan, have put in great effort to achieve this. Two earlier attempts of the US to improve international protection, as regulated by the Paris Industrial Property Convention (1883), failed. Both attempts - the formulation of the UNCTAD's Code of Conduct for the Transfer of Technology (1980) and the Revision Conference of the Paris Convention (1982), inspired by UNCTAD criticism on the international patent system - eventually missed the required unanimity because the demands of the Group of 77 (developing countries) were not accepted (Cornish 1989, Kunz-Hallstein 1989 and Ullrich 1989). These attempts were undertaken via the World Intellectual Property Organization, which performs the administrative tasks of the Paris Convention. Since more support for the proposal to extend global patent protection can be expected in the GATT, where Northern countries have more influence, much political pressure was used to get the issue on the Uruguay agenda.¹

The economic arguments underlying the pressure of the US, the EC and Japan, and the resistance of the developing countries are reasonably clear. In most discussions two parties are distinguished: the northern and the southern countries. The North is an advocate of extending its strong standards of intellectual property protection to the rest of the world. The main argument is that if Northern exports are not protected in the South against imitation, then Northern firms forego profits and, consequently, the incentive to invest in R&D weakens. According to the North, the absence of protection would harm the Southern countries too because welfare is missed if Northern firms do not export and face weaker innovation incentives. The developing countries make the point that strong intellectual property protection only benefits Northern firms - if these firms export to them at all - because larger profits can be expected with stronger protection. These profits flow back to the Northern home countries, and the only result is that more Southern consumer surplus

is lost. Furthermore, most innovations are developed primarily for the Northern market and are not necessarily appropriate for developing countries, which have their specific wants and needs.

Several studies on the international economics of intellectual property, both theoretical and empirical, have appeared recently. Feinberg and Rousslang (1990) estimate the economic effects of foreign patent infringement on US firms. Their analysis is based on a study of the US International Trade Commission on foreign infringement of US intellectual property. They show that due to foreign intellectual property infringements US firms have foregone profits of about 1% of their total 1986 sales. Most theoretical models on the topic use a technology-gap theory where trade between North and South occurs because of comparative advantage of the North in R&D and technology-intensive products.² Chin and Grossman (1990) study the argument of improved R&D incentives for Northern firms if the South strengthens its patent protection. Their model is a duopoly with a Northern firm, which alone can reduce costs through R&D, and a Southern firm, which can imitate perfectly. If the South protects the process innovation, the Northern firm has a cost advantage in the global competition with the Southern firm. Both firms compete on equal terms if the South does not provide protection for the process innovation. The interests of Northern and Southern governments generally conflict. The North always wants extension of protection whereas the South does not, unless it is a significant demander on the world market and, consequently, gains sufficiently from the process innovation. The optimal global protection can go either way. For instance, much global protection is optimal if the R&D productivity is high. Deardorff (1991) constructs a model which points at the decreasing positive effects on innovation incentive as patent protection is extended to a larger portion of the world. In a two-country model, the innovating country benefits from larger patent protection but the technology importing country often loses more. A richer model, applicable to both product and process innovations and allowing for more freedom of choice in the level of protection, is developed by Diwan and Rodrik (1991). Their main argument concerns the appropriateness of technical development for the South. If the South provides protection, it not only affects the intensity

but also the direction of R&D, namely toward technologies which are better suited for the South. This may partially offset the tendency for easy riding behaviour of the South.

This paper presents a model which incorporates two aspects of optimal global patent protection not dealt with before: (i) *transport costs* occurring in international trade; and (ii) *imperfect imitation* capability in the South. First consider the issue of transport costs. There is a rich tradition in empirical international economics, including most prominently Linneman (1966) and Leamer and Stern (1970), which studies the role of distance in trade. The results generally show that trade flows between two countries decrease if these countries are further apart. The distance between two countries should be interpreted broadly; it not only includes physical distance, measurable in miles, but can also include metaphorical distance, such as differences in culture. Consequently, Armington (1969) makes the observation that distance brings about that each country produces a unique good and that goods in international trade are thus differentiated by country of origin. Embedded in this empirical distance tradition, Ferrantino (1993) presents an empirical analysis of intellectual property rights. In brief, indeed he finds that for US exporters in 1982 distance from trading partners plays an important role. Furthermore, he finds, be it weak, evidence that exports are lower to countries with weak intellectual property protection (the extent of protection is, among others, measured by membership of the Paris or Berne Convention on intellectual property and patent durations). In this paper a theoretical model is advanced where distance, either physically or metaphorically interpreted, is included and plays an important role.

The second difference between the model presented here and the previous ones is the assumption on imitation in the South. All previous models assume that the Southern capability of imitating Northern goods is perfect. A study of David (1991) sheds a different light on the topic. His main argument is that the assumption that the South can imitate easily and perfectly is often not justified. Southern imitation capability might be poor indeed. It can therefore be in the interest of the South to provide intellectual property protection and induce Northern firms to export their new products to them. This argument rests on the historical

origin of patent systems. The very first patents in early Venice and England were granted to foreign masters in order to make them teach domestic apprentices their arts and skills. Without these exclusive rights, such skilful masters would never come and teach. Building further on David's argument, this essay studies scenarios in which Southern imitation is imperfect.

