Compulsory licensing and patent protection: a North-South perspective*

Short Title: Compulsory licensing and patent protection

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Abstract

In a stylized model involving a developing country (called South) and a foreign patent-holder, we analyze whether and how the incidence and social value of compulsory licensing (CL) depends upon the South's patent protection policy. If South is free to deny patent protection, CL fails to arise in equilibrium and the option to use it makes both parties worse off. If South is obligated to offer patent protection, CL can occur and even yield a Pareto improvement. The ability to control price increases the South's incentive for patent protection as well as the likelihood of CL.

The ratification of the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) by the World Trade Organization (WTO) in 1995 was a watershed event in the history of the multilateral trading system. Post TRIPS, international violations of intellectual property rights (IPRs) became subject to the potent dispute settlement mechanism of the WTO.[1] It is no secret that, prior to TRIPS, pervasive imitation and piracy in many developing countries of a wide range of products protected in the West by copyrights, trademarks, and patents – such as DVDs, designer consumer items, software, and

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[1]See Maskus (2000 and 2012) for comprehensive overviews of the economics of IPRs in a global setting.

pharmaceuticals – was a major source of friction between the developed and the developing world.

The text of the TRIPS agreement that eventually emerged out of the contentious and protracted negotiations of the Uruguay Round embodies the clashing views of developing and developed countries over IPR protection. On the one hand, TRIPS obligates all WTO members to offer and enforce certain minimum standards of IPR protection (such as twenty years for patents).[2] On the other hand, TRIPS contains some important *flexibilities* that allow national governments some degree of discretion in the implementation and enforcement of IPRs within their territories. Perhaps the most important such flexibility is contained in Article 31 of TRIPS that provides conditions under which WTO members can permit the "use of the subject matter of a patent without the authorization of the right holder, including use by the government or third parties", or what is commonly referred to as the *compulsory licensing* (CL) of a patent.[3] Article 31 requires the following: (a) the entity (company or government) applying for a compulsory license should have been unable to obtain a voluntary licence from the right-holder on "reasonable" commercial terms; (b) if a compulsory license is issued, adequate remuneration must be paid to the patent-holder; and (c) a compulsory license must be granted mainly to supply the domestic market.[4]

In this paper, we develop a simple model to evaluate the costs and benefits of CL as well as those of strengthening patent protection in developing countries. Our stylized model involves two parties: a developing country (called South) and a Northern firm (called patent-holder) whose patent over its product lasts for T periods. The order of decision

[2] In accordance with the notion of special and differential treatment that exists in other parts of the WTO contract, developing countries were given fairly long time horizons within which they had to make their IPR regimes TRIPS compliant, with greatest accommodations being made for the least developed countries.

[3] The other major TRIPS flexibility (that we do not analyze here) is specified in Article 6 which states that "nothing in this Agreement shall be used to address the issue of the exhaustion of intellectual property rights." For economic analyses of exhaustion policies, see Malueg and Schwarz (1994), Ganslandt and Maskus (2004), Valleti (2006), Grossman and Lai (2008), and Roy and Saggi (2012).

[4] While TRIPS mentions national emergencies, other circumstances of extreme urgency, and anti-competitive practices as possible grounds for compulsory licensing, a WTO member has the right to issue a compulsory license even when none of these conditions are met.

making is as follows. At the beginning of the first period, the South decides whether or not to protect the patent-holder's patent in its local market. Next, the patent-holder decides whether or not to enter the Southern market. If the South provides patent protection and the patent-holder does not enter in the first period, the South has the option of issuing a compulsory license to a domestic firm that authorizes it to produce (its own version of) the patented product for sale in the local market. In the event the South chooses not to implement patent protection, a competitive local industry producing an imitated version of the patented product comes into existence, regardless of whether the patent-holder enters or not. Due to the South's limited technological capacity, the quality of production under imitation is assumed to be lower than that of the patent-holder.

Our modeling of CL follows the relevant WTO rules quite closely. We require that the South allow the patent-holder a reasonable amount of time (assumed to be one period) for serving the local market prior to the issuance of the license. Furthermore, in the event of CL, the South is required to pay (an exogenously given) per-period royalty to the patent-holder. We make the reasonable assumption that the quality of production under CL is the same as that under imitation.[5]

We use our model to analyze the effect of introducing the option of CL under two alternative scenarios: a "pre-TRIPS" world wherein the South is free to choose whether or not to offer patent protection and a "post-TRIPS" world under which patent protection is mandatory. We show that if CL is not permissible then the South ends up granting patent protection in the pre-TRIPS world iff such protection is necessary to induce the patent-holder to enter its market *and* the quality of local production under imitation is sufficiently low.[6] We then show that the option of CL *reduces* the South's willingness to

[5] The available case-study evidence shows that even countries such as Brazil and Thailand have found it difficult to produce world class products under CL: see Baron (2008) and Daemmrich and Musacchio (2011).

[6] Our model suggests a non-monotonic relationship between a country's level of development and its degree of patent protection. Evidence of a U-shaped relationship between per capita GDP and the strength of intellectual property rights, as suggested by our results, is reported by Maskus (2000) and Chen and

offer patent protection, i.e., there exist parameter regions under which the South offers patent protection *only if* it cannot resort to CL. The intuition for this result follows from a two-step logic. First, the royalties involved under CL increase the patent-holder's payoff from not entering the South (and letting CL occur). Second, imitation dominates CL from the Southern viewpoint since it does not incur royalties and also avoids the (one-period) delay involved under CL. As a result, whenever the patent-holder prefers CL to entry, the South chooses *not* to offer patent protection since it prefers imitation to CL.[7]

We then consider the impact of CL in the post-TRIPS world where the South is required to provide patent protection. As expected, such forced patent protection benefits the patent-holder at the expense of the South. However, more interestingly, CL now emerges as an equilibrium outcome. This result formally confirms the insight that with imitation becoming difficult, developing countries have an incentive to turn towards CL as a means for accessing patented foreign products at low prices. Furthermore, we identify circumstances under which joint welfare decreases (as well as when it increases) due to the shutting down of Southern imitation. We also find that, given patent protection, the option to use CL can even make both parties better off.

Since prices of patented products are often negotiated between governments of developing countries and patent-holders, we extend our model to incorporate price negotiations between the two parties. We compare equilibrium outcomes under two contrasting scenarios: in the first scenario, consistent with our core model, the patent-holder makes a take-it-or-leave it price offer the South; in the second scenario, the South makes it to the patent-holder. This comparison is conducted for both when CL is an option as well as

Puttitanun (2005).

