Patent protection in developing countries and global welfare: WTO obligations versus flexibilities

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Abstract

This paper develops a North-South model to evaluate incentives for patent protection in the South when a Northern firm's investment in quality-enhancing research and development (R&D) is affected by the South's patent policy. We examine the consequences of requiring the South to offer patent protection and study the interplay between this core *obligation* facing all WTO members and the two main *flexibilities* available to them in the realm of intellectual property: the freedom to implement exhaustion policies of their choosing and the right to use compulsory licensing (CL). We provide conditions under which implementing patent protection in the South raises global welfare as well as when it does not. Two forces drive this welfare calculus: how much the firm invests in R&D and whether or not it finds it profit-maximizing to sell in the South. We show that, provided the firm sells in the South, global welfare and innovation are higher if the North follows national exhaustion as opposed to international exhaustion. Even though CL improves consumer access in the South, it undermines the firm's R&D incentive. Finally, not only is CL more likely to arise in equilibrium under international exhaustion, it is also more likely to be socially efficient relative to entry.

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1 Introduction

Perhaps the most important and controversial multilateral agreement to emerge out of the Uruguay Round of multilateral negotiations that led to the formal establishment of the World trade Organization (WTO) in 1995 was the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS). This landmark agreement requires all WTO members – regardless of their economic status – to offer and enforce certain minimum standards of protection for intellectual property rights (IPRs). As a result of TRIPS, the imitation and reverse-engineering of pharmaceutical products that was widespread in many developing countries became inconsistent with WTO rules. Given the human welfare implications potentially at stake, it is no surprise that most developing countries were adamantly opposed to TRIPS. However, they had to reluctantly accept it since the single undertaking nature of the WTO does not permit member states to pick and choose between its various multilateral agreements on an ala carte basis: to be part of the WTO, member states have to abide by all of its multilateral agreements.[1] Of course, developed countries – where much of world's R&D and intellectual property is located – have always held a rather sanguine view of the need for multilateral disciplines on IPRs in the WTO.

While TRIPS *obligates* all WTO members to adopt certain minimum standards of IPR protection (such as twenty years for patents), it also contains several important *flexibilities* that grant national governments some discretion in the design and enforcement of their respective IPR policies. More specifically, TRIPS provides two major flexibilities to WTO members: the right to use *compulsory licensing* (CL) to ease consumer access to patented products and the freedom to implement *exhaustion policies* of their choosing. This paper analyzes how these two policy flexibilities provided by TRIPS interact with its central obligation, both from the viewpoint of developing countries and global welfare. In so doing, the paper brings together two important but separate strands of the literature on IPRs and international trade: the rather well-developed literature exploring the economics of alternative exhaustion policies and the emerging literature on the effects of CL.[2]

Before describing our analytical approach in detail, we discuss the economically rele-

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[1]Of course, not all agreements at the WTO are multilateral in nature. For example, the Agreement on Government Procurement is a *plurilateral* agreement (i.e. only a subset of WTO members are signatories). It is clear, however, that a plurilateral approach would simply not have worked for TRIPS since it would have given developing countries (which is where IPR regimes were generally weak) the freedom to opt out.

[2]Major contributions to the literature on exhaustion of IPRs include Malueg and Schwarz (1994), Scherer and Watal (2002), Li and Maskus (2006), Valetti (2006), Ganslandt and Maskus (2004), Grossman and Lai (2008), Roy and Saggi (2012), and Saggi (2013). By contrast, the formal literature on CL is fairly nascent and recent contributions to it are Bond and Saggi (2014, 2017a, and 2017b).

vant institutional aspects of the two TRIPS flexibilities motivating this paper. Consider CL first. As per TRIPS rules, when a country is faced with no or limited access to a patented foreign product, it has the right to issue a compulsory license to someone other than the patent-holder to produce the product.[3] Article 31 of TRIPS provides conditions under which WTO members can resort to CL of a patent. This Article stipulates that the country issuing a compulsory license should provide adequate remuneration to the patent-holder and that the license should be granted mainly to supply the domestic market. Our model incorporates both of these key features of Article 31.

Now consider the policy flexibility available to WTO members with respect to exhaustion of IPRs. Article 6 of TRIPS explicitly states that "nothing in this Agreement shall be used to address the issue of the exhaustion of intellectual property rights". Exhaustion policies determine the legality of *parallel trade* – i.e. the type of trade that occurs when a product protected by an IPR offered for sale by the right holder in one country is re-sold in another country without the right holder's permission. As is clear, the incentive to engage in such trade naturally arises in the presence of significant international price differences. Furthermore, since parallel trade flows from low-price markets to high-price ones, the exhaustion policies of high-price markets are likely to be more consequential than those of low-price ones.[4] Accordingly, in our North-South framework we consider the effects of alternative exhaustion policies on the part of the North.[5] We examine *national* and *international* exhaustion: under the former policy, the North prohibits parallel imports into its market whereas under the latter policy, it permits it. The key difference between the two exhaustion policies from the perspective of the firm is that under national exhaustion it can charge its optimal monopoly price in each market whereas under international exhaustion it faces a trade-off: it can either sell only in the North at its optimal price for that market or sell in both markets at a common international price (so as to eliminate the flow of parallel imports into the Northern market). As a result, the firm is less inclined to sell in the South when the North implements international exhaustion.

Our stylized North-South model involves two parties: the Southern government and a Northern firm who faces perfect IPR protection its home market in the form of a patent that lasts for T periods. The timing of decision making is as follows. In the first period, the South decides whether or not to institute patent protection in its market while the firm chooses its investment in research and development (R&D) that determines the quality of its product. Given South's patent protection decision and the quality of its

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[3]The word 'compulsory' reflects the fact that the country issuing the license does not have to obtain the patent-holder's consent (who has not choice but to comply).

[4]See Maskus (2000b) for a discussion of the observed variation in exhaustion policies across countries.

[5]In our model, the exhaustion policy of the South is immaterial since equilibrium price is always (weakly) higher in the Northern market.

product, the firm decides whether or not to incur the fixed cost of entry necessary for selling its product in the Southern market. As in related literature, our model assumes that if the South does not implement patent protection the firm's technology diffuses in the Southern market and a competitive local industry producing an imitated version of the firm's product comes into existence. Due to the limited technological capability of the South, the quality of the imitated product is assumed to be (weakly) lower than that of the original.

Our core model assumes that the North follows national exhaustion and it focuses on the South's incentive for patent protection as well as the consequences of requiring it to institute patent protection when it does not wish to do so voluntarily. We derive three main results. First, we find that the South chooses to institute patent protection iff such protection is necessary and sufficient to induce entry by the firm and the quality disadvantage suffered by local imitators is sufficiently large. This finding clarifies exactly when the South finds it in its interest to voluntarily offer patent protection to the Northern firm. Our second key finding is that the introduction of patent protection in the South increases the firm's R&D investment as well as its incentive to enter the Southern market. The beneficial effect of Southern patent protection on R&D has consequences for not just the firm but also Northern consumers. The third major result delivered by the core model is that even if the firm is willing to sell in the South in the absence of local patent protection, providing such protection increases global welfare since the South's incentive for patent protection is too weak relative to what is jointly optimal. This last result provides a potential rationale for the strengthening of patent protection required under TRIPS. However, we also find that if the firm does not sell in the South even when it's granted patent protection, then forcing the South to offer such protection lowers global welfare. The intuition here is that if the Southern market does not factor into the firm's global profit then its patent policy has no implications whatsoever for its R&D decision. Under such a situation, denying Southern consumers access to the imitated product inflicts a loss on them without generating *any* gains for the firm or Northern consumers.

As the above discussion clarifies, an important driver of the welfare consequences of Southern patent protection in our model is its effect on the firm's entry decision. How relevant is this channel empirically? A well-developed empirical literature has demonstrated beyond doubt that this channel is very much operative in the real world. For example, using export data at the 3-digit ISIC level from 1962-2000, Ivus (2010) investigates the impact of TRIPS induced IPR reforms in developing countries on the exports of developed countries to their markets and finds that the strengthening of IPR protection undertaken by 18 non-colonies (in her set of 53 developing countries) increased the annual value of developed country exports to their markets in patent-sensitive industries by about $35 million (or about 8.6%). She also shows that the increases in the value of

imports was driven largely by changes in quantities as opposed to prices.[6] Using data on launches of 642 new drugs in 76 countries during 1983-2002, Cockburn et al. (2016) estimate that, controlling for a variety of economic and demographic factors, starting from the complete lack of patent protection, the introduction of product patents (lasting 18 years) increases the per-period hazard of drug launch in a country by about 55%. This finding is of vital importance since new drugs are launched only in a handful of rich countries and usually become available in other parts of the world with significant delay. For example, in their entire sample of 642 new drugs, 39% were launched in ten or fewer countries and only 41% were launched in more than 25 countries.[7]

We extend the core model to analyze the role of the two key TRIPS flexibilities discussed above: the South's right to use compulsory (CL) licensing and the North's right to implement the exhaustion policy of its choosing. Consistent with TRIPS rules, we incorporate CL in our analysis as follows: given that the South offers patent protection and the patent-holder chooses not to enter in the first period, for the remaining duration $(T-1)$ periods) of the patent the South has the authority to issue a compulsory license to a local producer who is required to set price equal to marginal cost. In the event of CL, the South pays a per-period royalty R to the Northern firm. This royalty captures the adequate remuneration requirement of Article 31 of TRIPS.

Since CL can only occur when the South implements patent protection, we analyze the effects of CL given the existence of patent protection in the South. Accommodating CL into the model generates two important results. First, making CL available to the South has an adverse effect on the firm's R&D incentive: whenever parameters are such that the firm prefers CL to entry, it chooses to invest less in R&D because the payoff under CL does not respond to the quality of its product in the way that it does under entry. Second, we identify circumstances where CL is preferable to entry from a joint welfare perspective as well as when it is not. The welfare trade-off between the two modes is that while CL dampens R&D incentives and delivers a lower quality product to Southern consumers, it also economizes on the fixed cost of entry. Thus, entry is jointly efficient whenever the fixed cost of entry is low and the technological disadvantage under CL is large. Conversely, CL dominates entry if the quality of production under CL is fairly close to that under entry and the cost of entry is relatively high.

Next, we examine how the firm and consumers in the two region fare if the North were to implement international exhaustion as opposed to national exhaustion. As in

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related literature, we find that holding constant the South's patent protection policy, the firm is more willing to sell in the South under national exhaustion. Furthermore, the South is better off under national exhaustion due to two separate reasons: first, holding constant the quality of the product across the two exhaustion regimes, price in the South is lower under national exhaustion. Second, the Northern firm invest more in R&D and therefore delivers a higher quality product under national exhaustion. From the North's viewpoint, these two forces work against each other: price is higher under national exhaustion but quality is also higher. All in all, national exhaustion delivers higher joint welfare than international exhaustion. This result fits well with the traditional argument that parallel trade reduces innovation incentives by undermining the ability of IPR holders to profit from their R&D investments.[8]

How do Southern incentives for patent protection depend upon North's exhaustion policy? As in the case of national exhaustion, the South chooses to provide patent production under international exhaustion only when its imitative ability is low and patent protection is necessary to induce entry by the firm although the relevant thresholds are not the same under the two scenarios. Interestingly, the fact that profits from entry are lower under international exhaustion results in an ambiguous relationship between North's exhaustion policy and Southern patent protection. Relative to national exhaustion, both the maximum level of the fixed entry cost below which the South is willing to offer patent protection and the minimum level of fixed entry cost above which patent protection is desirable for the South are lower under international exhaustion. As a result, the relationship between North's exhaustion policy and South's incentive for patent protection is generally ambiguous. This ambiguity implies that Northern R&D could be either higher or lower under national exhaustion once the induced effect of the South's patent policy on R&D is taken into account.[9] Finally, we examine the interaction between CL in the South and the nature of Northern exhaustion policy and show that not only is compulsory licensing more likely to arise in equilibrium under international exhaustion, it is also more likely to be socially efficient relative to entry.