To be more concrete, this paper develops a simple locational model of intellectual property rights in which the world is represented as a line from north to south and each country is a point on the line. The image is borrowed from the product differentiation literature in industrial organization, starting with Hotelling (1929).³ The "North" is defined as countries that provide protection and the "South" as countries that do not provide protection. Innovations only occur in the North, but they be imitated (though imperfectly) in the South. The value of an innovation diminishes with distance from the innovator, either because international transport costs are incurred in exporting the product, or because the technology becomes less suitable for more distant countries. The analysis aims at determining the optimal point dividing North and South. The model is appropriate to study various intellectual property rights such as trademarks, patents and copyright, but only in as far these rights can be exploited abroad by exporting products. The model does not cover technology that can be exploited abroad only through licensing or foreign direct investment because such technology is not likely to be imitated in the South. The focus of exposition in this paper is on patents, rather than on other forms of intellectual property.

The basic model, presented in section 2, examines the static welfare effects of strengthening worldwide patent protection and reveals, from this static point of view, the interests of the Northern and Southern regions and of the complete world. Endogenous innovation enters the analysis in section 3. The effects of patent protection on innovation incentives of Northern firms are included. Section 4 presents some extensions of the basic model. Section 5 finally concludes and points at directions for future research.

2. Global Patent Protection with Exogenous Innovation

Consider a linear world, similar to Hotelling's (1929) linear city, which extends from 0 to 1.⁴ Northern countries are located at the "left hand side" in this world with the most Northern country at 0. Moving to the "right" means moving Southwards where at 1 the Southernmost country is located. Countries are uniformly distributed along this world with density 1 and their location is given by $w \in [0, 1]$. Suppose there is a firm in the Northernmost country $w = 0$ (in section 4, other resident countries will be considered) which is a monopolist in the invention market of a worldwide industry and which has generated a product innovation. This firm wants to export its new product to the rest of the world and in order to protect its exports it seeks patent protection in as many countries as possible. Not every country, however, provides effective patent protection. Roughly representing the situation in the real world, suppose that the countries which do provide patent protection are located in the Northern region $[0, b)$ and the countries which do not are located in the South $[b, 1]$, where $b \in [0, 1]$ is the border country without an effective patent system.⁵ In order to simplify notations and verbal descriptions, let the North and the South be synonyms for the regions where effective patent protection is provided and not provided, respectively. The North and the South are treated here as two homogeneous coalitions in which individual countries are not concerned with their national interest but only with the interest of their coalition. I will discuss this coalition assumption later. The length and scope of protection within the North are furthermore assumed to be exogenous and uniform.⁶

The consumer surplus generated by the new product in each individual country on the line is given by:

$$U = \begin{cases} v - p - td & \text{if the country imports} \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

where v is the gross surplus which the innovation provides (the quality), p is the "free on

board" price of the innovation, t is the cost per unit distance of transporting the product over the world ($t > 0$), and d is the distance from the exporting country to the importing country w (in this case $d \in [0, 1]$). A country consumes one unit of the new product if its consumer surplus is non-negative, and no unit otherwise.⁷ Distance in this model can be interpreted literally in miles or kilometres; td is then the total cost of carrying the new product by cargo ship, truck, train or plane, from the innovating firm in country $w = 0$ to the importing country $w = d$. There is also an alternative, metaphorical interpretation of the transport costs, which is quite common in the product differentiation literature. A location on the line can be thought of as representing a country's most preferred variety of the new product. Each country has its own preferred variety of the new product, for example because of country specific parameters such as infrastructure, national consumption pattern, education level and natural environment. The transport cost is then analogous to a surplus penalty caused by importing a less preferred variety. According to this interpretation, the new product is most appropriate for the country from where it originates, maybe because the inventor knows the local circumstances and demand characteristics better (compare Diwan and Rodrik 1991 for the point of appropriate technologies). Countries on the line are ordered according to the distance of their preferred variety from the produced innovation. Although this ordering principle differs from the geographical principle, there certainly is a plausible correspondence. Fellow Northern countries face relatively small surplus losses and moving Southward these national losses grow larger as the product becomes less and less appropriate. This reflects the fact that the difference between Northern and Southern countries is larger than the differences within the North or the South.

The countries which do not provide effective patent protection are assumed to imitate the new product costlessly. Despite the absence of patents, which can hinder imitation, Southern countries are not able to imitate perfectly; their imitations generate less gross surplus, namely ρv , with $0 < \rho < 1$.⁸ The whole region $[b, 1]$ is filled up with these imperfect imitations ρv (see figure 1). By assumption, the innovator can not make any profits in the unprotected region $[b, 1]$. Imitation prevents this. What are the innovator's profits in the patent protected

region of the world $[0, b)$? Working backward, first I will determine the demand function for the patentholder which is based on the national consumer surplus function (1), and then derive the optimal price and (gross) profits. Together with an innovation cost function, these optimal gross profits will be used in the next section to determine the optimal innovation level. This section studies the optimal patent protection for exogenously given innovations. The implications of international patent policy for the static global welfare can be isolated this way.