[7] Thus, our analysis shows that developing countries may have had little use for CL when they were free to imitate foreign products that were protected by IPRs in other countries. In this context, it is worth noting that while CL was explicitly recognized in the Paris Convention for the Protection of Industrial Property of 1883, actual incidents of CL in the international context have started to emerge only during the post-TRIPS era. According to Beall and Kuhn (2012), during 1995-2011 there were 24 episodes where CL was explicitly and publicly discussed between government officials and foreign patent-holders. By contrast, during the pre-TRIPS era, we observed very little, if any, such international episodes of CL.

when it is not. The analysis yields several new insights. First, given that CL is not possible, having the ability to dictate price via a take-it-or leave it offer *makes the South more inclined to offer patent protection.* This happens because the patent-holder is willing to sell at a *lower* price when it does not face competition from imitators relative to when it does.[8] Second, the possibility of CL allows the South to secure the product at a more favorable price *even* if the patent-holder makes a take-it-or-leave it offer. This is because CL raises the South's disagreement payoff by making it possible for it to provide local consumers access to (at least) the lower quality version of the patented product. Third, by increasing the disagreement payoffs of both parties, the possibility of CL reduces the payoff of the party that makes the take-it-or-leave-it offer. As a result, the option of CL benefits the party with the weaker bargaining power during price negotiations.

Our paper contributes to the large and influential literature exploring the effects of IPR protection in a North-South setting.[9] Grossman and Lai (2004) develop a model of optimal patent protection and endogenous innovation and show that the international harmonization of IPR protection is neither necessary nor sufficient for efficiency. In a recent paper Mukherjee and Sinha (2013) consider the effects of strengthening Southern IPR protection in a duopoly model with market segmentation. They argue that by increasing the Southern firm's incentive for innovation, the strengthening of Southern IPR protection can actually make the Northern firm worse off; whether or not the welfare of each country (and that of the world as a whole) increases as a result of stronger IPR protection in the South turns out to depend upon the efficiency of Southern innovation.

Our benchmark case is similar to Saggi (2013) where the option to use CL does not exist. By endogenizing the South's decision regarding patent protection, we significantly expand the analysis of Bond and Saggi (2014) who examine the effects of CL under the

[8] This result implies that the strengthening of patent protection should make it possible for developing countries to tighten their price controls on foreign patent-holders as opposed to having to weaken them.

[9] For an in-depth survey of this literature, see Saggi (2016).

assumption that the South necessarily offers patent protection. Thus, the model developed in the present paper sheds light on two major issues that are outside the scope of Bond and Saggi (2014). One, it allows us to evaluate how the possibility of CL affects Southern incentives for patent protection. Two, we can assess whether and how the role of CL as a tool for gaining access to patented products has been modified due to the strengthening of patent protection in developing countries required under TRIPS.[10]

The rest of the paper is organized as follows. Section 1 presents our core model and its main results both with and without the option of CL. Next, in section 2, we consider the consequences of forcing the South to offer patent protection. This analysis sheds light on the welfare implications of TRIPS. Section 3 incorporates price negotiations into the model while section 4 concludes.

1 Model

We study the entry decision of a patent-holder into a developing country (South) where its technology is potentially subject to imitation. Our benchmark model is a two stage game between the patent-holder and the South. In the first stage, the South chooses whether or not to allow imitation (denoted by subscript I), where imitation generates local competition for the patent-holder. Next, the patent-holder decides whether to enter the South by incurring the fixed cost φ.[11]

[10] Bond and Saggi (2014) explicitly consider voluntary licensing (VL) in the context of CL. Here, to facilitate the analysis of patent protection, we abstract from the possibility of VL and focus on entry as the means via which the patent-holder can sell its product locally. Sinha (2006) develops a two-period oligopoly model in which a Northern firm chooses between licensing, direct entry, or exports and the degree of IPR enforcement in the South affects the firm's choice between these three supply modes as well as its investment in R&D. Yang and Maskus (2009) explore related questions in an oligopolistic setting while also considering the effect of Southern IPR protection on technology transfer and Southern exports.

[11] Any fixed costs involved under local production (either via CL or imitation) are normalized to zero. The parameter φ should be interpreted as the additional fixed costs that are faced by the patent-holder relative to local producers. Such additional costs could arise from not just production activities but also from having to secure approval from the local government prior to selling locally and/or from having to establish a local marketing and distribution network.

1.1 Demand and payoffs

There are a continuum of Southern consumers of measure 1, each of whom buys (at most) one unit of the product. If a consumer buys the product at price p, his utility is given by $U = \theta q - p$ where q measures quality and $\theta \geq 0$ is a taste parameter that captures the willingness to pay for quality. For simplicity, we assume that θ is uniformly distributed over the interval $[0, 1]$.

The patent-holder's patent lasts for T periods provided it is protected by the South. Let $\beta \in [0, 1)$ be the per period discount factor and let the marginal cost of production equal zero. Normalizing utility under no purchase to zero, the per-period demand $d(p, q)$ in the South for the patented product in the absence of imitation equals $d(p, q) = 1 - p/q$. In each period the patent-holder chooses its price p to maximize

$$\max \pi_E(p) = p\,(1 - p/q) \tag{1}$$

The present value of the patent-holder's entry profits (gross of fixed costs) as a function of its price p equals

$$v_E(p) = (1 + \Omega)\pi_E(p) \text{ where } \Omega = \sum_{t=1}^{T} \beta^t \tag{2}$$

The per-period consumer surplus that accrues to the South from purchasing the patented product at price p equals

$$s_E(p) = \int_{p/q}^{1} (q\theta - p)d\theta = \frac{(p - q)^2}{2q} \tag{3}$$

which implies that Southern welfare over the duration of the patent under entry at price p equals

$$w_E^S(p) = (1 + \Omega)s_E(p) \tag{4}$$

Solving the problem in (1) yields the patent-holder's optimal monopoly price $p^m = q/2$. Thus, the maximized payoff from entry to the patent-holder when its patent is protected

equals

$$v_E(p^m) = (1+\Omega)p^m\,(1-p^m/q) \tag{5}$$

while that to the South equals

$$w_E^S(p^m) = (1+\Omega)s_E(p^m) \tag{6}$$

When the South does not protect the patent-holder's patent, imitation results in the emergence of a competitive industry that produces a lower quality version of the patented product. Let γq denote the quality of Southern imitation where $0 < \gamma \leq 1$.[12]