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[8]We should note, however that several papers have shown that the traditional argument against parallel trade need not always hold. See, for example, Li and Maskus (2006), Li and Robles (2007), and Grossman and Lai (2008). In a model similar to us, assuming that the monopolist necessarily serves all markets, Valletti (2006) has shown that whether national exhaustion delivers more R&D than international exhaustion depends upon the underlying reason for international price discrimination on the part of the monopolist. He shows that when such discrimination is demand-based (as is the case in our model) then incentives for quality improvement are lower when parallel trade can occur but the opposite is true when discrimination arises because the monopolist faces different costs of accessing markets. See also Valletti and Szymanksi (2006).

[9]Grossman and Lai (2008) examine a case where the South government provides patent protection but also can set a price control for the patented product. They argue that there is a presumption that the induced change in the price control due to a switch from national to international exhaustion results in an increase in R&D.

2   Model

We consider a world economy comprising two regions: North (N) and South (S) denoted by subscript i where $i = N, S$. A single Northern firm sells a patented product (x) with quality level q (endogenously determined). While the firm's technology is protected in the North via the enforcement of intellectual property rights (IPRs), it is potentially subject to imitation in the South.

Our core model is a three stage game between the firm and the Southern government. In the first stage, the South chooses whether or not to offer patent protection in its market. Next, the firm invests in R&D that determines the quality of its product. Finally, given the policy set by the Southern government and the quality of its product as determined by its R&D investment, the firm decides whether or not to enter the South by incurring the fixed cost φ.

2.1   Demand and payoffs

Each consumer in region i buys at most 1 unit of the good at the local price p_i, where $i = N, S$. The number of consumers in region i equals n_i. If a consumer buys the good, her utility is given by $u_i = q\theta - p_i$, where θ measures the consumer's taste for quality. Utility under no purchase equals zero. For simplicity, θ is assumed to be uniformly distributed over the interval $[0, \mu_i]$ where $\mu_i \geq 1$.

Demand structures in the two regions differ in two ways. First, Northern consumers value quality relatively more, that is, $\mu_N = \mu \geq 1 = \mu_S$. Second, the Northern market is larger: $n_H = n \geq 1 = n_F$. As one might expect, given these differences in demand, the firm has an incentive to price discriminate internationally. We assume that the North practices national exhaustion of IPRs so that the firm is free to set a market specific price in each region to maximize its global profit.[10] Let the firm's marginal cost of production equal zero. The firm's monopoly in the North lasts for the entire life of the product (which equals T periods). In the South, it enjoys monopoly status only if the South offers patent protection.

If the South does not offer patent protection, the firm's technology is imitated locally and imitation leads to the emergence of a competitive industry that produces a lower quality version of the firm's product. Let the quality of the Southern imitation be

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[10]In section 3.2, we consider a scenario where the Northern policy is international exhaustion under which the firm ends up setting a common international price to eliminate competition from parallel imports.

denoted by γq where $0 < \gamma \leq 1$.[11] Observe that when $\gamma = 0$, the South is incapable to imitation so that its patent protection policy becomes moot.

2.1.1 Pricing and profits

If the South offers patent protection to the firm and the firm chooses to sell there, it sets its market-specific price in each period to solve:

$$\max_{p_N} \ \pi_N(p_N) \equiv n p_N (1 - p_N/\mu q) \text{ and } \max_{p_S} \pi_S(p_S) \equiv p_S(1 - p_S/q) \tag{1}$$

It is straightforward to show that the firm's optimal prices in the two markets are: $p_N^*(q) = \mu q/2$ and $p_S^*(q) = q/2$. The associated sales in each market equal $x_N^* = n/2$ and $x_S^* = 1/2$. Denote the firm's maximized profit in region i when the South offers patent protection by $\pi_i^*(p_i^*(q))$ where $\pi_N^* = n\mu q/4$ and $\pi_S^* = q/4$.

In the absence of Southern patent protection, competition within the Southern imitative industry ensures that the imitated good is sold at marginal cost in the local market.[12] Given our assumptions on consumer preferences, when two different qualities are available for purchase at prices p_S (high quality) and 0 (low quality), Southern consumers can be partitioned into two groups: those in the range $[0, \theta(p_S; \gamma)$ buy the low quality whereas those in $[\theta(p_S; \gamma), 1]$ buy the high quality where

$$\theta(p_S; \gamma) = \frac{p_S}{q(1 - \gamma)} \tag{2}$$

When facing competition from imitation in the Southern market, the patent-holder chooses its Southern price p_S to maximize

$$\max_{p_S} \ \pi_S(p_S; \gamma) = p_S[1 - \theta(p_S; \gamma)]$$

The firm's profit maximizing price in the face of imitation equals $p_S^I = q(1 - \gamma)/2 = (1 - \gamma)p_S^*$ where the superscript I indicates the presence of competition between the patent-holder and the imitative industry. Observe that $p_S^I < p_S^*$ since $0 < \gamma \leq 1$.

Let $\beta \in [0, 1)$ be the per period discount factor so that the present value of the firm's profits from region i equals

$$(1 + \Omega)\pi_i^*(q) \text{ where } \Omega = \sum_{t=1}^{T} \beta^t \tag{3}$$

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[11] In the context of the pharmaceutical industry the imitated product is probably best viewed as a generic that can only be sold in the South.

[12] We assume that due to enforcement of IPRs in the North, the imitated product can only be sold in the South.

Competition from imitation lowers the firm's gross payoff from entering the Southern market to

$$v_S^I(q; \gamma) = (1 + \Omega)(1 - \gamma)\pi_S^*(q) = (1 - \gamma)v_S^*(q) \tag{4}$$

The per-period consumer surplus that accrues to region in i from purchasing the product at price p_i equals

$$cs_i = n_i \int\limits_{p_i/q}^{\mu_i} \frac{(q\theta - p_i)}{\mu_i} d\theta = \frac{n_i(\mu_i q - p_i)^2}{2q\mu_i} \tag{5}$$

2.1.2 R&D and Entry

While conducting its R&D, the firm makes a forward looking decision that takes into account both the fixed cost of selling in the South and the policies of the two governments. We require that the firm's R&D investment be time-consistent with its eventual decision regarding entry into the Southern market. For simplicity, we assume that the cost function for R&D is $c(q) = tq^2/2$ where $t > 0$.

Given patent protection, the firm's optimal R&D investment when it intends to sell in both markets solves

$$\max_q \ (1 + \Omega) \sum_i \pi_i^*(q) - c(q)$$

Let the solution to this problem be denoted by q^* and let

$$v^*(q^*) = (1 + \Omega) \sum_i \pi_i^*(q^*) - c(q^*)$$

If the firm intends to sell only in the Northern market, it solves

$$\max_q \ (1 + \Omega)\pi_N^*(q) - c(q)$$

Denote the firm's optimal R&D investment when it sells only in the North by q^N and let

$$v^N(q^N) = \ (1 + \Omega)\pi_N^*(q^N) - c(q^N)$$

It is easy to show that $q^N < q^*$ – i.e. the firm invests more in R&D when it sells in both markets relative to when it sells only at home since the marginal benefit of R&D is strictly higher in the former case.

Given these optimal R&D investments, the firm prefers selling in both markets to selling only at home iff

$$v^*(q^*) - \varphi \geq v^N(q^N)$$

Let
$$\varphi^* \equiv v^*(q^*) - v^N(q^N)$$
define the threshold value of the fixed cost φ below which the firm prefers selling in both markets to selling only at home. We can show that $\partial \varphi^* / \partial n > 0$ and $\partial \varphi^* / \partial \mu > 0$: when there is patent protection in the South, there is a *positive* link between the relative size and profitability of the Northern market (as captured by n and μ) and the incentive to sell in the South since the firm's R&D investment is based on the global market. A larger or more profitable Northern market increases the firm's incentive to invest in R&D which, ex post, also makes it more attractive for it to sell in the South.

The firm's maximized payoff function under patent protection equals

$$\begin{cases} v^*(q^*) - \varphi \text{ if } \varphi \leq \varphi^* \\ \\ v^N(q^N) \text{ if } \varphi > \varphi^* \end{cases}$$

The firm's R&D decision in the absence of patent protection in the South is analogous to above. Let

$$q^I = \arg\max_q (1 + \Omega)[(1 - \gamma)\pi_S^*(q) + \pi_N^*(q)] - c(q)$$

and let

$$v^I(q^I) = (1 + \Omega)[(1 - \gamma)\pi_S^*(q^I) + \pi_N^*(q^I)] - c(q^I)$$

Since imitated products are not sold in the North, the firm's R&D investment if it sells only in the North continues to equal q^N. Given this, when facing competition from imitated products in the South, the firm prefers selling in both markets to selling only at home iff

$$\varphi \leq \varphi^I \text{ where } \varphi^I \equiv v^I(q^I) - v^N(q^N)$$

We can show that $\partial \varphi^I / \partial n > 0$ and $\partial \varphi^I / \partial \mu > 0$. As before, these comparative statics arise from the fact that increases in n or μ induce the firm to invest more in R&D (i.e. $\partial q^* / \partial n > 0$ and $\partial q^* / \partial \mu > 0$) so that the profit that accrues to the firm from the Southern market increases thereby making it more willing to enter. Furthermore, as one might expect, $\partial \varphi^I / \partial \gamma < 0$; $\partial^2 \varphi^I / \partial^2 \gamma > 0$; and if $\gamma = 0$ we have $\varphi^I = \varphi^*$. Finally, note that $\varphi^I = 0$ when $\gamma = 1$ – i.e. if Southern imitation suffers from no quality disadvantage relative to the patented product then the firm is unwilling to enter the South even when such entry entails no fixed costs since price competition eliminates all rents in such a situation.

The firm's maximized payoff in the absence of Southern protection equals

$$
\begin{cases}
v^I(q^I) - \varphi \text{ if } \varphi \leq \varphi^I \\
\\
v^N(q^N) \text{ if } \varphi > \varphi^I
\end{cases}
$$

We can show the following:

Proposition 1. *The lack of patent protection in the South reduces the firm's R&D investment (i.e. $q^I \leq q^*$) as well as its incentive to enter the Southern market (i.e. $\varphi^I \leq \varphi^*$). Furthermore, changes in the pattern of Northern demand (such as increases in μ or n) that increase the firm's R&D investment (q^*) strengthen its incentive to sell in the South (i.e. $\partial\varphi^*/\partial n > 0$ and $\partial\varphi^*/\partial\mu > 0$). Finally, the stronger the intensity of imitative competition in the South, the lower the firm's investment in R&D (i.e. $\partial q^I/\partial\gamma < 0$) and the weaker its incentive to sell in the South (i.e. $\partial\varphi^I/\partial\gamma < 0$).*

2.2 Southern patent protection

The South sets its patent protection policy anticipating the patent-holder's R&D and entry decisions. We assume that the objective of the South is to maximize local consumer welfare over the life of the product. As we explain below, Southern consumer surplus depends upon not just its patent protection policy but also on the R&D and entry decisions of the firm.