The innovator is assumed to be perfectly able to price discriminate over countries. This assumption is not decisive for the eventual conclusions; the results are very similar in the case of uniform pricing. The marginal cost of production is set equal to 0 for convenience. The patentholder maximizes his profits by choosing a price which totally absorbs the consumer surplus in the Northern region:

$$p^* = v - tw \tag{2}$$

The profit of the patentholder is depicted in figure 1 by the spotted area. **[FIGURE 1]**

Each country $w \in [0, b)$ is prepared to pay the value of the innovation v minus the transport costs tw that must be incurred to import the innovation. Since the Northern consumer surplus flows entirely to the patentholder, his profits make up the total social welfare in the North (W_N). For further analysis, a distinction has to be made between large and small innovations. Large innovations (i.e., large relative to the unit transport cost and the global patent protection) provide positive net surplus in the whole Northern region, whereas small innovations stop providing positive net surplus before the border of protection b is reached. First consider innovations with high v . Large innovations serve the complete Northern region and the border of protection becomes restrictive for their demand. Country b is then the most Southward located Northern country that imports (by assumption the innovator can not serve the South). The Northern welfare (equal to the innovator's profit) is

given by: $W_N = \int_0^b (v - tw)dw = bv - b^2t/2$. As a benchmark, the maximum welfare in the North is bv and would be present if all Northern countries would extract the full surplus v from the innovation. Welfare losses, however, are inevitable because fellow Northern countries face transport costs associated with their imports. These welfare costs are equal to $b^2t/2$. Now consider the case of small innovations. If an innovation v is small, the country that is indifferent between importing and not importing is given by $w' = v/t$. The countries North of w' will thus not consume the product. The Northern welfare is then given by $W_N = \int_0^{w'} (v - tw)dw = v^2/2t$.

The welfare in the Southern region (W_S) without patent protection is totally made up of consumer surplus as depicted by the shaded area in figure 1. Each Southern country can imitate and thus incurs no transport cost. Yet welfare losses will occur because surplus is lost while imitating the original innovation. For both large and small innovations, the Southern welfare is $W_S = (1 - b)pv$.

Based on the welfare functions for the North and the South, the optimal level of global patent protection can be determined. Before examining the optimal global level, however, first I will study the interests of the Northern and Southern regions separately. As mentioned above, the North and South are treated as coalitions, where individual countries do not pursue national interest. In the simple scenario studied here, with only one innovator resident in the most Northern country, one could object that fellow Northern countries ignore their national interests as their consumers' surpluses flow away to the patentholder and for some of them imitation would yield more national welfare. Two arguments can be advanced as defence. First, the assumption of homogeneous coalitions is inspired by the practice of the GATT negotiations where indeed two blocks can be found. The Northern block represents the interests of innovators in general because, unlike the simple scenario studied here, in all these countries innovators are likely to be resident. Second, even in the simple scenario studied here, there is a possible justification for the existence of a homogeneous Northern coalition. Suppose that the patentholder compensates all countries that provide protection. In the

extreme case that the innovator pays an amount equal to his total profit to all Northern countries, the goal of profit maximization remains unchanged and is common to all Northern countries. This also holds for intermediate cases.

What is the optimal level of global protection from the Northern point of view? The Northern welfare, given by $W_N = bv - tb^2/2$, is maximized for the patent coverage:

$$b_N^* = \min (v/t, 1) \quad (3)$$

Northern welfare increases in b as long as the marginal country enjoys potentially non-negative surplus. For large innovations, this implies a worldwide protection of 1. If the innovation is small, the country that is indifferent between importing and not importing is given by $w' = v/t$. Increasing patent coverage then only diminishes the Northern welfare, because an increasing number of countries will not buy the innovation. According to expression (3), the optimal Northern protection level can increase in v and decrease in t . The country that is indifferent between importing and not importing is located more Southward if the innovation provides more surplus. The alternative of not importing is also more attractive if the transport costs are larger.

The welfare in the Southern region without patent protection is totally made up of consumer surplus. The Southern welfare always decreases in world patent coverage ($dW_s/db < 0$ for $b \in [0, 1]$) because the region shrinks without getting better innovations in return. The negative effect of extending global protection intensifies if ρ and v are larger. So the optimum from the Southern perspective is to provide no protection at all (assuming that the innovator then still generates his innovation so that imitation stays possible).

How do these optimal levels of the North and the South, which can be extreme opposites (none vs. total protection), combine in one optimal global level of protection? The unweighed sum of the Northern and Southern welfare is taken as the global objective function. The

optimal extent of protection that maximizes the objective function is:

$$b_G^* = \min (v(1 - \rho)/t, 1) \quad (4)$$

Notice that this optimal global protection is smaller than or equal to the optimal one from the Northern point of view (given by 3), and always larger than the optimal Southern level. An interesting property of the optimal global level is that it decreases in the imitation capability of the South. The reason is that the South loses more when it provides patent protection if its imitation capability is high.

3. Endogenous Innovation

The analysis thus far has revealed the interests of the North and South from a static perspective, i.e., for given innovations. This section will take into account the effects of protection on the R&D incentive of the innovator. The innovation v is chosen endogenously by the innovator. His choice of R&D expenditures is a function of, among others, the global patent protection provided. On the basis of the gross profits (net of R&D costs) which can be gained with a certain innovation, the inventor has to choose an innovation level. Suppose that increasing R&D expenditures leads to a higher gross surplus being generated by the product innovation, and suppose that this is decreasingly so. A simple deterministic innovation cost function which catches this idea of exhausting innovation opportunities is:

$$c(v) = \alpha v^2 \quad \alpha > 0 \quad (5)$$

where c are the R&D expenditures and v^+ is the upper limit of v (the final improvement possible): $0 \leq v \leq v^+$. For small innovations - the ones that do not serve all countries - the net profit function is $\pi(v; p^*) = v^2/(2t) - \alpha v^2$. If the innovation costs are relatively high ($\alpha \geq 1/(2t)$), then the innovation will not be developed at all. If the innovation costs are relatively