Competition within the Southern industry ensures that the imitated good is sold at marginal cost. When two different qualities are available for purchase at prices p (high quality) and 0 (low quality), Southern consumers can be partitioned into two groups: those in the range $[0, \theta_h(p;\gamma)$ buy the low quality whereas those in $[\theta_h(p;\gamma), 1]$ buy the high quality where

$$\theta_h(p;\gamma) = \frac{p}{q(1-\gamma)}$$

When facing competition from imitation, the patent-holder chooses its price p to maximize

$$\max \pi_I(p;\gamma) = p[1-\theta_h(p;\gamma)]$$

with the associated value $v_I(p) = (1+\Omega)\pi_I(p)$. The patent-holder's profit maximizing price when facing competition from the imitative industry equals

$$p_I^m(\gamma) = q(1-\gamma)/2 = (1-\gamma)p^m$$

Observe that $p_I^m \leq p^m$ since $0 < \gamma \leq 1$. Thus, competition from imitation lowers the patent-holder's gross entry payoff to

$$v_I(p_I^m;\gamma) = (1+\Omega)(1-\gamma)\pi^m = (1-\gamma)v_E(p^m) \tag{7}$$

[12] 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.

where $\gamma \leq 1$.

If the South permits imitation and the patent-holder does not enter then local consumers obtain access (only) to the lower quality imitated good at a price equal to marginal cost (set to zero). Under this scenario, Southern welfare equals

$$w_N^S(\gamma) = (1+\Omega)s_N(\gamma) \text{ where } s_N(\gamma) = \int_0^1 \gamma q\theta d\theta \tag{8}$$

However, if the patent-holder enters the Southern market despite imitation, Southern welfare equals

$$w_I^S(p_I^m;\gamma) = (1+\Omega)s_I(p_I^m;\gamma) \text{ where } s_I(p_I^m;\gamma) = \int_0^{1/2} \gamma q\theta d\theta + \int_{1/2}^1 [q\theta - p_I^m]\, d\theta \tag{9}$$

It is straightforward to show that $w_I^S(p_I^m;\gamma) > w_E^S(p^m)$. Thus, provided the patent-holder enters, Southern welfare increases due to imitation. When the South permits imitation, those Southern consumers that are unwilling to pay the price for the higher quality product sold by the patent-holder gain access to a lower quality version that sells at a lower price. This *variety enhancing effect of imitation* is one reason the South benefits from imitation. The second reason, of course, is that the imitated product competes with the patented product and this competition lowers the price of the high quality.

In the absence of competition form imitation, only half of the market in the South is covered since $\theta_h(p^m) = p^m/q = 1/2$ in equilibrium. By contrast, when imitation occurs, all those consumers that buy the high quality in the absence of imitation continue to do so although they now pay a lower price for it. In addition, all consumer in the range $[0, 1/2]$ end up buying the low quality imitative good so that the entire Southern market ends up being covered.

1.2 Equilibrium

The patent-holder's entry decision at the second stage depends upon the patent protection policy implemented by the South at the first stage. Given patent protection, the patent-

holder sells in the South iff

$$v_E(p^m) - \varphi \geq 0 \Leftrightarrow \varphi \leq \varphi_E \equiv v_E(p^m) \tag{10}$$

Similarly, when facing imitation, the patent-holder chooses to enter iff

$$v_I(p_I^m;\gamma) - \varphi \geq 0 \Leftrightarrow \varphi \leq \varphi_I \equiv v_I(p_I^m;\gamma) \tag{11}$$

Since $\varphi_I \leq \varphi_E$, the lack of patent protection makes the patent-holder *less willing* to sell in the South.

Anticipating the patent-holder's entry decision, the South's optimal patent protection policy is as follows:

PROPOSITION 1. *In the benchmark model (where compulsory licensing is not possible), the South offers patent protection if and only if (i)* $\varphi_I < \varphi \leq \varphi_E$ *and (ii)* $\gamma \leq \gamma^S \equiv 1/4$.

Figure 1 illustrates Proposition 1. In this figure, the equilibrium outcome is denoted by a pair (X, Y) where X=I or P denotes the South's patent protection policy and Y=E or N denotes the patent-holder's entry decision. In region **A**, where $\varphi < \varphi_I$, the patent-holder enters even if it faces imitation in the South. Given entry by the patent-holder, South has no incentive to offer patent protection since doing so lowers local consumer surplus by eliminating the imitated (low quality) product from the market. As a result, the equilibrium outcome over region **A** is (I,E). In region **D**, where $\varphi > \varphi_E$, the South once again has no incentive to grant patent protection since the patent-holder does not sell in the South even if its patent is protected. Here, the equilibrium outcome is (I,N). When $\varphi_I < \varphi \leq \varphi_E$, the patent-holder enters iff the South offers patent protection. Under such a situation, the South faces a trade-off: imitation provides consumers access to the low quality product while *simultaneously denying* access to the high quality. As a result, the South's decision is determined by the quality gap ($1/\gamma$) between the two products. When this gap is large, as illustrated by region **B** where $\gamma \leq \gamma^S$, the South offers patent protection and the outcome is

(P,E). For the remaining areas, **C** and **E**, the quality of the imitated product is sufficiently high that the South prefers it over the patented product at monopoly price so that the equilibrium outcome is (I,N).

[Figure 1 here]

The main insight behind Proposition 1 is that the South grants patent protection iff such protection is *necessary* to induce the patent-holder to sell locally *and* the quality of local production under imitation is sufficiently low that shutting down imitation to obtain access to the high quality patented product raises local welfare.

It is also useful to compare the South's decision on whether to grant patent protection with the decision that would maximize joint welfare. Defining joint welfare as the sum of their individual welfare levels, joint welfare in the case where the South offers patent protection will be

$$w_E(p^m) = (1+\Omega)s_E(p^m) + v_E(p^m) - \varphi$$

Given patent protection, if the patent-holder does not enter (which it does not whenever $\varphi > \varphi_E$), the welfare of each party equals zero. Therefore, entry is jointly optimal iff

$$w_E(p^m) \geq 0 \;\Leftrightarrow \varphi \leq \varphi_E^m$$

where $\varphi_E^m > \varphi_E$ which reflects the fact that the patent-holder ignores local consumer surplus. Through-out the paper we assume that $\varphi < \varphi_E^m$.