Southern welfare under patent protection equals

$$
\begin{cases}
w_S^*(q^*) = (1 + \Omega)cs_S(p_S^*(q^*)) \text{ if } \varphi \leq \varphi^* \\
\\
0 \text{ if } \varphi > \varphi^*
\end{cases}
$$

Note that when $\varphi > \varphi^*$, the firm does not sell in the South even if its patent is protected and Southern consumers have no access to its product so that $w_S = 0$.

If the South permits imitation and the firm sells only in the Northern market, then Southern consumers have access to only the low quality imitated product and per-period consumer surplus equals

$$
cs_S^L(\gamma q_N) = \int_0^1 \gamma q_N \theta d\theta, \tag{6}
$$

whereas if the firm sells in both markets then per-period consumers surplus in the South equals

$$
cs_S(p_S^I(q^I); \gamma) = \int_0^{1/2} \gamma q^I \theta d\theta + \int_{1/2}^1 \left[q^I \theta - p_S^I(q^I)\right] d\theta
$$

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Thus, the Southern welfare function in the absence of patent protection equals

$$
\begin{cases}
w_S^I(q^I) = (1+\Omega)cs_S(p_S^I(q^I); \gamma) \text{ if } \varphi \leq \varphi^I \\
\\
w_S^L(\gamma q^N) = (1+\Omega)cs_S^L(\gamma q^N) \text{ if } \varphi > \varphi^I
\end{cases}
$$

When $\varphi > \varphi^I$, the firm does not enter the Southern market and local consumers obtain access (only) to the lower quality imitated good at a price equal to marginal cost (set to zero) and Southern welfare equals $w_S^L(q^N; \gamma)$ where the superscript L indicates that Southern consumers have access to only the low-quality imitated product. However, if the firm enters the Southern market despite imitation (which it does when $\varphi \leq \varphi^I$), Southern welfare equals $w_S^I(q^I; \gamma)$. Observe that since the firm does greater R&D when it sells in both markets, the quality of the product that Southern consumers obtain access to via imitation is lower when the firm sells only in the Northern market (i.e. $q^I \geq q^N$).

It is straightforward to show the following:

Lemma 1. *The following hold: (i) $w_S^I \geq \max\{w_S^*, w_S^L\}$ and (ii) there exists γ^* such that $w_S^* \geq w_S^L$ iff $\gamma \leq \gamma^*$ where $\partial \gamma^*/\partial n < 0$ and $\partial \gamma^*/\partial \mu < 0$.*

Lemma 1 says that the South's most preferred outcome is one where it allows imitation and the firm enters its market despite the competition it faces from imitators. The reason $w_S^I \geq w_S^L$ is easy to see: not only do local consumers have access to both products when the firm enters despite imitation, the quality of the two products is also higher since the R&D investment of the firm is higher when it sells in both markets ($q^I \geq q^N$).

Given that the firm is willing to sell in the South even without IPR protection, Southern consumers value imitation due to two reasons. First, imitation increases variety in the local market and those Southern consumers that are unwilling to pay the price for the high quality patented product gain access to the low quality imitated version that sells at a lower price. Second, competition from the imitated product lowers the price of the high quality patented product. However, these two positive effects of imitation are counterbalanced by the fact that offering patent protection induces the firm to invest more in R&D so that the quality of the patented product is higher under patent protection ($q^* > q^I$). It turns out that, from the South's perspective, the two positive effects of imitation on consumer welfare dominate the negative effect that results from the reduction in the firm's R&D investment. As a result, given that the firm sells in its market, the South is better off without patent protection.

Finally, when the firm sells in the South only if its patent is protected, the South faces the following trade-off: it can either provide local consumers with the high quality

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patented product at the firm's optimal monopoly price or the low quality imitated product at the competitive price (i.e. at marginal cost). In such a scenario, the South is better off with patent protection only when the quality disadvantage suffered by local imitators is sufficiently large (i.e. $\gamma \leq \gamma^*$). An important point to note here is that the larger or more profitable the Northern market is, the less likely the South is to offer patent protection (i.e. $\partial \gamma^*/\partial n < 0$ and $\partial \gamma^*/\partial \mu < 0$) because Southern protection is relatively less important for incentivizing R&D when n and/or μ are large.

We can now state the following:

Proposition 2. *In equilibrium, the South offers patent protection to the firm iff such protection is necessary and sufficient to induce entry by the firm (i.e. $\varphi \in [\varphi^I, \varphi^*]$) and the quality disadvantage suffered by local imitators is sufficiently large (i.e. $\gamma \leq \gamma^*$).*

2.3 Global welfare and TRIPS

Northern welfare when the South implements patent protection equals

$$
\begin{cases}
w_N^*(q^*) - \varphi \text{ where } w_N^*(q^*) = (1 + \Omega)cs_N(p_N^*(q^*)) + v^*(q^*) \text{ if } \varphi \leq \varphi^* \\
\\
w_N^N(q^N) = (1 + \Omega)cs_N(p_N^*(q^N)) + v^N(q^N) \text{ if } \varphi > \varphi^*
\end{cases}
$$

whereas Northern welfare in the absence of patent protection equals

$$
\begin{cases}
w_N^I(q^I) - \varphi \text{ where } w_N^I(q^I) = (1 + \Omega)cs_N(p_N^I(q^I)) + v^I(q^I) \text{ if } \varphi \leq \varphi^I \\
\\
w_N^N(q^N) = (1 + \Omega)cs_N^N(p_N^*(q^N)) + v^N(q^N) \text{ if } \varphi > \varphi^I
\end{cases}
$$

It is obvious that the firm is better off when the South offers patent protection relative to when it does not. A slightly more subtle observation is that Southern patent protection is also in the interest of Northern consumers since, given that the firm sells in both markets, the firm invests more in R&D when its patent is protected relative to when it is not – i.e. the quality of the product sold in the North is higher if the South implements patent protection (i.e. $q^* > q^I$) when the firm sells in the South. A related point is that, all else equal, Northern consumers benefit if the firms sells in the South since it invests more in R&D when it serves both markets relative to when it sells only at home (i.e. $q^* > q^N$ and $q^I > q^N$). Of course, both the firm and the Southern government ignore the impact of their respective decisions on Northern consumers.

Global welfare under Southern patent protection equals

$$
\begin{cases}
w^*(q^*) - \varphi \text{ where } w^*(q^*) = w_N^*(q^*) + w_S^*(q^*) \text{ if } \varphi \leq \varphi^* \\
\\
w^N(q^N) = w_N^N(q^N) \text{ if } \varphi > \varphi^*
\end{cases}
$$

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whereas in the absence of patent protection it equals

$$
\begin{cases}
w^I(q^I) - \varphi \text{ where } w^I(q^I) = w^I_S(q^I) + w_N(q^I) \text{ if } \varphi \leq \varphi^I \\
\\
w^L(q^N; \gamma) = w^L_S(\gamma q^N) + w^N_N(q^N) \text{ if } \varphi > \varphi^I
\end{cases}
$$

We have:

Proposition 3. *(i) Even if the firm is willing to sell in the South in the absence of patent protection (i.e. $\varphi \leq \varphi^I$), providing such protection increases world welfare: $w^I(q^I) < w^*(q^*)$.*

(ii) If patent protection is necessary to induce the firm to sell in the South (i.e. $\varphi^I < \varphi < \varphi^*$), it is jointly optimal to provide such protection iff $\varphi < \varphi^w$ where $\varphi^w \equiv w^*(q^*) - w^L(q^N; \gamma)$ where (a) $\partial \varphi^w / \partial \gamma < 0$, $\partial \varphi^w / \partial n > 0$, and $\partial \varphi^w / \partial \mu > 0$, and (b) $\varphi^w \geq \varphi^*$ iff $\gamma \geq \gamma^w$ where (a) $\gamma^w > \gamma^*$, (b) $\partial \gamma^w / \partial n < 0$ and $\partial \gamma^w / \partial \mu < 0$.[13]

(iii) If the firm does not sell in the South even if its granted patent protection (i.e. $\varphi > \varphi^*$), then offering such protection lowers welfare: $w^L(q^N; \gamma) > w^N(q^N)$.

Figure 1 illustrates the South's optimal patent policy as well as the firm's equilibrium decision and it proves useful for assessing the welfare effects of TRIPS. In this figure, the equilibrium outcome is denoted by pair (X, Y) where $X = P$ or I where P denotes the existence of patent protection in the South and I denotes imitation (or, equivalently, the absence of patent protection) and $Y = E$ or N denotes the firm's equilibrium choice, with E denoting entry and N its decision to stay out of the Southern market. Furthermore, the joint welfare maximizing outcome is denoted by an asterisk.

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[13]The three statements of Lemma 1 together imply that joint welfare is maximized by having the South offer patent protection whenever $\varphi \leq \min\{\varphi^*, \varphi^w\}$.
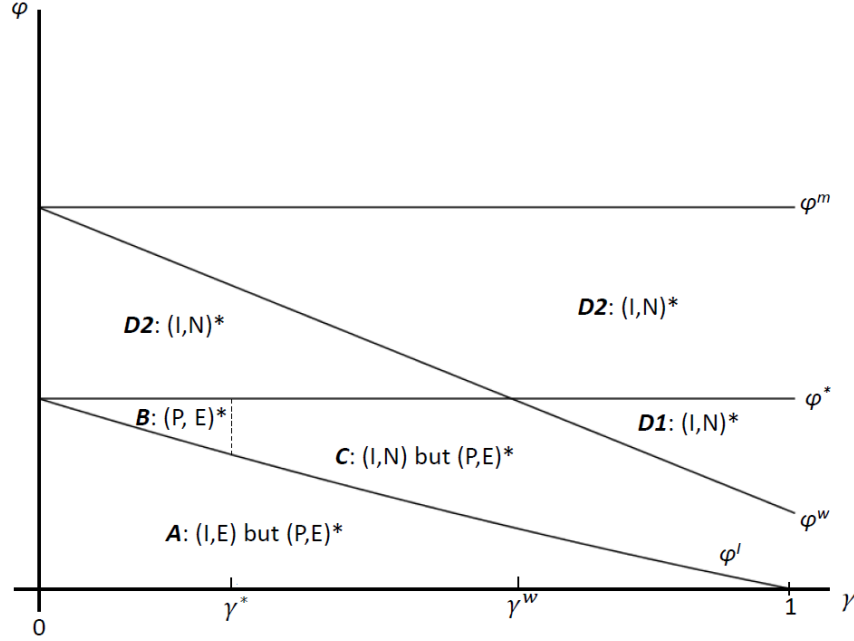
Figure 1: Equilibrium outcomes and efficiency

In Figure 1, the South chooses to offer patent protection in only region **B** since its technological disadvantage over this region is large (i.e. $\gamma \leq \gamma^*$) and patent protection is necessary to induce the firm to enter its market (i.e. $\varphi^I < \varphi < \varphi^*$). For all other parameter values, the South chooses to deny patent protection to the firm. Whereas South offers patent protection only over region **B** in Figure 1, it is jointly optimal to offer it over regions **A**, **B**, and **C**. While setting its patent policy, though the South accounts for the effects of R&D on local consumers, it ignores not just the profit effects of R&D but also the benefits enjoyed by Northern consumers.