low ($\alpha < 1/(2t)$), which I will focus on from now on, the innovator always gains with investing more R&D. The upper limit v^+ will occur when the innovation opportunities are completely exhausted before the border of patent protection is reached ($v^+ < tb$). The market will then not be completely served and the global patent protection provided does not affect the innovation incentive. For these innovations, the optimal global protection is identical to the one that maximizes static welfare $b_G^* = \min(v^+(1 - \rho)/t, 1)$, as given by (4). If, however, the upper limit on surplus is relatively high ($v^+ \geq tb$), we enter the regime where the most Southward importing country is located at the border b . For this regime, the net profit function (gross profit minus R&D cost) is $\pi(v; p^*) = bv - tb^2 - \alpha v^2$. The optimal innovation level which maximizes this net profit function is:

$$v^* = b/(2\alpha) \tag{6}$$

This expression indicates that a higher unit innovation cost α makes the optimal level of innovation lower. Furthermore, the optimal innovation is positively related to the level of innovation. So the claim of the Northern countries in the Uruguay Round that strengthening world protection improves the R&D incentive of Northern firms indeed is captured by the model. Again, the welfare in the North is given by the profits of the discriminating monopolist: $W_N = bv^* - tb^2/2 - \alpha v^{*2}$. The extent of patent coverage b has opposing effects on Northern welfare. The positive welfare effects are, first, that increasing coverage improves the induced innovation (v^* increases in b) and, second, but this is due to the terminology used, that the size of the Northern region increases. There are also negative effects on Northern welfare. First, just like in the static analysis, an increase of b causes larger transport costs. Second, since the induced innovation is larger, the R&D costs are relatively higher. The gain in welfare turns out to be always large enough to compensate for the extra transport and R&D costs. To see this, substitute the optimal innovation level (5) in the welfare function and see it reduce to: $W_N = b^2(1 - 2\alpha t)/(4\alpha)$. Since the current analysis is based on relatively low innovation cost ($\alpha < 1/(2t)$), Northern welfare always increases (quadratically) in b . Therefore, the optimal protection from the Northern point of view is the corner solution

$$b_N^*(v^*) = 1.$$

Again the welfare in the Southern region $[b, 1]$ is totally made up of consumer surplus. For the optimal development level v^* , the Southern welfare is:

$$W_S = (1 - b)\rho v^* = (1 - b)(\rho b/2\alpha) \quad (7)$$

Contrary to the previous section, the South faces a trade-off now. More patent protection enhances the R&D incentive, which improves the product innovation and, consequently, the Southern imitations on the one hand, but causes welfare loss due to decreased size of the Southern region on the other. From the Southern point of view the optimal patent coverage is:

$$b_S^*(v^*) = 1/2 \quad (8)$$

"Equatorial" protection is now in best interest of the South. Compared to the case of exogenous innovation discussed in the previous section, it is now in the interest of the South to provide some protection in order to induce sufficient innovation incentive.

The global welfare is the unweighed sum of Northern and Southern welfare, $W_G = bv^* - tb^2/2 + (1 - b)\rho v^* - \alpha v^{*2}$, and is maximized for:

$$b_G^*(v^*) = \begin{cases} 1 & \text{if } \rho \leq 1 - 2\alpha t \\ \rho/(2\rho + 2\alpha t - 1) & \text{if } \rho > 1 - 2\alpha t \end{cases} \quad (9)$$

Solution (9) has some important properties for international patent policy. If the imitation capability in the South is poor ($\rho \leq 1 - 2\alpha t$), a benevolent global social planner provides worldwide patent protection of 1. Apart from imitation capability ρ , the size of the regime of complete coverage also depends on the unit innovation transport cost t and the innovation

cost α . This regime enlarges if the unit transport cost decreases, relative to the innovation cost ($1 - 2\alpha t$ is larger then). So innovations that cause relatively low transport costs, i.e., whose value decrease slowly when moving South-ward (for example technologies that are appropriate for all countries), should get worldwide protection. A regime of non-worldwide protection emerges if the South is better able to imitate ($\rho > 1 - 2\alpha t$). From the optimal protection level onwards, an extra Southern country that provides protection adds insufficiently to the innovation incentive in order to make up for the difference in net surplus between the original innovation and the imitation. Because in this regime $2\alpha t - 1 < 0$, the optimal global protection is always larger than $1/2$. Table 1 presents some numerical examples. The table shows that the globally optimal levels of patent coverage are higher if ρ is lower. It furthermore shows that, irrespective of ρ , the optimal levels are lower if the transport cost, relative to the innovation cost, is higher. This can be the case for a high absolute transport cost but also for a low absolute innovation cost.

Table 1. Optimal global patent coverage

Transport cost t	b_G^* ; $\rho = 0.8$	b_G^* ; $\rho = 0.6$	b_G^* ; $\rho = 0.4$	$b_G^* < 1$
$1/(10\alpha)$	1	1	1	$\rho > 0.82$
$1/(4\alpha)$	0.727	0.857	1	$\rho > 0.50$
$1/(3\alpha)$	0.632	0.692	0.857	$\rho > 0.33$
$1/(2.1\alpha)$	0.515	0.521	0.532	$\rho > 0.06$

What the simple model developed in this section has thus demonstrated is that the aim of Northern countries in the Uruguay Round to extend patent protection globally need not to be welfare improving from the global point of view. There are two motivations why the optimal level of protection is not worldwide protection. First, if the capability in the South to imitate Northern innovations is high, the welfare emerging from South imitations is higher than the welfare emerging from stronger innovation incentives. Second, if the unit transport cost is relatively high (if, in other words, the innovation is only appropriate for the direct

neighbourhood of the innovator), worldwide protection would provide too strong an incentive to the innovator and overcompensate him. Although these conclusions are intuitively clear, one should keep in mind that they are based on a simple model which focuses only on imperfect imitation and transport costs. Of course, more serious policy conclusions should be based on more realistic models. But the result that worldwide protection does not need to be optimal, as Northern countries generally claim, should be kept in mind in North-South negotiations.