The Southern government's decision regarding patent protection does not take into account the welfare of the patent-holder. As a result, the South's incentive for patent protection is weaker than what joint optimality requires, as shown in the following result:

PROPOSITION 2. *Given that the patent-holder makes the profit-maximizing entry decision, joint welfare is maximized by having the South offer patent protection over the following parameter regions:*

(a) $\gamma \leq \gamma^S \equiv 1/4$ *and* $\varphi_I < \varphi \leq \varphi_E$

(b) $\varphi \in [\varphi_I, \varphi_E^w]$ *and* $\gamma \in [\gamma^S, \gamma^w]$, *where* $\varphi_E^w \equiv q(3-4\gamma)(1+\Omega)/8$ *and* $\gamma^w = 1/2$.

For all other parameter values, joint welfare is maximized by allowing imitation in the South.

Proposition 2 can be illustrated using Figure 1. The jointly efficient outcome in this figure over each particular region is denoted by an asterisk superscript, i.e., as $(X,Y)^*$ where $X{=}I$ or P and $Y{=}E$ or N. The South's decision to deny patent protection is jointly optimal for all $\varphi \in [0, \varphi_I]$ (region **A** in Figure 1) as well as for $\varphi > \varphi_E$ (region **D**). For parameters in region **A**, the outcome is socially optimal because the patent-holder enters even though the South does not offer patent protection; for parameters in region **D**, the patent-holder would not enter even if its patent were protected which makes it socially optimal to not protect it. For region **B,** we have $\varphi \in [\varphi_I, \varphi_E]$ and $\gamma < \gamma^S$ so that patent protection is socially optimal and the South chooses to offer it. Here, even though the patent-holder acts as a monopolist, its quality advantage over Southern imitators (if allowed to operate) is so large that it is optimal to restrict competition from imitation.

For region **C** in Figure 1, we have $\varphi \in [\varphi_I, \varphi_E^w]$ and $\gamma \in [\gamma^S, \gamma^w]$. In this region the equilibrium outcome is for the South to allow imitation and the patent-holder not to enter, i.e., (I,N), while joint welfare is maximized under (P,E) wherein the South offers patent protection and the patent-holder enters. From the South's perspective, the technological superiority of the patent-holder is outweighed by the cost to the Southern consumers of allowing it monopoly power in this region. But taking account of the profits earned by the patent-holder (which the South ignores) tips the balance in favor of patent protection. In region **E** in Figure 1 we have $\max\{\varphi_I, \varphi_E^w] < \varphi < \varphi_E$ and the South's decision to deny patent protection is again optimal. Here, the quality of the imitated product is high enough to render monopoly pricing for the patented product socially suboptimal and the costs of entry are low enough that the patent-holder enters despite imitation.

1.3 Model with compulsory licensing

We now extend the model to include a third stage where the South decides whether or not to grant a compulsory license. If the product has not been sold in the market in the first period, the South can issue a compulsory license to a local firm who pays the per-period royalty R to the patent-holder for the duration of the patent. The royalty R reflects the TRIPS requirement of "adequate remuneration" being paid to the patent-holder in the event of CL. With these assumptions, the welfare of the South under a compulsory license equals:

$$w_{CL}^{S}(\gamma, R) = \Omega \left[s_N(\gamma) - R \right] \tag{12}$$

CL is a credible threat for $w_{CL}^{S}(\gamma, R) \geq 0 \Leftrightarrow \gamma \geq \gamma_m = R/p^m$. Thus, CL is a credible threat so long as the quality of licensed production is not so low that the total surplus generated for Southern consumers is insufficient to cover the royalty R paid to the patent-holder.

When making its entry decision, the patent-holder takes the possibility of CL into account. If given patent protection by the South, the patent-holder has to decide whether to (a) incur the fixed cost φ and collect the payoff $v_E(p^m)$ or (b) to not enter and wait for CL to occur in the next period under which its payoff is ΩR. The patent-holder prefers entry to CL iff

$$v_E(p^m) - \varphi \geq \Omega R \Leftrightarrow \varphi \leq \varphi_E(R) \equiv v_E(p^m) - \Omega R \tag{13}$$

Thus, the patent-holder chooses entry for all $\varphi \leq \varphi_E(R)$ whereas it waits for CL if $\varphi > \varphi_E(R)$. Observe that $\varphi_E(R) = \varphi_E - \Omega R$, i.e., the possibility of CL makes the patent-holder *less willing* to enter by allowing it to collect royalty payments from the Southern market for the duration of the compulsory license if it chooses to stay out.[13]

[13] In formulating this problem, we simplify the analysis by ruling out the possibility of the patent-holder delaying entry until a later period. Delayed entry has the potential to affect the South's decision regarding compulsory licensing since the patent-holder could enter and compete with the licensee after the South has granted a CL or it could enter as a monopolist if the South chooses not to issue a CL in period two. Introducing these possibilities into the model substantially complicates the analysis without affecting the qualitative nature of our main results.

As before, if imitation is allowed by the South, the patent-holder's payoff from entry falls to $(1-\gamma)v_E(p^m)-\varphi$. Observe that $\varphi_E(R) = \varphi_I \Leftrightarrow v_E(p^m)-\Omega R = (1-\gamma)v_E(p^m)$ which holds when $\gamma v_E(p^m) = \Omega R$. Since imitation precludes CL, the patent-holder's decision in the face of imitation is trivial: it prefers entry to staying out iff $\varphi \leq \varphi_I$. Foreseeing the patent-holder's decision, the South sets the following patent protection policy:

PROPOSITION 3. *When compulsory licensing is an available option, the South chooses to grant patent protection iff (i)* $\varphi_I < \varphi \leq \varphi_E(R)$ *and (ii)* $\gamma \leq \gamma^S$.

Observe that for $R > 0$, $\varphi_E(R) < \varphi_E$: given that CL yields a strictly positive royalty payment to the patent-holder, *the South is less willing to offer patent protection when it has the option to use CL.* More specifically, over the parameter region $max\{\varphi_E(R), \varphi_I\} < \varphi < \varphi_E$ (region **B1** in Figure 2) the option to use CL leads the South to not offer patent protection since, over this set of parameter values, the patent-holder would prefer to stay out to collect royalties under CL *even if* it is protected from imitation. It is important to note that though CL does not arise in equilibrium, by raising the patent-holder's payoff from staying out the *possibility* of CL increases the likelihood that the South denies patent protection.