Figure 1 shows that once the effects of Southern patent policy on all parties are accounted for, it is generally optimal to institute patent protection in the South whenever the firm is willing to enter given protection (i.e. $\varphi \leq \varphi^*$) except for when γ is high and φ is close to or exceeds φ^* (i.e. in region **D1**). In region **D1**, $\varphi \simeq \varphi^*$, the Southern market yields very little to the firm in the way of rents and is therefore not particularly consequential for incentivizing innovation on its part and the negative spillover on Northern consumers caused by the lack of patent protection in the South is rather small. Furthermore, since γ is near 1 in region **D1**, the imitative capacity of the South is high (and the local product is fairly close in quality to the Northern product). Under such circumstances, offering patent protection to induce entry by the firm is especially damaging to Southern consumers since the patented product is sold at monopoly price whereas the local imitated product is available at price equal to marginal cost. When

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$\varphi > \varphi^*$ (i.e. in region **D2**) the Southern market has absolutely no effect on innovation since the firm has no interest in selling there even if its patent is protected. As a result, all over region **D2**, the lack of patent protection in the South does not affect the firm or Northern consumers while offering large gains to Southern consumers, thereby making it socially optimal.

What are the implications of shutting down Southern imitation (i.e. TRIPS)? As Figure 1 shows, such a policy change raises welfare in regions **A** and **C** whereas it lowers it in region **D1** and **D2**. In region **A**, although the firm sells the South even in the absence of patent protection, TRIPS raises welfare by increasing the firm's R&D investment. In region **C**, while patent protection does not induce entry by the firm, the benefits to the South of imitation are trumped by the losses suffered by the firm and Northern consumers owing to its reduced R&D. For $\varphi > \varphi^*$ (i.e. region **D2**), the firm continues to stay out of the South even when its granted patent protection. As a result, its R&D incentive is unchanged due to TRIPS, and shutting down imitation makes the South lose access to the imitated product without conferring any welfare gain on the North. Thus, for all $\varphi > \varphi^*$, enforcing patent protection in the South reduces welfare. Finally, as explained above, over region **D1**, while the North loses from lack of patent protection, its loss is dominated by South's gain due to its strong ability to imitate.

To better understand the consequences of requiring the South to offer patent protection, it is useful to consider the globally optimal level of R&D investment. Assuming the South implements patent protection and the firm sells in both markets, the globally optimal R&D is given by

$$q_w \equiv \arg\max w_N^*(q) + w_S^*(q)$$

where we can show that $q_w > q^*$ – i.e. the firm under-invests in R&D since it does not take into account the additional consumer surplus generated by its R&D investment. Similarly, the optimal R&D investment for when the firm sells only in the North is defined by $q_w^N \equiv \arg\max w_N^*(q)$ where $q_w^N > q^N$.[14] Thus, in our model, patent protection is attractive whenever it helps nudge the firm's R&D investment in the right direction.

3   Compulsory licensing and exhaustion policy

We first extend our model to allow for the possibility of compulsory licensing and then examine the robustness of our key conclusions for the case where the North practices international exhaustion of IPRs.

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[14]Note that we could also discuss the socially optimal entry thresholds if R&D is done at the socially optimal level.

3.1 Incorporating compulsory licensing

As noted above, forcing the South to offer patent protection can lead to a situation where the imitated product is eliminated from its market but the patent-holder still does not enter. Under such a situation, patent enforcement hurts the South without offering any benefit to the North. As we noted earlier, in such a situation, the South has the option of issuing a compulsory license to a local producer who is granted the authority to produce the patented product for the local market.

We now extend the model to include a fourth stage where the South decides whether or not to use compulsory licensing. We assume that only if the patented product has not been sold in the South in the first period, can the South issue a compulsory license to a local firm. In the event of CL, the South pays a per-period royalty R to the patent-holder for the duration of the patent.

The firm takes the possibility of CL into account when making its R&D decision. At the R&D stage, the firm foresees two options for selling in the South: (a) incur the fixed cost φ and enter or (b) stay out of the South in the first period and wait for CL to occur in the next period. Observe that the firm's optimal R&D investment when it expects to avail of CL equals q^N. This is because this R&D investment is chosen to maximize $v^N(q) + \Omega R$ which is the same as maximizing $v^N(q)$. As before, the firm's R&D investment when it plans to enters equals q^*.

Given these R&D investments, the firm prefers entry to CL iff

$$v^*(q^*) - \varphi \geq \Omega R + v^N(q^N) \Leftrightarrow \varphi \leq \varphi^*_{CL} \equiv v^*(q^*) - v^N(q^N) - \Omega R \qquad (7)$$

Observe that $\varphi^*_{CL} = \varphi^* - \Omega R$, i.e., the possibility of CL makes the firm less willing to enter the Southern market. This reduced entry incentive in turn undermines the firm's R&D incentive:

Proposition 4. *For $\varphi \in [\varphi^*_{CL}, \varphi^*)$ the possibility of CL reduces the firm's R&D investment from q^* to q^N.*[15]

The welfare of the South under CL equals:

$$w_S^{CL}(\gamma, R) = \Omega \left[cs_S(\gamma q^N) - R \right] \qquad (8)$$

CL is a credible threat for $w_{CL}^S(\gamma q^N, R) \geq 0 \Leftrightarrow \gamma \geq \gamma_m$ where $\gamma_m = R/p_S^*(q^N)$. Thus, CL is a credible threat so long as the quality of licensed production is not so low that

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[15] For all other parameter values, the possibility of CL does not affect the firm's R&D investment. For $\varphi < \varphi^*_{CL}$, it invests q^* whereas for $\varphi > \varphi^*$ it invests q^N.

the consumer surplus generated for Southern consumers by CL is insufficient to cover the royalty R paid to the firm.

South prefers CL to entry iff

$$w_S^*(q^*) \leq w_S^{CL}(\gamma, R) \Leftrightarrow (1 + \Omega)cs_S(p_S^*(q^*)) \leq \Omega \left[cs_S(\gamma q^N) - R \right]$$

which is the same as

$$\gamma \geq \gamma_{CL} \equiv (1 + 1/\Omega)\gamma^* + \gamma_m \tag{9}$$

Note that the minimum value of γ above which the South prefers CL to entry, γ_{CL}, exceeds the minimum value at which imitation is preferred to entry, γ^*, because CL delays access to the product relative to imitation while also requiring royalties to be paid to the firm. The term $1 + 1/\Omega$ captures the importance of the delay relative to the overall life of the product while the term $R/p_S^*(q^N)$ reflects the importance of the royalty payment. Furthermore, as expected $\gamma_{CL} > \gamma_m$.

We can show that $\partial \gamma^{CL}/\partial n < 0$ and $\partial \gamma^{CL}/\partial \mu < 0$: either an increase in n or μ makes it more likely that the South prefers CL to entry since the Northern market becomes more important in incentivizing R&D and the reduced R&D incentive of the firm under CL becomes less consequential.

Northern welfare under CL equals

$$w_N^{CL}(R) = v^N(q^N) + \Omega R + (1 + \Omega)cs_N^N(p_N^*(q^N))$$

As one might expect, the North fares better under CL relative to when the firm does not sell at all in the Southern market: while the R&D investment of the firm and its domestic profit under the two modes is the same, CL generates a flow of royalties relative to when the firm stays completely out of the South. Indeed, $w_N^{CL}(R) - w_N^N = \Omega R$.

From a joint welfare perspective, entry is preferable to CL iff

$$w_S^*(q^*) + w_N^*(q^*) - \varphi \geq w_S^{CL}(\gamma, R) + w_N^{CL}$$

which is the same as

$$w_S^*(q^*) + w_N^*(q^*) - \varphi \geq w_S^{CL}(\gamma, R) + w_N^{CL}$$

Observe that $w_S^{CL}(\gamma, R) + w_N^{CL} = v^N(q^N) + (1 + \Omega)cs_N^N(p_N^*(q^N)) + \Omega cs_S(\gamma q^N)$. Though CL economizes on the fixed costs of entry, it also leads to lower R&D on the part of the firm while simultaneously delaying Southern consumers' access to the product by one period.

Entry yields higher joint welfare than CL iff

$$\varphi \leq \varphi_{CL}^w = w_S^*(q^*) + w_N^*(q^*) - w_S^{CL}(\gamma, R) - w_N^{CL}(R)$$

where $\partial \varphi_{CL}^w / \partial n > 0$ and $\partial \varphi_{CL}^w / \partial \mu > 0$. Thus, increases in the size or the profitability of the Northern market make it more likely that entry is welfare-preferred to CL since the fixed costs of entry becomes less important. Furthermore, as one might expect, $\partial \varphi_{CL}^w / \partial \gamma < 0$: i.e. reductions in the quality disadvantage suffered by the South make entry less attractive relative to CL.

Figure 2 shows the equilibrium choice of the firm between CL and entry as well as the welfare desirability of the two modes of supply.
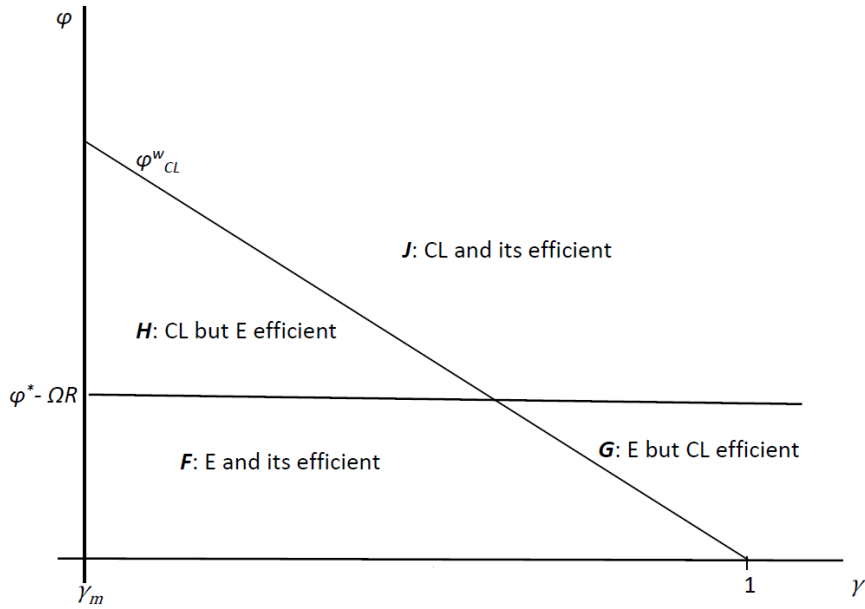

Figure 2: Effects of CL on equilibrium and joint welfare

Figure 2 shows when the equilibrium choice of the firm between CL and entry is jointly efficient as well as when it is not. In region **F** (defined by $\varphi \leq \min\{\varphi_{CL}^w, \varphi^* - \Omega R)$ the firm chooses to enter and its decision is efficient: here the entry cost is low and the technological disadvantage under CL is large so that entry is preferable to CL from a joint welfare perspective. Similarly, in region **J** (defined by $\varphi > \max\{\varphi_{CL}^w, \varphi^* - \Omega R\}$, the firm prefers to wait for CL and its choice is once again efficient: here the quality of production under CL is fairly close to that under entry and the cost of entry is fairly high so that CL maximizes joint welfare. Since the firm's net profit from the Southern

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market is small when φ is large, its R&D investment under entry is not significantly different from that under CL. In regions **G** and **H**, the firm's choice does not maximize joint welfare: in region **H**, we have $\varphi > \varphi^* - \Omega R$ and the firm waits for CL even though the quality of production is fairly low under CL since it ignores the fact that entry delivers much higher surplus to Southern consumers. By contrast, in region **G**, we have $\varphi < \varphi^* - \Omega R$ and the firm ends up choosing entry since its entry cost is low even though the quality of production (and therefore Southern consumer surplus) under CL would have been rather high.