4. Some Extensions of the Basic Model

To relax some of the simplifying assumptions, this section will study three extensions of the basic model. The first extension (a) examines other locations of the innovator than in the basic model where the innovator was resident in the most Northern country. The second extension (b) studies the effect of an uneven international income distribution. The final extension (d) analyzes the "exhaustion doctrine", which is often practised in international jurisdiction.

(a) Innovator Resident in Another Northern Country

Up to this point, the innovator has been a resident of the most Northern country $w = 0$. Suppose now that the innovator is resident of a country $w^* \in [0, b)$. What is the effect of location of the innovator? Suppose that the complete Northern region is served ($\alpha < 1/(2t)$, $v^* > \max(t(b - w^*), tw^*)$). The profit of the patentholder is then given by $\pi = \int_0^{w^*} (v - t(w^* - w))dw + \int_{w^*}^b (v - t(w - w^*))dw = bv - t(b^2 - 2bw^* + 2w^{*2})/2$. The optimal innovation based on this gross profit function and the R&D cost function (4) is independent of location of the innovator: $v^* = b/(2\alpha)$. Relative to the basic analysis in section 3, the profit of the innovator and therefore the Northern welfare has increased. The reason is that a more central location of the innovator causes less transport costs.⁹ The optimal levels of protection from both regional perspectives remain unchanged: $b_N^* = 1$ for the North and $b_S^* = 1/2$ for the South. The increased welfare in the North, however, does show up in the optimal level of protection

from the global point of view:

$$b_G^* = \begin{cases} 1 & \text{if } \rho \leq 1 - 2\alpha t(1 - w^*) \\ (\rho + 2\alpha w^*t)/(2\rho + 2\alpha t - 1) & \text{if } \rho > 1 - 2\alpha t(1 - w^*) \end{cases} \quad (10)$$

The optimal level is larger if the innovator is located more Southward. The reason is that the marginal effect on the innovation incentive of an extra Southern country providing patent protection is larger if the innovator is located more Southward. The qualitative results of the basic model remain unchanged: non-worldwide protection is optimal if the imitation capability is good and the unit transport cost t is large, relative to the innovation cost α .

(b) Differences in National Income

Extension (a) might indicate that firms located in the centre of the Northern region are more innovative since they can gain more from an innovation. The notion that there are differences in national income over the world and that Southern countries often are poorer might offset this tendency. The national consumer surplus function as given by (1) can be extended such that differences in national incomes between countries are incorporated. Consider the following national consumer surplus function:

$$U = \begin{cases} mv - p - td & \text{if the country buys} \\ 0 & \text{otherwise} \end{cases} \quad (11)$$

where m is a country specific parameter which indicates the intensity in which that country appreciates the innovation ($m \in [y, z]$, $z \geq y$). This innovation preference intensity parameter m can be interpreted as the marginal rate of substitution between national income and importing the innovation. Consider for example (see Tirole 1989, p.97) the separable utility function $U = u(I - p) + v$, where I is national income. Let I be much larger than p . A first-order Taylor expansion of this utility function is: $U \approx -u'(I)p + v$. Define $m = 1/u'(I)$. If u is concave, wealthier countries have a low $u'(I)$ and therefore a higher m .

It is commonly known that national incomes are not uniformly distributed over the world. Northern countries are generally richer and Southern countries poorer. In order to give (extreme) credit to this fact, let the Northernmost country $w = 0$ be the richest ($m = z$) and moving Southward countries become poorer with the poorest country ($m = y$) being the Southernmost one at $w = 1$. In other words, let $m = z - (z - y)w$. Figure 2 illustrates the income differences for $z = 1$ and $y = 0$ and shows that the potential national surpluses decrease while moving Southwards. Again the innovator is located in the most Northern country and chooses country specific discriminating prices.¹⁰ [FIGURE 2]

The profit maximizing price charged to country w is:

$$p^*(w) = mv - p - tw = (z - (z - y)w)v - tw \quad (12)$$

Let the Northern region be served completely. The patent coverage is then restrictive and the profits of the patentholder are given by: $\pi = \int_0^b ((z - (z - y)w)v - tw)dw = zvb - (vb^2(z - y))/2 - tb^2/2$. Based on these gross profits and the R&D cost function, the optimal innovation level is:

$$v^* = (2zb - (z - y)b^2)/(4\alpha) \quad (13)$$

Expression (13) has some interesting properties. The optimal innovation level v^* is larger if the richest country z is richer and smaller if the difference between the richest and the poorest ($z - y$) is larger. In fact, $(z - y)$ represents the skewness of global income distribution (since the world line stays of length 1). The levelling of incomes has thus a positive effect on the innovation v being chosen.