1.4 Welfare effects of CL

How does the option of CL affect the two parties? The result here is surprising and clear:

PROPOSITION 4. *Given that the South is free to allow imitation, not only does CL fail to arise in equilibrium but the option to use CL makes both parties worse off.*[14]

The intuition for this result is as follows. We noted above that when $max\{\varphi_E(R), \varphi_I\} < \varphi < \varphi_E$ and $\gamma \leq \gamma^S$ the possibility of CL induces the South to not offer patent protection since, for this set of parameter values, the patent-holder prefers to stay out of the South in order to collect royalty payments under CL if its patent is protected. This, in turn, makes

[14]Both parties strictly lose when $max\{\varphi_E(R), \varphi_I\} < \varphi < \varphi_E$ and $\gamma \leq \gamma^S$ whereas they are unaffected otherwise.

patent protection counter-productive for the South: since Southern welfare under imitation dominates that under CL (due to the delay involved and the royalties incurred under CL), the South is better off permitting imitation to preclude CL.

The important point is that for this set of parameter values, the South would actually be better off if only the patented product were to be sold in its market since the local industry's product is of fairly low quality ($\gamma \leq \gamma^S$). Similarly, the patent-holder would be strictly better off under entry since $v_E(p^m) > \varphi$ for $\varphi < \varphi_E$. It follows then that if imitation is possible then a credible commitment on the part of the South to not use CL would make both parties better off when $max\{\varphi_E(R), \varphi_I\} < \varphi < \varphi_E$ and $\gamma \leq \gamma^S$. As we shall see below, the option to use CL can never make both parties worse off if the South cannot allow local imitation.

2 If South must offer patent protection

What are the consequences of forcing the South to offer patent protection, say due to an international agreement such as TRIPS? Figure 2 proves useful in addressing this question.

[Figure 2 here]

When imitation is not permitted, the patent-holder chooses entry for all $\varphi \leq \varphi_E(R)$ whereas it waits for CL to occur when $\varphi > \varphi_E(R)$. If $\varphi > \max\{\varphi_E(R), \varphi_I\}$, (regions **B1**, **E1**, and **D** in Figure 2) in the absence of TRIPS, the South permits imitation whereas the patent-holder stays out. Shutting down imitation converts the market outcome from one where a competitive local industry supplies the low quality product to one where the same product is supplied by the local licensee (at price equal to marginal cost) under CL. While the price and quality under CL and imitation are the same, CL occurs with *delay* since, as per WTO rules, the South is required to give the patent-holder a chance to work its patent. Furthermore, the South has to pay royalties under CL whereas it does not compensate the

patent-holder under imitation. Both the delay involved under CL and the compensation paid to the patent-holder make the South worse off. The patent-holder obviously benefits: absent CL, it stays out and collects no profit from the Southern market.

Next consider the parameter range where $\varphi_E(R) < \varphi < \varphi_I$ (region **A1** in Figure 2). Over this range, in the absence of TRIPS, the patent-holder enters the South despite the fact that South permits imitation. With TRIPS in place, the patent-holder chooses to stay out and wait for CL to occur since the value of royalty payments under CL exceeds its payoff under entry (even though entry is profitable in an absolute sense). When this happens, the South loses because the high quality product is eliminated from the market (i.e. both competition and variety decline). It is worth noting here that for $\varphi_E(R) < \varphi < \varphi_I$ it is patent protection that induces the patent-holder to stay out of the Southern market, as opposed to the lack of such protection. This happens because the payoff under CL to the patent-holder exceeds that under entry even though it chooses to enter when patent protection is missing.

Over the range $\varphi_I < \varphi < \varphi_E(R)$ the consequences of requiring South to extend patent protection depend upon whether or not $\gamma \leq \gamma^S$. When this inequality holds (i.e. region **B2** in Figure 2), local production suffers from a large enough quality gap that the South willingly offers patent protection to induce the patent-holder to sell locally. Thus, the South is coerced to offer patent protection only when $\gamma > \gamma^S$ (i.e. regions **C1** and **E2** in Figure 4). Suppose this inequality holds. Then, forcing the South to implement patent protection converts the local market from a competitive imitative industry selling the low quality product to one where the patent-holder sells the high quality at its optimal monopoly price. This switch benefits the patent-holder at the expense of the South (who does not find it worthwhile to offer such protection due to the relatively small quality gap between the patented and the imitated product). Furthermore, this switch also increases joint welfare for $\varphi \in [\varphi_I, \varphi_E^w]$ and $\gamma \in [\gamma^S, \gamma^w]$ (region **C1** in Figure 2). But for parameters outside these

ranges (i.e. in region **E2** in Figure 2) this change reduces joint welfare.

Finally, over the range where $\varphi < \min\{\varphi_I, \varphi_E(R)\}$ (i.e. region **A2** in Figure 2) the patent-holder enters the South regardless of whether or not its patent is protected. Under such a scenario, shutting down local imitation hurts the South because it reduces competition as well variety in the local market. For the same reasons, joint welfare declines.

We summarize this discussion below:

PROPOSITION 5. *Requiring the South to offer patent protection benefits the patent-holder at the expense of the South. In addition, it has the following effects:*

(i) If $\varphi > \max\{\varphi_E(R), \varphi_I\}$, *imitation is replaced by CL and joint welfare declines.*

(ii) If $\varphi_E(R) < \varphi < \varphi_I$, *CL replaces a market structure where the patent-holder competes with the imitative industry and joint welfare declines.*

(iii) Over the range $\varphi_I < \varphi < \varphi_E(R)$, *when* $\gamma > \gamma^S$, *the low quality Southern imitative industry is replaced by the high quality patent-holder and joint welfare increases iff* $\varphi \in [\varphi_I, \varphi_E^w]$ *and* $\gamma \in [\gamma^S, \gamma^w]$.[15]

(iv) For $\varphi < \min\{\varphi_E(R), \varphi_I\}$, *joint welfare declines because competition from the imitative industry is eliminated.*

An important insight provided by Proposition 5 is that, *when forced to offer patent protection, the South turns towards CL as a means for securing the product at a low price.* Recall that when imitation is possible, CL does not even arise in equilibrium since, from the Southern viewpoint, it is dominated by imitation. Thus, even though CL predates the TRIPS agreement, our model shows that one should expect it to be observed more frequently during the post TRIPS era during which member countries of the WTO have had to clamp down on imitation.

[15] The two parties are unaffected if $\gamma \leq \gamma^S$ since the South willingly offers patent protection and the patent-holder chooses to enter.