Next, we derive the equilibrium outcome of our game for the case where the North practices international exhaustion of IPRs as opposed to national exhaustion.

3.2 International exhaustion of IPRs

3.2.1 Product market

When the North implements international exhaustion of IPRs, when selling in both markets it is optimal for the firm to set a common global price to eliminate any possible competition from parallel imports. This global price p solves:

$$\max_p \pi(p) \equiv np(1 - p/\mu q) + p(1 - p/q)$$

which yields the optimal global price

$$p^G = \frac{\mu q}{2} \frac{n+1}{n+\mu}$$

It is straightforward to show that $p_S^* < p^G < p_N^*$ – i.e. the firm's common international price under international exhaustion is bound by its optimal discriminatory prices for the two markets. Let the firm's maximized per-period profit under international exhaustion be denoted by $\pi^G = \pi(p^G) = p^G(n+1)/2$.

If the firm faces competition from imitators in the South then its optimal price under international exhaustion equals

$$p^{IG} = \frac{\mu q}{2} \frac{(n+1)(1-\gamma)}{n(1-\gamma)+\mu}$$

which can be rewritten as

$$p^{IG} = \sigma(\gamma)p_N^*$$

where $0 \leq \sigma(\gamma) < 1$. Furthermore, p^{IG} is increasing in m and n whereas it is decreasing in γ – i.e. competition from imitation partly spills over to the Northern market under

international exhaustion. Furthermore, as one might expect, we have $p^{IG} > p_S^*$. It is worth noting that $p^{IG} > (1 - \gamma)p^G$. In other words, since the firm sets a common international price under international exhaustion, the price reduction that the South enjoys due to imitation is relatively smaller when the firm sets a common international price relative to when the firm price discriminates internationally (as it does when North practices national exhaustion of IPRs). We have $\pi^{IG}(q) = p^{IG}(n+1)/2$.

3.2.2 R&D

Let $q^G = \arg\max \ (1 + \Omega)\pi^G(q) - c(q)$ be the optimal R&D investment of the firm in the presence of patent protection in the South. Similarly, let $q^{IG} = \arg\max \ (1 + \Omega)\pi^{IG}(q) - c(q)$ be its R&D investment in the absence of patent protection. As before, let $v^G = (1 + \Omega)\pi^G(q^G) - c(q^G)$ and $v^G = (1 + \Omega)\pi^{IG}(q^{IG}) - c(q^G)$.

The firm's maximized payoff under international exhaustion when its patent is protected in the South equals

$$
\begin{cases}
v^G - \varphi \text{ if } \varphi \leq \varphi^G = v^G - v_N^* \\[3mm]
v_N^* \text{ if } \varphi > \varphi^G
\end{cases}
$$

Similarly, the firm's payoff under international exhaustion in the absence of patent protection equals

$$
\begin{cases}
v^{IG} - \varphi \text{ if } \varphi \leq \varphi^{IG} = v^{IG} - v_N^* \\[3mm]
v_N^* \text{ if } \varphi > \varphi^{IG}
\end{cases}
$$

We can use these conditions to obtain the following result on the threshold values at which the firm will enter the South market under international exhaustion.

Lemma 2.
(i) $\varphi^G \geq 0$ iff $\mu \leq \mu^* \equiv 2 + 1/n$.
(ii) $\partial\varphi^G/\partial\mu\big|_{\mu=1} > 0$ whereas $\partial\varphi^G/\partial\mu\big|_{\mu=\mu^*} < 0$.
(iii) $\varphi^{IG} \geq 0$ iff $\mu \leq (1 - \gamma)\mu^*$.

Part (i) of Lemma 2 says that when $\mu > \mu^*$, the firm prefers to sell only in the North even when the fixed cost of selling in the South equals zero and its patent is protected there. Part (iii) establishes a similar (and more stringent) condition for the firm to be willing to sell in the South in the absence of patent protection. These conditions show that when the willingness to pay is sufficiently higher in the North market, preserving profit in the Northern market is important and the firm is willing to forsake the Southern

market to charge its optimal price in the North. The condition is more stringent without patent protection because the firm faces competition from imitators. In contrast, the firm will be willing to enter the South when fixed costs are zero under national exhaustion for all values of μ because there is no spillover of the price in the South market to sales in the North market.

Part (ii) of Lemma 2 highlights the fact that the fixed cost threshold φ^G below which the firm is willing to sell in the South is a non-linear function of μ. When $\mu \approx 1$, consumer preferences in the two regions are very similar and an increase in the willingness to pay on the part of Northern consumers makes the firm more willing to sell in the North whereas the opposite is true $\mu \approx \mu^*$. This result reflects two conflicting effects. As μ increases, the firm's R&D investment q^G goes up and this makes selling in the South more profitable. On the other hand, the larger is μ the greater the loss the firm suffers in terms of reduced profitability in the Northern market from having to set a common international price under international exhaustion. For μ small, the R&D effect dominates whereas for μ large, the loss in Northern profits implied by uniform pricing drives the firm's entry decision.

We can show the following:

Proposition 5.
(i) Even when the North practices international exhaustion of IPRs, the lack of IPR protection in the South reduces the firm's R&D investment (i.e. $q^{IG} \leq q^G$) as well as its incentive to enter the Southern market (i.e. $\varphi^{IG} \leq \varphi^G$). Furthermore, the stronger the intensity of imitative competition in the South, the lower the firm's investment in R&D (i.e. $\partial q^{IG}/\partial \gamma < 0$) and the weaker its incentive to sell in the South (i.e. $\partial \varphi^{IG}/\partial \gamma < 0$).
(ii) For a given South patent policy, the firm is more willing to sell in the South under national exhaustion ($\varphi^G < \varphi^*$ and $\varphi^{IG} < \varphi^I$) and chooses a higher level of R&D under national exhaustion ($q^G \leq q^*$ and $q^{IG} \leq q^I$).
(iii) There exists $\gamma^f \geq 0$ such that $\varphi^I > \varphi^G$ iff $\gamma \leq \gamma^f$ where (a) $\partial \gamma^f/\partial n > 0$; (b) $\partial \gamma^f/\partial \mu > 0$; and (c) at $\mu = \mu^*$, $\gamma^f = 1$.
(iv) $q^I \geq q^G$ iff $\gamma \leq \gamma^f$

Part (i) of this Proposition establishes that the threshold level of fixed costs for entry with international exhaustion is lower when the South does not provide patent protection, which is similar to the result obtained in Proposition 1 for the case of national exhaustion. Part (ii) is easy to understand: having to set a common international price under international exhaustion makes the firm more reluctant to sell in the South because of the resulting loss in profits in the North market. Furthermore, the fact that profits from entering the South market are higher with national exhaustion means that there is a greater incentive to improve the quality of the product by investing in R&D.

Parts (iii) addresses the relative impact of the loss of patent protection and the inability to price discriminate on the profitability of entry in the South. The profit from entry without patent protection is decreasing in the South's imitative ability, so there is a critical value γ^f at which the firm earns the same level of profits with price discrimination and no patent protection as it does with no price discrimination and patent protection. This threshold level of the South's imitative ability is increasing in μ and n because the inability to price discriminate is more damaging to firm profits when the North market is more profitable. Interestingly, part (iv) shows that the marginal profit from improving product quality is also equalized between the cases of national exhaustion without patent protection and international exhaustion with patent protection when $\gamma = \gamma^f$ so $q^I(\gamma^f) = q^G$. Since q^I is decreasing in the imitative ability in the South, $q^I(\gamma) > q^G$ for $\gamma > \gamma^f$ if the firm enters under both regimes.

3.2.3 South's patent protection policy

Having derived the firm's payoffs, we are now ready to derive the South's equilibrium patent policy. Southern welfare under patent protection equals

$$\begin{cases} w_S^G = (1+\Omega)cs_S(p^G(q^G)) \text{ if } \varphi \leq \varphi^G \\ \\ 0 \text{ if } \varphi > \varphi^G \end{cases}$$

whereas that in the absence of patent protection equals

$$\begin{cases} w_S^{IG} = (1+\Omega)cs_S(p^{IG}(q^{IG}); \gamma) \text{ if } \varphi \leq \varphi^{IG} \\ \\ w_S^L = (1+\Omega)cs_S^L(\gamma q^N) \text{ if } \varphi > \varphi^{IG} \end{cases}$$

We are now ready to state the following:

Lemma 3. *The following hold regarding Southern welfare under various outcomes:*
(i) $w_S^{IG} \geq \max\{w_S^G, w_S^L\}$ *for* $\mu \leq (1-\gamma)\mu^*$.
(ii) There exists γ^G *such that* $w_S^G \geq w_S^L$ *iff* $\gamma \leq \gamma^G$ *where* $\partial\gamma^G/\partial n < 0$ *and* $\partial\gamma^G/\partial\mu < 0$.
(iii) $\gamma^G < \gamma^*$.
(iv) $w_S^G \leq w_S^*$ *for* $\mu < \mu^*$.

Part (i) establishes that the best outcome for the South occurs if the firm's entry costs are sufficiently low that it enters without patent protection. The fact that entry is desirable when there is no patent protection is immediate, since it increases product variety and leads to a higher quality level. Compared to entry with patent protection,

the South gets lower prices and greater variety without protection but a lower product quality. As in the case of national exhaustion, the former effects dominate and the South is better off if the firm enters without patent protection. Part (ii) shows that Southern consumers are better-off having access to (only) the patented product relative to consuming when the South's imitative ability is below a threshold level. Part (iii) says that the maximum level of imitative ability for preferring patent protection is lower under international exhaustion than under national exhaustion because the price of the patented product is higher under international exhaustion.