In order to prevent that the expressions for the optimal levels of protection become untransparantly complex, I set the income parameter y equal to 0 and z equal to 1. Table 2 presents the optimal coverage for various constellations of the unit transport cost t and the

Southern imitation capability ρ . Contrary to the previous results for large innovations, table 2 (second column) shows optimal levels of protection from the Northern perspective which are smaller than 1. The exact optimal level for the North is $b_N^* = (3 - \sqrt{16\alpha t + 1})/2$ and is always smaller than 1. The result is thus general for the incomes chosen here. Reason is that all countries are poorer (except for $w = 0$) than in the basic analysis. Because the surplus of a marginal Northern country is always lower than before, the positive effects of extending patent protection are weakened. Another point is that the optimal Northern protection levels are lower if the transport cost is relatively higher. Country specific innovations now thus deserve also less protection from the Northern perspective. In the basic model this became only visible in the globally optimal level. The welfare in the South, now given by $W_s = \int_0^{b_s^*} (\rho m v^*) dw$, is maximized for $b_s^* = 1 - \sqrt{2}/2 (\approx 0.293)$. This optimal Southern level is lower as compared to the basic analysis of the previous section (where it was $1/2$). Reason is that expansion Northwards is longer welfare improving as richer countries join the region and extract more surplus from imitation. Table 2 reveals some interesting aspects of the optimal level of protection from a global perspective. As before the optimal global levels are lower if the unit transport cost is higher, relative to the innovation cost. But opposed to before, we see that the optimal level of protection can decrease if the Southern imitation capability is worse. This is the case for high transport costs ($t = 1/(3\alpha)$ and $t = 1/(2.1\alpha)$). Relatively high transport costs make the wasteful transport loss so large that, even inferior, imitations are the best alternative.

Table 2. Optimal coverages with national income differences ($z = 1, y = 0$)

Transport cost t	b_N^*	b_s^*	$b_G^*; \rho = 0.8$	$b_G^*; \rho = 0.6$	$b_G^*; \rho = 0.4$
$1/(10\alpha)$	0.694	0.293	0.477	0.527	0.586
$1/(4\alpha)$	0.382	0.293	0.322	0.329	0.339
$1/(3\alpha)$	0.242	0.293	0.278	0.275	0.270
$1/(2.1\alpha)$	0.032	0.293	0.227	0.215	0.198

(c) *The Exhaustion Doctrine and Parallel Imports from the South*

The basic analysis in the previous section has assumed that the patent rights in the North make the patentholder an absolute monopolist in that region. In real case law, however, it has become apparent that patent rights can be exhausted under certain circumstances. For instance, in the case of lower priced parallel imports. Consider in figure 3 the country which is located just a little North to the border of protection b and faces a considerable (delivery) price differential between the original Northern product and the Southern imitation, as illustrated by Δp . A court in this country may easily interpret the price differential as being a signal of abuse of monopoly power and hold the patentholder's rights to be exhausted. The main argument for this *exhaustion doctrine* is that it promotes the free trade of new products and sets (indirect) limits to the monopoly price of a patentholder. The patentholder always has to take into account, when choosing his price, that foreign competitors can be permitted to enter. Judging from international case law, the exhaustion doctrine is widely spread. In the US and the EC, for example, it is common practice (Cornish 1989).

In terms of the basic model, the exhaustion doctrine implies that patents only provide protection against imitations or duplications which are made within the patent granting country, but not against cheaper imitations made abroad. The patentholder actually faces import competition from the South now and must compete in the region $[0, b)$ with the closest imitation from country b . In the Northern region there are two firms competing now, the innovator and the imitator from b . The imitator has an advantage in the Southern part of the North because countries located there face higher transport costs when buying from the original innovator. The advantage of the original innovator is that his product provides more surplus. Again assume that the imitation industry in the South is competitive (imitators are present in each country) and that the imitator in b charges the competitive price of $p = 0$. The country which is indifferent between buying from the original innovator at the (perfectly discriminating) price $p^* = v - tw$, and from the imitator in b is given by $w' = (v(1 - \rho) + tb)/(2t)$ (see figure 3). No country to the South of w' buys the original innovation because the surplus from the imitation is larger. Countries to the North of w' all buy the

original innovation at price $p^* = v - tw$.¹¹ The gross profits of the patentholder are given by: $\pi = \int_0^{w'} (v - tw)dw = (v(1 - \rho) + bt)(3v + \rho v - bt)/(8t)$. Based on these gross profits and the innovation production function, the optimal innovation level is: $v^* = bt(1 + \rho)/(\rho^2 + 2\rho + 8\alpha t - 3)$. The welfare in the North now includes the profits of the patentholder, illustrated by the dotted area in figure 3, and the consumer surplus in the countries South of w' that buy an imitation at a competitive price from country b, illustrated by the shaded area. The welfare in the Southern region does not change compared to the basic scenario. [FIGURE 3]

Table 3 compares the globally optimal coverages under the exhaustion doctrine with the ones from the basic analysis. A surprising result emerges for relatively low transport cost ($t = 1/(10\alpha)$ and $t = 1/(8\alpha)$).¹² Under the exhaustion doctrine, the optimal global patent coverage is smaller than in the basic case. The effects of strengthening protection are somewhat different compared to the basic case. The positive effect of a larger b on the profit and innovation level is weakened because part of the increasing demand now goes to the imitator. The negative effect, however, of a larger b on the transport losses is now weakened too. For relatively low transport costs (or high innovation cost), even without much protection, the negative effect is relatively stronger. For higher costs, the results of the basic analysis are confirmed and the optimal levels decrease in t .