In light of Proposition 5, it is worth asking how the option to use CL affects the two parties when the South can no longer avail of imitation. For $\varphi \leq \varphi_E(R)$, the patent-holder enters with and without CL so neither party is affected. For $\varphi \in (\varphi_E(R), \varphi_E]$ the possibility of CL induces the patent-holder to stay out of the market in order to collect royalties under CL. While the patent-holder necessarily gains from this switch, the South benefits from it iff

$$(1+\Omega)s_E(p^m) \leq \Omega\left[s_N(\gamma) - R\right]$$

which is the same as

$$\gamma \geq \gamma_{CL} \equiv (1+1/\Omega)\,\gamma^S + R/p^m \tag{14}$$

Note that the minimum value at which the South prefers CL to entry, γ_{CL}, exceeds the minimum value at which imitation is preferred to entry, γ^S, because CL involves delay in obtaining the product as well as royalty payments. The term $1 + 1/\Omega$ captures the importance of the delay relative to the overall life of the product while the term R/p^m reflects the importance of the royalty payment. Of course, for $\gamma \geq \gamma_{CL}$, the South is actually better off under CL but the patent-holder preempts it by entering. We can now state:

PROPOSITION 6. *Given that the South must grant patent protection, the option of using CL has the following effects:*

(i) For $\varphi \leq \varphi_E(R)$, entry occurs whether or not the South can use CL. However, for $\gamma \geq \gamma_{CL}$ the South is better off with CL but the patent-holder preempts it via entry.

(ii) When $\varphi \in (\varphi_E(R), \varphi_E]$, the patent-holder chooses to stay out and wait for CL. If $\gamma < \gamma_{CL}$ the patent-holder gains while the South loses; otherwise, both parties gain.

(iii) For $\varphi > \varphi_E$, the option of CL benefits both parties.

In part (i), when $\gamma \geq \gamma_{CL}$ the South has sufficient technological capability that it is better off producing the product under CL but the patent-holder's entry costs are low

enough that it chooses to enter thereby precluding CL. In part (ii), the possibility of CL can hurt the South when its technological capability is relatively weak (i.e. $\gamma < \gamma_{CL}$) but the costs of entry are high enough for the patent-holder to prefer royalty payments under CL to entry.[16]

Our analysis has shown that the desirability of the CL option hinges very much on whether or not the South is free to deny patent protection. When the South can do so, CL is essentially counter-productive – not only does it not arise in equilibrium, but the option to use it makes both parties worse off; when South must offer patent protection, CL can play a much more useful role and can even make both parties better off.

Thus far we have assumed that the patent-holder is free to charge its optimal monopoly price p^m when selling in the South. We now extend our model to incorporate price negotiations between the two parties.

3 Entry with price negotiations

Since the South may not equate the availability of the patented product at monopoly price to having access to it at "reasonable commercial terms", it is worthwhile to extend the model to allow for price negotiations between the South and the patent-holder. Rather than assuming a specific bargaining protocol for price negotiations, we illustrate the impact of these negotiations by comparing the case where the patent-holder achieves its most preferred price outcome with that when the South achieves its best outcome.[17]

[16] Since the interests of the two parties can conflict, it is worth asking when CL yields higher joint welfare than entry. We can show that $w^S_{CL}(\gamma, R) > w_E(p^m)$ iff $\varphi > \varphi_{CL} = q[3(1+\Omega) - 4\Omega\gamma]/8$ and that $\varphi_{CL} > \varphi_E$ iff $\gamma < \gamma^w_{CL} = (1+\Omega)/4\Omega$.

[17] In Bond and Saggi (2016) we analyze a finite-horizon alternating offers game in which the patent-holder bargains with the South over the local price of its patented good. The focus of that paper is on how the presence of international price spillovers (between the South and the patent-holder's home market) and the threat of CL alter the equilibrium of the bargaining game.

3.1 Price negotiations without CL

For the case where the South does not have the option of issuing a compulsory license, we analyze a two stage game in which the South chooses whether or not to offer patent protection in the first stage and then negotiates with the patent-holder over price in the second stage. We consider two different scenarios at the second stage: one where the patent-holder makes a take-it-or-leave it price offer and another where the South does so.

If the South has granted patent protection at the first stage, the maximum price that it is willing to accept is q, since it receives a payoff of zero if the patent-holder does not enter. The patent-holder's disagreement payoff is also zero because it cannot enter the market if the two parties fail to reach agreement. The minimum price that the patent-holder would accept is the solution to $v_E(p) = \varphi$ which yields

$$p_E^{\min}(\varphi) = p^m \left[1 - \left(1 - \frac{4\varphi}{q(1+\Omega)}\right)^{1/2}\right] \tag{15}$$

Any price above the monopoly price p^m is Pareto dominated by p^m, so the interval $[p_E^{\min}(\varphi), p^m]$ is the set of prices that are individually rational and not Pareto dominated. The set of feasible prices, $[p_E^{\min}(\varphi), p^m]$, is non-empty for $\varphi \leq \varphi_E$.

If the South had chosen not to provide patent protection in the first stage, the minimum price that the patent-holder is willing to accept is the price at which it earns zero profits when facing competition from imitators, which equals

$$p_I^{\min}(\varphi, \gamma) = p_I^m \left[1 - \left(1 - \frac{4\varphi}{q(1-\gamma)(1+\Omega)}\right)^{1/2}\right] \tag{16}$$

where p_I^m is the maximum price that the patent-holder would ever charge and $p_I^m = (1 - \gamma)p^m$. The set of feasible prices $[p_I^{\min}(\varphi), p_I^m]$ is non-empty for $\varphi \leq \varphi_I$.

If the patent-holder makes a take-it-or-leave-it offer, it offers the price p^m if the South implements patent protection and the price p_I^m if it does not. The analysis in this case is identical to the case without price bargaining, so the South's choice of patent policy in the

absence of CL is identical to that reported in Proposition 1.

If the South makes a take-it-or-leave-it offer, it offers the price $p_E^{\min}(\varphi)$ under patent protection and the price $p_I^{\min}(\varphi)$ in its absence. The following proposition, proven in the Appendix, derives the range of parameter values for which the South provides patent protection when it has all of the bargaining power:

PROPOSITION 7. *Suppose that the South makes a take-it-or-leave-it price offer for the patented product and compulsory licensing is not an option.*

(i) In region ***A*** *of Figure 3, the South provides patent production and the patent-holder enters at price* $p_E^{\min}(\varphi)$.