Parts (iv) of Lemma 3 says that, given that it implements patent protection, the South is better off under national exhaustion. This is due to two reasons. First, holding constant the quality of the product across the two exhaustion regimes, price in the Southern market is lower under national exhaustion (i.e. $p_S^* < p^G$). Second, the firm invest more in R&D and therefore delivers a higher quality product under national exhaustion. From the South's viewpoint, both forces reinforce each other thereby making national exhaustion clearly preferable to international exhaustion.[16]

Using Lemma 3, we can now state the South's optimal patent protection policy when the North implements international exhaustion:

Proposition 6. *Suppose the Northern policy is international exhaustion and compulsory licensing is not an option. Then, the South's equilibrium patent protection policy is as follows: (i) If $\mu < (1 - \gamma)\mu^*$, the South offers patent protection to the firm iff $\varphi \in [\varphi^{IG}, \varphi^G]$ and $\gamma \leq \gamma^G$; (ii) If $\mu \in [(1 - \gamma)\mu^*, \mu^*]$ the South offers patent protection iff $\varphi \in [0, \varphi^G]$ and $\gamma \leq \gamma^G$; and (iii) if $\mu > \mu^*$ the South does not offer patent protection regardless of its local technological capability (γ) or the fixed costs of entry (φ).*

The basic message of Proposition 6 is that the South will only provide patent protection in cases where the level of φ is such that the firm will enter only if it receives patent protection and the level of γ is sufficiently low that that the products of imitators are less attractive than the patented product. This result is is analogous to Proposition 2, which established the corresponding range of parameter values for which the South provides patent protection under a North policy of national exhaustion. The important point to note is that international exhaustion affects the parameter values for which the South provides patent protection. For parameter values at which the South chooses to provide patent protection under national exhaustion, patent protection may no longer be sufficient to induce entry under international exhaustion because entry in the South is less attractive for the firm. For these parameter values, imitation becomes relatively

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[16]From the North's viewpoint, the two effects work in opposite directions because $p_N^* > p^G$ whereas $q^G < q^*$ – i.e. international exhaustion helps lower the price in the North but it also lowers the firm's incentive to invest in R&D.
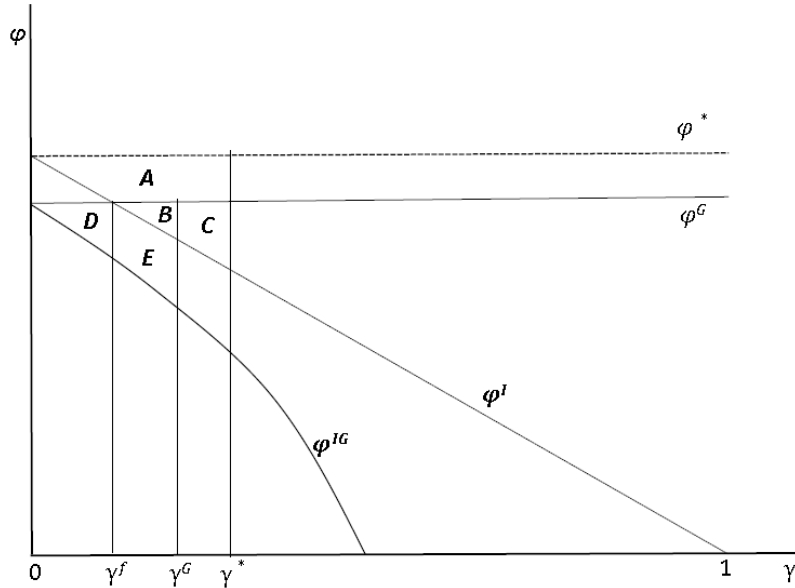
Figure 3: Equilibrium outcomes with International Exhaustion

more attractive to the South. Observe however that for parameter values at which the firm entered without patent protection under national exhaustion, the firm may no longer choose to enter without patent protection under international exhaustion. For $\varphi \in [\varphi^{IG}, \varphi^I)$, providing patent protection for the South becomes relatively more attractive under international exhaustion when imitators are of relatively low quality because it can be used to induce entry by the firm.

The impact of the North's exhaustion policy on the South's patent decision is illustrated in Figure 3, which compares the entry thresholds under international exhaustion, φ^G and φ^{IG}, with those under national exhaustion, φ^* and φ^I for a case where $\mu < \mu^*$. For the values of μ and n used in Figure 3, the horizontal intercept of the φ^{IG} line occurs at $\gamma = 1 - \frac{\mu}{\mu^*} > \gamma^G$. The set of values of $\{\varphi, \gamma\}$ for which the South offers patent protection under international exhaustion is illustrated by the triangular area made up of regions $\mathbf{B}, \mathbf{D}$, and $\mathbf{E}$ in Figure 3, as that area satisfies part (i) of Proposition 6. This area can be compared with the triangular area made up of regions $\mathbf{A}$, $\mathbf{B}$, and $\mathbf{C}$, which is the set of values of $\{\varphi, \gamma\}$ for which the South offered patent protection under national exhaustion. The fact that the price the South faces when the firm enters under international exhaustion is higher than that under national exhaustion means that the threshold quality at which the South prefers imitated goods is lower under international

exhaustion, as established in Lemma 3(iii). Furthermore, the fact that the firm earns less profit from the South market under international exhaustion means that the threshold levels of fixed costs for entry, φ^G and φ^{IG}, are lower than their corresponding values under national exhaustion as established in Proposition 5.[17]

When $\mu > \mu^*$, the firm does not sell in the South even when its patent is protected and the fixed cost of entry equals zero since it wants to preserve its profit in the Northern market. When such is the case, the South has no incentive to offer patent protection under international exhaustion since doing so eliminates the low quality imitated product from the local market without eliciting entry by the firm. By contrast, under national exhaustion, even when $\mu > \mu^*$ the South is willing to offer patent protection so long as it is necessary and sufficient to induce entry by the firm and $\gamma \leq \gamma^*$.

For a given patent policy in the South, international exhaustion results in lower innovation that national exhaustion. The negative effect of international exhaustion on R&D is reinforced if the South has a weaker incentive to offer patent protection under international exhaustion. On the other hand, a more stringent patent policy in the South under international exhaustion has a conflicting effect on firm R&D. Figure 3 can also be used to illustrate how the policy reaction of the South affects R&D incentives under national exhaustion relative to international exhaustion. In regions **A** and **C**, a switch from national to international exhaustion causes the South to drop its patent protection. The elimination of patent protection in the South further reduces the incentive of the firm to do R&D, so a switch to international exhaustion must unambiguously reduce the quality of the product in regions **A** and **C**. In regions **D** and **E**, the switch from national to international exhaustion causes the South to introduce patent protection. In these two areas, the change in South patent policy tends to raise the firm's innovation incentive while the North's policy change to international exhaustion tends to reduce it. Applying Proposition 5(iv), the firm's innovation is lower under international exhaustion in region **D** (since $\gamma < \gamma^f$) while it is greater under international exhaustion in Region **E**.

In summary, innovation is higher under international exhaustion relative to national exhaustion only in cases where the Southern market is sufficiently profitable relative to the Northern one ($\gamma^f < \gamma^G$) and only for entry costs satisfying $\varphi \in [\varphi^{IG}, \varphi^I]$. For all other areas of the parameter space where the firm would enter with national exhaustion, innovation is lower under international exhaustion. Our results on the effect of international exhaustion on R&D can be compared with those of Grossman and Lai (2008), who consider the case where the South provides patent protection but also imposes price controls on the Northern producers. In their model, the South chooses a more liberal price

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[17]If $1 - \frac{\mu}{\mu^*} < \gamma^G$, the horizontal intersection of the φ^{IG} locus occurs to the left of γ^G. In that case part (i) of the proposition applies for $\gamma \in [0, 1 - \frac{\mu}{\mu^*}]$ and part (ii) applies for $\gamma \in (1 - \frac{\mu}{\mu^*}, \gamma^G]$.

control under international exhaustion, leading to a presumption that Northern firms engage in more R&D under international exhaustion. In contrast, we find that when the South's policy instrument is patent protection, the induced policy change in the South under international exhaustion may either increase or decrease R&D incentives. The South has an incentive to drop patent protection under international exhaustion in cases where patent protection is needed to induce entry with national exhaustion. However, it may choose to adopt patent protection to induce entry under international exhaustion in cases where the firm is willing to enter without patent protection under national exhaustion.

3.2.4 Welfare

Let global welfare under international exhaustion when the firm sells in both markets under patent protection be given by w^G where

$$w^G = w_S^G + w_N^G - \varphi$$

and $w_N^G \equiv (1 + \Omega)cs_N(p^G(q^G)) + v^G$. Similarly define

$$w^{IG} = w_S^{IG} + w_N^{IG} - \varphi$$

where $w_N^{IG} \equiv (1 + \Omega)cs_N(p^{IG}(q^{IG})) + v^{IG}$. We can show the following:

Lemma 4. *The following inequalities hold regarding global welfare (gross of fixed costs of entry) under different policy regimes:*
(i) $w^{IG} \leq w^G$ *and* $w^I \leq w^*$.
(ii) $w^G \leq w^*$ *and* $w^{IG} \leq w^I$.
(iii) $w^I \leq w^G$ *iff* $\gamma > \gamma^f$

Part (i) of Lemma 4 says that, provided the firm sells in both markets regardless of the global policy environment faced by it, total welfare is higher if the South offers patent protection relative to when it does not. In other words, the introduction of patent protection in the South raises global welfare under both national and international exhaustion provided the firm sells in both markets under all possible policy configurations. Part (ii) of Lemma 4 informs us that, provided the firm sells in both markets, national exhaustion delivers higher joint welfare than international exhaustion when the South's patent protection policy is held constant across the two regimes. In a model with linear demands and no innovation, international exhaustion is preferable to national exhaustion when there is patent protection in the South provided the firm sells in both markets. With a fixed quality, the firm's total output is equal under national and international exhaustion, but it is more efficiently allocated under international exhaustion because price is equalized across markets. Our result shows that when quality is endogenously

determined by the firm's R&D investment and the South's patent policy is held constant, the welfare gain arising from the greater level of innovation under national exhaustion dominates the efficiency gains from arbitrage under international exhaustion.

Part (*iii*) of Lemma 4 shows that world welfare could be higher under international exhaustion if it leads the South to switch from a no patent protection to patent protection. If $\gamma = \gamma^f$, the switch from national exhaustion without patent protection to international exhaustion with patent protection leaves world welfare unaffected because the the level of firm profits and world consumer surplus are unaffected. For $\gamma > \gamma^f$, the increased innovation resulting from a switch to international exhaustion results in higher world welfare. Thus, for parameter values in region E in Figure 3, world welfare is higher under international exhaustion than under national exhaustion. For the other parameter values at which the firm enters with national exhaustion, world welfare will be lower under international exhaustion.

The patent decision made by the South may fail to maximize world welfare, because it fails to take into account the impact of its decision on firm profits. Similarly, the North decision concerning exhaustion policy fails to take into account its impact on the South market. We can use the above results to derive the globally optimal pair of patent and exhaustion policies. First note that if $\varphi > \varphi^*$ the firm does not sell in the South even when North implements national exhaustion and the South offers patent protection so that it is socially optimal to not enforce patent protection in the South (to allow Southern consumers access to the imitated product) and the North's exhaustion policy is irrelevant. The analysis for the case where $\varphi \leq \varphi^*$ is presented in the appendix and the main result is as follows:

Proposition 7. *The socially optimal pair of policies calls for national exhaustion in the North and patent protection in the South except for the parameter regions **D1** (defined by $\gamma > \gamma^w$ and $\varphi^I < \varphi \leq \varphi^*$) and **D2** (defined by $\varphi > \varphi^*$) in Figure 1: for parameter values in region **D1** and **D2**, it is socially optimal to not provide patent protection in the South and the nature of North's exhaustion policy is inconsequential since the firm does not sell in the South under either exhaustion policy.*

A noteworthy aspect of Proposition 7 is that international exhaustion never welfare dominates national exhaustion: at best it provides the same level of global welfare as national exhaustion (which happens over regions **D1** and **D2** in Figure 1) and it only does so when the firm does not sell in the South so that exhaustion policy is essentially irrelevant.