Table 3. Optimal patent coverage with and without the exhaustion doctrine ($\rho = 0.8$)

Transport cost t	Exhaustion Doctrine	No Exhaustion Doctrine
$1/(10\alpha)$	0.120	1
$1/(8\alpha)$	0.502	0.941
$1/(4\alpha)$	0.806	0.727
$1/(3\alpha)$	0.746	0.632
$1/(2.1\alpha)$	0.626	0.515

5. Conclusions

A simple locational model of global patent protection is developed which shows that the proposal of the US, the EC and Japan, during the Uruguay Round, to extend protection worldwide, does not need to be beneficial for the global welfare. Strengthening worldwide protection is likely to be beneficial if the imitation capability in the South is poor. The South can then better provide patent protection, thereby improving the Northern innovation incentive, and import the original innovation instead of producing a poor imitation itself. If, however, the imitation capability in the South is better, extending protection might worsen global welfare. An imitation provides then more surplus than the original innovation which involves transport costs. The level of optimal global protection in general decreases for higher transport costs (relative to innovation costs). So innovations which are only locally appropriate should get no worldwide protection. Several extensions of the basic model are examined but in general do not change the main message very much.

It should be stressed here that the above conclusions follow from a model with simple specifications. The transport costs, the R&D cost function, the distribution of consumers and producers could be modelled more generally. Especially the incorporation of non-unitary and elastic national demand curves may lead to richer conclusions. Besides these refinements, some other applications of the model stay also open for future research. The practices of licensing and foreign direct investment, for example, make the transport costs decrease and, consequently, the welfare costs of extending global protection lower. Another application concerns the trade-off between extending patent protection to more countries and improving the protection within countries. This trade-off is very similar to the one occurring in Gilbert and Shapiro (1990) and Klemperer (1990) on the optimal mix of patent length and breadth. In some cases it might be more efficient to provide infinitely long protection in one country and no protection in others, while in other cases shorter lived rights in the whole world might be optimal.

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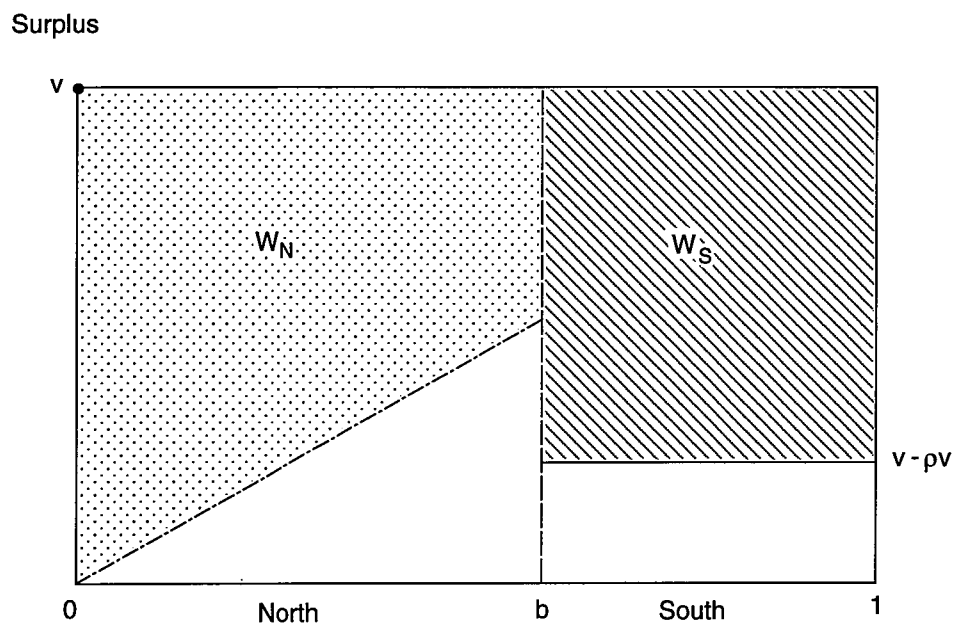