(ii) In regions ***B*** *and* ***F****, the South provides patent protection and the patent-holder enters at price* $p_E^{\min}(\varphi)$ *where region* ***F*** *is determined by conditions (a)* $\gamma \geq \gamma^S$ *and (b)* $\varphi \in [\varphi_I, \varphi^B]$ *where*

$$\varphi^B(\gamma) \equiv q(\sqrt{\gamma} - \gamma)(1 + \Omega)$$

(iii) In regions ***G*** *and* ***D****, the South does not grant patent protection and the patent-holder chooses not to enter.*

In region **A**, $\varphi \leq \varphi_I$ and the patent-holder can earn positive profits regardless of whether it receives patent protection. If the South does not offer patent protection, it gets the product at a price $p_I^{\min}(\varphi) < p_I^m$ when it has all of the bargaining power. Note however, the South's power is limited by the fact that the patent-holder sells fewer units at any given price when there is imitation (with $\gamma > 0$). As a result, the patent-holder requires *a higher minimum price* to enter in the absence of patent protection: i.e. $p_I^{\min}(\varphi, \gamma) > p_E^{\min}(\varphi)$ for $\gamma > 0$. The trade-off for the South is that if the South offers patent protection, it loses the product variety benefit of having the lower quality product available to consumer but it is able to obtain the high quality product at a lower price. It is shown in the Appendix that the latter effect dominates, so that the South will provide patent protection in region A.

[Figure 3 here]

For regions **B**, **F**, and **G,** the patent-holder enters only if it obtains patent protection. It is in the interest of the South to provide patent protection iff the consumer surplus from the patented product, $s_E(p_E^{\min}(\varphi))$, is greater than the surplus obtained from consuming only the imitated product, $s_N(\gamma)$. The critical value $\varphi^B(\gamma)$ that separates regions **F** and **G** is the level of fixed cost for which these payoffs are equal to each other. The South obtains a price for the patented product that is sufficiently low in regions **B** and **F** that it is willing to offer patent protection but such is not the case in region **G**. Observe that $\varphi^B(\gamma)$ is decreasing in γ, because an increase in the quality of the imitated product reduces the maximum price that the South is willing to pay for the patented product.

A comparison of Propositions 1 and 7 illustrates that the South's ability to drive the patent-holder to its minimum acceptable price *significantly expands* the parameter region over which it chooses to provide patent protection. In regions **A** (i.e. $\varphi \leq \varphi_I$) and region **F** ($\gamma > \gamma^S$ and $\varphi < \varphi^B(\gamma)$), the South offers patent protection when it has all of the bargaining power but does not offer patent protection when the patent-holder has all of the bargaining power. In addition, the South obtains the patented product at a more favorable price in region **B** when it has all of the bargaining power.[18]

3.2 CL, bargaining, and patent protection

We now examine price negotiations when the South has the option of issuing a compulsory license if no agreement is reached after the first period. Since patent protection is a prerequisite for CL, we assume that the South provides patent protection throughout this subsection.

The option of CL alters the South's disagreement point from a payoff of 0 to present

[18] Note that the result that price negotiations expand the range of γ for which the South prefers patent protection holds for any degree of bargaining power for the South that yields a price below the monopoly price.

value of consumer surplus under CL, which equals $(s_N(\gamma)-R)(1+\Omega)$. For the patent-holder, the fact that the South would issue a compulsory license in the absence of an agreement raises its disagreement payoff from zero to the present value of royalty payments it would obtain under CL, which equals ΩR. We show below that this change in the disagreement payoffs of the two parties due to the option of CL narrows the range of fixed costs for which an agreement can be reached while also altering the price that is negotiated in the event that the patent-holder enters.

We first consider the effects of CL on the subgame in which the South provides patent protection. From (15), due to existence of royalty payments under CL, the minimum price the patent-holder is willing to accept is $p_E^{\min}(\varphi + \Omega R)$. Since $p_E^{\min}(\varphi + \Omega R)$ is increasing in R, the possibility of CL *raises* the minimum price that the South must pay to induce entry.

The existence of CL can also affect the maximum price that the South is willing to pay. To see why, first note that the price that makes the South indifferent between entry and CL solves the following equation:

$$(1+\Omega)s_E(p) = \Omega\left[s_N(\gamma) - R\right] \Leftrightarrow \int_{p/q}^{1} (q\theta - p)d\theta = \frac{\Omega}{1+\Omega}\left[\int_0^1 \gamma q\theta d\theta - R\right]$$

which yields

$$p_E^{\max}(\gamma, R) = q\left[1 - \left(\frac{(\gamma q - 2R)\,\Omega}{q(1+\Omega)}\right)^{1/2}\right] \tag{17}$$

Observe that $p_E^{\max}(\gamma, R)$ is decreasing in γ and increasing in R, because CL is more attractive to the South the greater is the quality of the imitated product and the lower is the royalty rate under CL. The possibility of CL *reduces* the maximum price the South is willing to pay only when $p_E^{\max}(\gamma, R) < p^m$, which is satisfied only if the imitative capacity of the South is such that it prefers CL to entry at the monopoly price, i.e., $\gamma \geq \gamma_{CL}$ as defined in (14). In the core model without price negotiations, the South does not have the ability to deny entry by the patent-holder because it was assumed that entry by the patent-holder preempted the South's right to issue a compulsory license.

When CL is an available option, the patent-holder and the South negotiate over prices that lie in the interval $[p_E^{\min}(\varphi + \Omega R), \min\{p_E^{\max}(\gamma, R), p^m\}]$. An agreement is reached for all levels of fixed costs for which this interval is non-empty. For $\gamma < \gamma_{CL}$, CL is not a credible threat for the South and an agreement is reached for $\varphi \leq \varphi_E(R)$. For $\gamma \geq \gamma_{CL}$, this interval is non-empty for $\varphi \leq \varphi_{CL}^B(\gamma, R)$, where $\varphi_{CL}^B(\gamma, R)$ is the solution to $p_E^{\min}(\varphi + \Omega R) = p_E^{\max}(\gamma, R)$. Since $p_E^{\max}(\gamma, R) < p^m$ for $\gamma > \gamma_{CL}$, we have $\varphi_{CL}^B(\gamma, R) < \varphi_E(R)$.

We can now determine how the possibility of CL affects the equilibrium outcome. When CL is not an option, the patent-holder enters for $\varphi \leq \varphi_E$ and does not sell the product otherwise. When CL is an option, the patent-holder enters in the first period for $\varphi < \min[\varphi_E(R), \varphi_{CL}^B(\gamma, R)]$ and waits for CL to issued in the next period otherwise. This results in a switch from entry to CL for $\varphi \in [\min[\varphi_E(R), \varphi_{CL}^B(\gamma, R)], \varphi_E]$, which is shown by regions **V**, **W**, and **X** in Figure 4.