Finally, we discuss the role of CL under international exhaustion.

3.2.5 CL under international exhaustion

First note that the payoff to the firm and the welfare of the two regions under CL do not depend upon the exhaustion policy of the North. But exhaustion policy does affect the entry incentive of the firms as well as the desirability of CL relative to entry from the perspective of both regions.

First consider the firm's incentives. Given that the Northern policy is international exhaustion, the firm prefers entry to CL iff $v^G(q^G) - \varphi \geq \Omega R + v^N(q^N) \Leftrightarrow \varphi \leq \varphi_{CL}^G \equiv v^G(q^G) - v^N(q^N) - \Omega R$. Since $v^G(q^G) < v^*(q^*)$, it immediately follows that $\varphi_{CL}^G < \varphi_{CL}^*$ – i.e. the firm is more likely to prefer CL to entry under international exhaustion relative to national exhaustion. From a joint welfare perspective, CL is preferable to entry iff $\varphi \leq \varphi_{CL}^{WG} = w^G(q^G) + w_S^{CL}(\gamma, R) - w_N^{CL}(R)$. Observe that since $w^G(q^G) < w^*(q^*)$, we immediately have $\varphi_{CL}^{WG} < \varphi_{CL}^W$ – i.e. CL is more likely to be socially efficient than entry under international exhaustion.

We can now state the following:

Proposition 8. *Not only is compulsory licensing more likely to arise in equilibrium under international exhaustion, it is also more likely to be socially efficient relative to entry.*

4 Conclusion

The TRIPS agreement of the WTO forced many developing countries to strengthen their IPR regimes. However, at the same time it left WTO members unconstrained in two key respects: they could avail of compulsory licensing to provide local consumers greater access to patented products and were free to implement exhaustion policies of their choice. This paper provides a unified analysis of the key TRIPS obligation calling for harmonized patent protection across all member states and the two main policy flexibilities it granted them. In so doing, the paper integrates several strands of existing literature that explore various aspects of the multi-faceted relationship between IPR protection and international trade.

Our analysis is couched in a simple North-South model where the two regions differ in terms of their demand structure as well as their innovative capacity (with all of the R&D being done by a Northern firm). We show that the South's unilateral incentive for patent protection is too weak relative to what is jointly optimal. However, this does not imply that forcing the South to offer patent protection is *always* welfare improving. The welfare effects of TRIPS in our model are driven by two forces: how much the firm invests

in research and development (R&D) and whether or not it finds it profit-maximizing to sell in the South. Accordingly, we show that if the Northern firm is unwilling to sell in the South even when it is granted patent protection, forcing the South to implement patent protection makes it worse off without making the North better off. Luckily, however, by including the possibility of CL the TRIPS agreement provides developing countries with an important flexibility that allows them to secure access to foreign patented products when local patent protection fails to induce patent-holders to sell their products in their markets. We show that while CL has the potential to make both regions better off ex-post, it also reduces the ex-ante R&D investment of the firm. Somewhat ironically, the adverse effect of CL on R&D arises only when the firm itself *prefers* CL to entry. When this happens, global welfare declines due to the reduction in the firm's R&D.

Finally, we examine how the exhaustion policy of the North affects the two regions as well as the likelihood of CL arising in equilibrium. We show that global welfare and innovation are higher if the North follows national exhaustion as opposed to international exhaustion. Finally, we examine the interplay between the two flexibilities and show that CL more likely to arise in equilibrium under international exhaustion because the firm is less likely to sell in both markets when it has to set a common international price. Furthermore, CL is more likely to be socially efficient relative to entry under international exhaustion relative to national exhaustion.

5   Appendix

Proof of Proposition 1

It is straightforward to show that

$$q^I = \frac{(1+\Omega)(n\mu + 1 - \gamma)}{4t} \tag{10}$$

where

$$q^* = q^I\big|_{\gamma=0} \tag{11}$$

Observe that $\partial q^I / \partial \gamma < 0$. It follows then that $q^* > q^I$ for all $\gamma \in [0,1)$.

Next, note that

$$\varphi^* = \frac{(1+\Omega)^2(2n\mu + 1)}{32t} \tag{12}$$

It is obvious that φ^* is increasing in n and μ.

We have

$$\varphi^I = \frac{(1+\Omega)^2(1-\gamma)(2n\mu + 1 - \gamma)}{32t} \tag{13}$$

so that

$$\frac{\partial \varphi^I}{\partial \gamma} = -\frac{(1+\Omega)^2(n\mu + 1 - \gamma)}{16t} < 0$$

Proof of Lemma 1

Direct calculations show that

$$w_S^* - w_S^L = \frac{(1+\Omega)^2(n\mu + 1 - 4\gamma n\mu)}{32t}$$

from which it immediately follows that

$$w_S^* \geq w_S^L \text{ iff } \gamma \leq \gamma^* \equiv \frac{n\mu + 1}{4n\mu} \tag{14}$$

It is obvious that γ^* is decreasing in n and μ.

Proof of Proposition 3

(i) We have

$$w^* - w^I = \frac{(1+\Omega)^2\gamma^2}{16t} \geq 0 \tag{15}$$

(ii) Direct calculations show that

$$\varphi^w = w^* - w^L = \frac{(1+\Omega)^2(2n\mu(1-\gamma) + 1)}{16t} \tag{16}$$

from which it directly follows that $\partial \varphi^w / \partial \gamma < 0$; $\partial \varphi^w / \partial \mu < 0$; and $\partial \varphi^w / \partial n < 0$. Also, we have

$$\varphi^w - \varphi^* = \frac{(1+\Omega)^2}{32}\frac{2n\mu + 1 - 4n\gamma\mu}{t}$$

From this expression, it immediately follows that $\varphi^w \geq \varphi^*$ iff $\gamma \geq \gamma^w$ where

$$\gamma^w = \frac{2n\mu + 1}{4n\mu} \tag{17}$$

Note that $\partial \gamma^w / \partial \mu < 0$ and $\partial \gamma^w / \partial n < 0$.

Proof of Lemma 2

(i) We have

$$\varphi^G = \frac{\mu^2(2n^2 + 2n + 1 + n\mu)(2n + 1 - n\mu)(1+\Omega)^2}{32t(n+\mu)^2} \tag{18}$$

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from which it directly follows that $\varphi^G \geq 0$ iff $\mu \leq \mu^* = 2 + 1/n$.

(ii) We have

$$\partial \varphi^G / \partial \mu \big|_{\mu=1} = \frac{(1+\Omega)^2}{16} \frac{n}{t} > 0$$

and

$$\partial \varphi^G / \partial \mu \big|_{\mu=\mu^*} = -\frac{n(1+\Omega)^2}{16} \frac{(2n+1)^2}{t(n+1)^2} < 0$$

(iii) We have

$$\varphi^{IG} = \frac{(1+\Omega)^2 \mu^2 [(2n^2+2n+1)(1-\gamma) + n\mu)][(2n+1)(1-\gamma) - n\mu]}{32t(n(1-\gamma) + \mu)^2} \tag{19}$$

Observe that $\varphi^{IG} \geq 0$ iff $(2n+1)(1-\gamma) - n\mu \geq 0$ or $\mu \leq (1-\gamma)\mu^*$. Also note that

$$\frac{\partial \varphi^{IG}}{\partial \gamma} = -\frac{(1+\Omega)^2 \mu^3 (n+1)^4 (1-\gamma)}{16t(n(1-\gamma) + \mu)^3} \leq 0$$

Proof of Proposition 5

(i) We have

$$q^{IG} = \frac{(1-\gamma)(1+\Omega)\mu(n+1)^2}{4t(n(1-\gamma) + \mu)} \tag{20}$$

where

$$q^G = q^{IG} \big|_{\gamma=0} = \frac{(1+\Omega)\mu(n+1)^2}{4t(n+\mu)} \tag{21}$$

We have

$$\partial q^I / \partial \gamma = -\frac{(1+\Omega)\mu^2(n+1)^2}{4t(n(1-\gamma) + \mu)^2} < 0$$

It follows then that $q^G > q^{IG}$ for all $\gamma \in [0,1)$.

(ii) We have

$$\varphi^I - \varphi^{IG} = \frac{(1+\Omega)^2 n^2 (\gamma + \mu - 1)^2 (2\mu n^2(1-\gamma) + n(\mu+1-\gamma)^2 - \gamma\mu)}{32t(n(1-\gamma) + \mu)^2} \geq 0$$

This implies $\varphi^* - \varphi^G \geq 0$. Similarly,

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$$q^I - q^{IG} = \frac{(1+\Omega)n(\gamma + \mu - 1)^2}{4t(n(1-\gamma)+\mu)} \geq 0,$$

which implies $q^* - q^G \geq 0$.

(*iii*) Using the definitions of φ^I and φ^G we have:

$$\varphi^I \geq \varphi^G \text{ iff } \gamma \leq \gamma^f = \frac{n(\mu-1)^2}{n+\mu} \tag{22}$$

using which the stated properties of γ^f can be established immediately.

(*iv*) If follows from (10) and (21) that $q^I - q^G$ is decreasing in γ, and is equal to 0 at γ^f.

Proof of Lemma 3

(*i*) $w_S^{IG} > w_S^L$ follows immediately from the fact that $q^{IG} \geq q^N$ and that consumers have an additional option to purchased the imitated product when the firm enters without patent protection. To establish that the South's payoff under entry without patent protection exceeds that from entry with patent protection, we can write the difference in payoffs as:

$$w_S^{IG} - w_S^G = A(\mu, n, \gamma)B(\mu, n, \gamma), \tag{23}$$

where

$$A(\mu, n, \gamma) = \frac{\gamma\left(\Gamma\mu(1+n)\right)^2}{32(\mu+n)^3 t(\mu + n(1-\gamma))^3} \geq 0$$

and

$$\begin{aligned} B(\mu, n, \gamma) &= (1-\gamma)^2(\mu n^5 + (10\mu - 4)n^4) - (2(2-\gamma)\mu^4 + (5 - 13\gamma + 4\gamma^2)\mu^3)n \\ &\quad -(3(1-\gamma)\mu^3 + -12(2 - 3\gamma + \gamma^2)\mu^2 + 7(1-\gamma)\mu)n^3 \\ &\quad -((2-\gamma)\mu^4 - 2(9 - 9\gamma + 2\gamma^2)\mu^3 + 4\gamma(3 - 2\gamma)\mu^2)n^2 \end{aligned}$$

The differential (23) is non-negative if $B(m, n, \gamma)$ is non-negative on the region of the parameter space where the firm would enter without patent protection, which is the set $F = \{(\mu, n, \gamma) | \mu \in [1, \mu^*(1-\gamma)], n \geq 1, \gamma \in [0, 1 - \frac{1}{\mu^*}]\}$.

The proof (available online) shows that for given (m, n), the function B is (a) strictly convex in γ for $, \gamma \in [0, 1 - \frac{1}{\mu^*}]$, (b) positive and decreasing in γ at $\gamma = 0$, and (c) positive and decreasing in γ at $\gamma = \frac{1}{\mu^*}$. As a result, $B > 0$ for $\gamma \in [0, 1 - \frac{1}{\mu^*}]$.