Figure 1 Northern and southern welfare

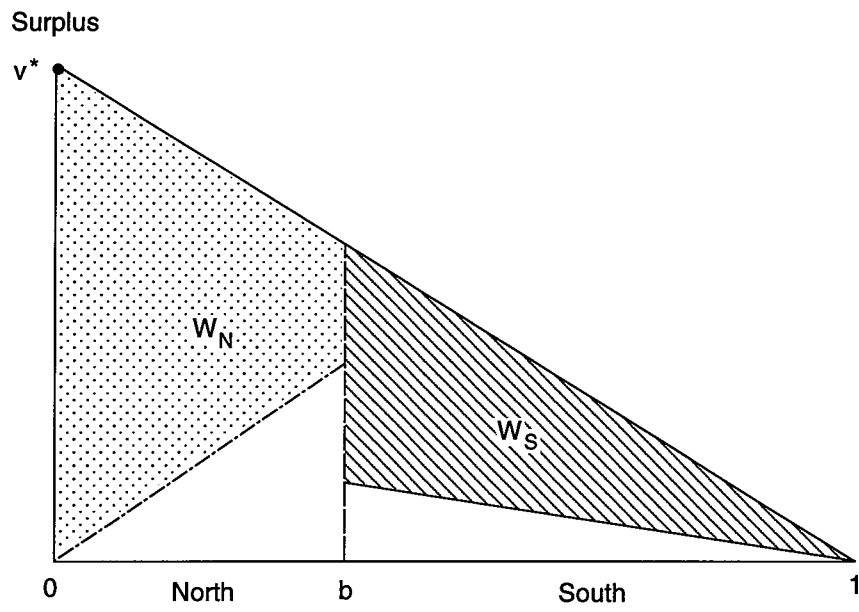


Figure 2 Differences in national income

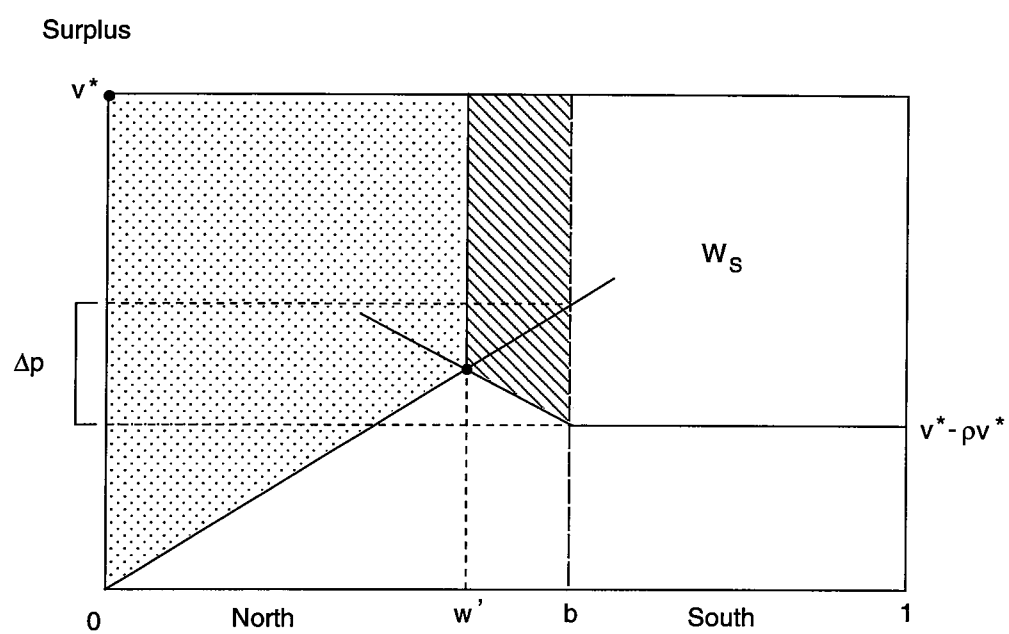


Figure 3 The exhaustion doctrine

NOTES

1. Besides, according to the rules of the Paris Convention, unanimity is not required if an amendment in the form of an agreement, as could be the result of the Uruguay Round, is to be accepted; the adoption of a special agreement only requires the consensus of a limited number of states (Kunz-Hallstein 1989).
2. See Krugman (1979a) for a typical technology gap model and Soete (1981) for empirical evidence on technology driven trade.
3. The first application of location models in a theoretical international trade context is Lösch (1954); later on, Lancaster (1980) was the first using Hotelling-type, or address models in international trade whereas Krugman (1979b) started the Chamberlinian, non-address paradigm of product differentiation in this context.
4. One way of imagining the transformation of the world as a globe into one as a line is the following: collect all countries which are located at the same degree of latitude at one degree of longitude. A location on the line then represents all countries at the same degree of latitude. In the line presentation distances West- and Eastward, between countries at the same degree of latitude, are lost.
5. I am aware that this picture violates the fact that some Southern countries such as New Zealand, Australia and South Africa do provide effective protection.
6. An interesting problem, which will not be studied here, would be how the scope of protection that the North wants for the whole world affects the Southern decision on patent protection. If the scope of protection is narrow and a patentholder consequently has weak monopoly power (Gilbert and Shapiro 1990 and Klemperer 1990), the South may be more inclined to provide effective protection and license the innovation at better terms. In the case of broad protection, on the contrary, the South may be more inclined to illegal borrowing.
7. The assumption that the demand per country is unitary and inelastic of course foregoes the notion of distance within a country and a national demand function.

8. The imitation parameter ρ may, for example, be a function of the national knowledge base which can be dependent on the average level of education or the regional R&D expenditures. See Verspagen (1991) on the determinants of international spill-overs and national learning capabilities. Taylor (1993), on the other hand, develops a model where the ease of imitation is determined by the original innovator, who can masque his innovation as to make imitation more difficult. Finally, the lower surplus of Southern imitations can be the result of a lower *perceived* quality. All three interpretations can be behind the imperfect imitation capability here.

9. The best location for the innovator, from the Northern point of view, would be the centre of the Northern region $w^* = b/2$. The total Northern transport costs $t(b^2 - 2bw^* + 2w^{*2})/2$ are minimized then.

10. Notice that profitable arbitrage can occur. Consider two countries with different income, m_1 and m_2 , with $m_1 > m_2$. Country m_2 can resale the new product to the richer country m_1 (which appreciates the innovation more than itself) and make profits of $v(m_1 - m_2)$. The practice of arbitrage between countries, however, is excluded from the analysis here.

11. Notice that, theoretically, the full discriminating price p^* is not correct since countries North of w' may not have a reservation price of 0 anymore (the alternative of not buying). Their reservation price is the net surplus of the imitation from the South $(pv - t(b - w))$. The true discriminating price for country w is then: $p = \min(v - tw, v - tw - (pv - t(b - w)))$. Although theoretically incorrect, in order to simplify calculations I do not take into account these new reservation prices. The effect is that the profits of the innovator are overestimated and that, consequently, the North gets too much weight in the global welfare function. This might lead to optimal coverages which are too high. Qualitatively, however, the results are very similar.

12. I checked whether for $t = 1/(10\alpha)$ and $b = 0.120$ the net surplus of the indifferent country w' is still positive. This is indeed the case.