(*ii*) The critical value of γ at which welfare under patented entry is equal to that under imitation without entry is the solution to $w_S^G = w_S^L$, which yields

$$\gamma^G \equiv \frac{1}{4}\frac{(n+1)^2[n(\mu-2)-\mu]^2}{n(n+\mu)^3}. \tag{24}$$

The fact that γ^G is decreasing in n and μ follows by differentiation of (24).

(iii) From the definitions of the two thresholds, we have $\gamma^* - \gamma^G = (\mu - 1)[\mu^2(\mu + 1) + (5\mu + 1)\mu n + (7\mu - 1)n^2 + (3 - \mu)\mu n^3]/(4\mu(\mu + n)^3)$, which must be non-negative for $\mu \le \mu^* \le 3$.

(iv) With patent protection, the quality of the good is higher under national exhaustion,

$$q^* - q^G = \frac{(1 + \Omega)n(\mu - 1)^2}{4t(n + \mu)} \ge 0$$

and the price per unit quality in the South is lower

$$\frac{p^*}{q^*} = \frac{1}{2} \le \frac{p^G}{q^G} = \frac{\mu(n + 1)}{2(\mu + n)}$$

Therefore, welfare in the South is higher with patent protection when the North follows a policy of national exhaustion.

Proof of Lemma 4

(i) We have

$$w^* - w^I = \frac{(1 + \Omega)^2 \gamma^2}{16t} \ge 0$$

Furthermore, we have

$$\frac{\partial w^G}{\partial \gamma} = -\frac{(1 + \Omega)^2(n + 1)^2 \mu^2 F(m, n, \gamma)}{8t(n(1 - \gamma) + m)^3}$$

where

$$F(m, n, \gamma) = \gamma(2mn + m - n) + n(m - 1)^2$$

Observe that $\frac{\partial w^G}{\partial \gamma} \le 0$ iff $F(m, n, \gamma) \ge 0$.

Next, note that

$$\frac{\partial F(.)}{\partial \gamma} = (2m - 1)n + m > 0$$

and that $F(m, n, \gamma)|_{\gamma = 0} = n(m - 1)^2 > 0$. This means that $F(m, n, \gamma) > 0$ for all γ. Thus, we must have

$$\frac{\partial w^G}{\partial \gamma} < 0$$

which implies that $w^G > w^{IG}$ since $w^G = w^{IG}\big|_{\gamma = 0}$.

(ii) We can show that

$$w^* - w^G = \frac{(1+\Omega)^2 n^2 (\mu - 1)^4}{16t(n+\mu)^2} \geq 0 \tag{25}$$

Next note that

$$w^I - w^{IG} = \frac{(1+\Omega)^2 n^2 (\mu + \gamma - 1)^2 G(m,n,\gamma)}{16t(n(1-\gamma)+\mu)^2}$$

where

$$G(m,n,\gamma) = 2m\gamma(n+1) + n(m-1)^2 - \gamma^2 n$$

Observe that $w^I - w^{IG} \geq 0$ iff $G(m,n,\gamma) \geq 0$. Next, note that

$$\frac{\partial G(.)}{\partial \gamma} = 2n(m-\gamma) + 2m > 0$$

and that $G(m,n,\gamma)|_{\gamma=0} = n(m-1)^2 > 0$. This means that $G(m,n,\gamma) > 0$ for all γ. Thus, we must have

$$w^I \geq w^{IG}$$

(iii) Taking the difference of (15) and (25) yields

$$w^I - w^G = \frac{n^2 (\mu - 1)^4 - (\mu + n)^2 \gamma^2}{16(\mu + n)^2 t},$$

which is decreasing and strictly concave in γ, positive at $\gamma = 0$, and equal to 0 at $\gamma = \gamma^f$. ||

Proof of Proposition 7: The policy pair implemented by the social planner be denoted by (X,Y) where X denotes the exhaustion policy for the North and X=IE or NE while Y denotes the patent protection policy in the South where Y= P or I. Let equilibrium global welfare under the policy pair (X,Y) gross of the fixed cost of entry φ be denoted by W(X,Y).

We know (i) $\varphi^{IG} \leq \varphi^G$; ($ii$) $\varphi^I \leq \varphi^*$; (iii) $\varphi^G < \varphi^*$; (iv) $\varphi^I \leq \varphi^G$ iff $\gamma \leq \gamma^f$; and (v) $\varphi^w \leq \varphi^*$ iff $\gamma \leq \gamma^w$. Furthermore, we know that $\varphi^{IG} \geq 0$ iff $\mu \leq \mu^*(1-\gamma)$.

In what follows, we focus on a scenario where all of the cost thresholds are positive (i.e. $\varphi^{IG} \geq 0 \Leftrightarrow \mu \leq \mu^*(1-\gamma)$). The analysis of the other cases is straightforward and it yields relatively similar conclusions.

Case A: $0 \leq \varphi^{IG} \leq \varphi^G \leq \varphi^I \leq \varphi^*$.

(i) Suppose $\varphi \in (0, \varphi^{IG}]$. Then, the firm sells in both markets regardless of the policy vector it faces. Then, given Lemma 4(i), it follows that welfare is maximized by implementing (NE, P).

(ii) Next suppose $\varphi \in (\varphi^{IG}, \varphi^{G})$. Here, the firm serves both markets under NE regardless of the patent protection policy implemented in the South but under IE it only sells in the South if its patent is protected. From Lemma 4 we know that if the planner chooses NE, then welfare is higher with patent protection, i.e., $W(\text{NE,P}) > W(\text{NE,I})$. Now consider the socially optimal patent policy under IE. We can show that there exists γ_G^w such that $W(\text{IE,P}) > W(\text{IE,I})$ only if $\gamma \leq \gamma_G^w$. Suppose this inequality is satisfied. Then, the planner's choice is between (NE,P) and (IE,P) with the firm selling in the South under both types of exhaustion policies. From Lemma 4(ii), we know that we must have $W(\text{NE,P}) = w^* - \varphi > W(\text{IE,P}) = w^G - \varphi$ when the firms sells in both markets. Now suppose $\gamma > \gamma_G^w$ so that $W(\text{IE,I}) = w^L > W(\text{IE,P}) = w^G - \varphi$. For $\gamma > \gamma_G^w$, the planner prefers (IE,I) to (NE,P) iff $w^L > w^* - \varphi$ which only holds for $\gamma > \gamma^w$. But note that $\varphi^{IG} \geq 0$ iff $\gamma \leq \gamma^m = 1 - n\mu/(2n + 1)$. It is straightforward to show that $\gamma^w > \gamma^m$, which means that over the permissible parameter range, we must have $w^* - \varphi > w^L \Leftrightarrow W(\text{NE,P}) > W(\text{IE,I})$. Thus, we have shown that for $\varphi \in (\varphi^{IG}, \varphi^{G})$, the planner implements (NE,P).

(iii) Now consider the range where $\varphi \in (\varphi^{G}, \varphi^{I}]$. Here, if the planner implements IE then the firm does not sell in the South, in which case it is socially optimal to not offer patent protection there. If the planner implements NE then the firm sells in the South even in the absence of patent protection, in which case we know from Lemma 4(i) that patent protection is optimal: $W(\text{NE,P}) = w^* - \varphi > W(\text{NE,I}) = w^I - \varphi$. Thus, for $\varphi \in (\varphi^{G}, \varphi^{I})$, the planner has to choose between (IE,I) and (NE,P). We know that $W(\text{NE,P}) = w^* - \varphi > W(\text{IE,I}) = w^L$ iff $\varphi < \varphi^w$. But since $\varphi^w > \varphi^I$, this condition is necessarily satisfied for $\varphi \in (\varphi^{G}, \varphi^{I}]$ so that once again the planner opts for (NE,P).

(iv) Finally, consider $\varphi \in (\varphi^{I}, \varphi^*]$. Here, the firm does not serve the South under IE regardless of whether its patent is protected or not which makes it optimal to not provide patent protection under IE, i.e. $W(\text{IE,I}) = w^L > W(\text{IE,P}) = w^N$. If the planner implements NE in the North then the firm sells in the South only if its patent is protected. Furthermore, $W(\text{NE,P}) = w^* - \varphi > W(\text{NE,I}) = w^L$ only when $\gamma \leq \gamma^w$. Suppose $\gamma > \gamma^w$, then it follows that $W(\text{NE,P}) < W(\text{IE,I}) = W(\text{NE,I})$. When $\gamma \leq \gamma^w$, we have $W(\text{NE,P}) \geq W(\text{IE,I}) = W(\text{NE,I})$. Thus, for $\gamma > \gamma^w$ the planner does not implement patent protection in the South and is indifferent between NE and IE since the firm sells only in the North under either type of exhaustion policy whereas for $\gamma \leq \gamma^w$, the planner implements (NE,P).

Case B: $0 < \varphi^{IG} \leq \varphi^{I} \leq \varphi^{G} \leq \varphi^*$.

(i) The argument for $\varphi \in (0, \varphi^{IG}]$ is identical to that in Case $\mathbf{A}(i)$.

(ii) Next suppose $\varphi \in (\varphi^{IG}, \varphi^{I}]$. Here, in the absence of patent protection, the firm sells in the South only under NE and we know from lemma 4 that $W(\text{NE},\text{P}) = w^* - \varphi > W(\text{NE},\text{I}) = w^I - \varphi$. Furthermore, under IE we have $W(\text{IE},\text{P}) = w^G - \varphi > *W(\text{IE},\text{I}) = w^L$ only if $\gamma \leq \gamma_G^w$. We also know from Lemma 4 that when the firm sells in both markets then $W(\text{NE},\text{P}) > W(\text{IE},\text{P})$ so that for $\gamma \leq \gamma_G^w$, the planner will implement (NE,P). Now suppose $\gamma > \gamma_G^w$ so that $W(\text{IE},\text{I}) > W(\text{IE},\text{P})$. Here, the planner has to choose between $W(\text{IE},\text{I}) = w^L$ and $W(\text{NE},\text{P}) = w^* - \varphi$ and we know that $W(\text{NE},\text{P}) > W(\text{IE},\text{I})$ only if $\gamma > \gamma^w$ which cannot hold since $\varphi^{IG} \geq 0$ requires $\gamma \leq \gamma^m$ where $\gamma^m < \gamma^w$. Hence the planner implements (iii) Let $\varphi \in (\varphi^I, \varphi^G]$. Here, firm serves the South only if its patent is protected and from Lemma 4 we know that $W(\text{NE},\text{P}) > W(\text{IE},\text{P})$. Furthermore, we have $W(\text{NE},\text{I}) = W(\text{IE},\text{I}) = w^L$. This means the planner implements (NE,P) if $\gamma \leq \gamma^w$ and is indifferent between (NE,I) and (IE,I) otherwise since $W(\text{IE},\text{I}) = W(\text{NE},\text{I}) = (iv)$ Let $\varphi \in (\varphi^G, \varphi^*]$. As in case (iii) we have $W(\text{NE},\text{I}) = W(\text{IE},\text{I}) = w^L$ and $W(\text{NE},\text{P}) = w^* - \varphi > W(\text{IE},\text{P}) = w^N$. This means that the same conclusion as part (iii) applies.

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