[Figure 4 here]

In region **D**, the option to use CL causes a switch from the product not being sold in the South to Southern consumers having access to it via the issuance of a compulsory license. The option to use CL expands consumer access to the product in the South, but it also reduces the range of fixed costs for which the patent-holder is willing to enter. Note that the interval over which entry occurs depends on the imitative ability of the South and the required royalty payment, but is independent of the relative bargaining power of the two parties.

Comparing Figures 2 and 4, it can be seen that CL replaces entry for a larger range of parameter values when the patent-holder and the South negotiate over the entry price than when there is no negotiation. For fixed costs in region **X** in Figure 4, the option to issue a compulsory license results in a switch from entry to CL when price is negotiated between the two parties. In contrast, the patent-holder enters with or without CL in region **X** when

price negotiations are absent. In region **X**, the South's ability to imitate is sufficiently high that it prefers to deny entry at the patent-holder's preferred price to obtain the product under CL when it is able to negotiate with the patent-holder.

A second important effect of CL is to influence the price that is negotiated between the two parties. If the patent-holder has all of the bargaining power, it sells at the maximum price in the range of feasible prices. Referring to Figure 4, the patent-holder makes a take or leave it offer of p^m to the left of the vertical line line at γ_{CL} for $\varphi \leq \varphi_E(R)$. For $\gamma > \gamma_{CL}$, the patent-holder makes an offer of $p_E^{\max} < p^m$ for $\varphi \leq \varphi_{CL}^B(\gamma, R)$. The ability of the South to deny entry by the patent-holder benefits the South by reducing the price from p^m to $p_E^{\max}$ when CL is a credible threat. On the other hand, when the South makes a take or leave it offer, it offers the lowest price in the range of feasible prices for $\varphi < \min\{\varphi_E(R), \varphi_{CL}^B(\gamma, R)\}$. The price at which the South obtains the product increases from $p_E(\varphi)$ to $p_E(\varphi + \Omega R)$ due to the option of CL, because the South must compensate the patent-holder for the royalty it would receive under a compulsory license.

Combining the effect of CL on the region over which the patent-holder enters and the impact on the negotiated price under entry, we obtain the following result (proven in the Appendix) regarding the impact of the threat of CL on both parties:

PROPOSITION 8. *Suppose that the South offers patent protection.*

(i) If the patent-holder has all of the bargaining power, the threat of CL benefits the South in regions ***D****,* ***W****,* ***X****, and* ***Z*** *in Figure 4 whereas it harms the South in region* ***V****. The patent-holder benefits from the possibility of CL in regions* ***D****,* ***V****, and* ***W*** *whereas it loses in regions* ***X*** *and* ***Z****. Neither party is affected in region* ***Y****.*

(ii) If the South has all of the bargaining power, the threat of CL benefits the patent-holder in all regions in Figure 4. The South also gains in region ***D*** *and over portions of regions* ***W*** *and* ***X*** *for which* $p_E^{\max}(\gamma, R) < p_E^{\min}(\varphi)$.

Proposition 8 illustrates that the South's ability to deny entry by the patent-holder

under price negotiations benefits the South. This can be seen by comparing the result of Proposition 8(i) with the effect of allowing CL in the absence of price negotiations. The South gains from the option of CL for parameter values in region **X** when price is negotiated but loses when it is not. For parameter values in region **X** the imitative ability of the South is sufficiently high that it prefers CL to entry at the monopoly price and price negotiations make it possible for it to deny entry.

An important insight contained in Proposition 8 is that the South's ability to impose CL *primarily benefits the party whose bargaining power is weaker*. The option of CL raises the disagreement payoff of each party and the party making a take-it-or-leave-it offer has to account for the other party's higher disagreement payoff. This effect benefits the South in regions **X** and **Z** when the patent-holder has all of the bargaining power and CL is a credible threat. For the patent-holder, the existence of a positive royalty payment under CL provides a benefit that must be compensated for all parameter values for which it would be willing to enter at the monopoly price. Finally, Proposition 8 highlights the role of the South's imitative ability in determining the effects of CL since the threat of CL is credible only when $\gamma > \gamma_{CL}$.

4 Conclusion

TRIPS flexibilities such as compulsory licensing are intended to provide member countries of the WTO with a safety valve when domestic considerations make it imperative to opt out of TRIPS obligations. While CL predates TRIPS, developing countries had little use for it when they were free to deny patent protection to foreign firms. During the pre-TRIPS era, imitation and reverse-engineering allowed developing countries with adequate technological capability to obtain cheap access to pharmaceuticals that were patented in the rest of the world. Even those developing countries that lacked the ability to produce pharmaceuticals domestically were able to import them from countries such as India and

China. But with the ratification of TRIPS, developing countries have come under increasing pressure to offer and enforce patent protection at a level that is on par with the Western world. As a result, during the post-TRIPS era CL has the potential to become an important policy tool using which developing countries can provide local consumers access to patented pharmaceuticals at reasonable prices provided its use is not met with serious resistance from developed countries.

We construct a stylized model in which a developing country (South) chooses its patent protection policy taking into account the effect of its policy on the incentive of a patent-holder to sell in its market. As per TRIPS rules, we assume that the South has the option to issue a compulsory license to a local firm only if the patent-holder chooses not to work its patent locally. Our analysis provides several interesting insights. First, we find that the South has an incentive to offer patent protection if and only if it is necessary for inducing the patent-holder to serve its market and the quality of the imitated local product is sufficiently low. Second, from the Southern perspective, TRIPS consistent CL is an imperfect substitute for imitation: not only does it involve a waiting period (during which the patent-holder is given an opportunity to work its patent), it also requires royalties to be paid to the patent-holder. Third, from the perspective of joint welfare, the desirability of CL hinges very much on whether or not the South has the freedom to deny patent protection. When the South has such policy freedom, CL is essentially counter-productive: not only does it not arise in equilibrium, but the option to use it results in a Pareto inferior outcome. On the other hand, when the South has no choice but to offer patent protection (as is basically true today for all members of the WTO), CL plays a much more useful role: not only does it arise in equilibrium, it can even generate a Pareto improving outcome. This result argues in favor of Article 31 of TRIPS under which CL is sanctioned by the WTO.

We also extend the basic model to the case where the patent-holder and the South bargain over the price. We show that patent protection becomes more likely when the

South can negotiate a price below the optimal monopoly price. This effect arises in two ways. First, if the patent-holder would not enter in the absence of patent protection, the ability to obtain the higher quality product at a lower price makes entry more attractive to the South than relying on the low quality imitated product. Second, when the South makes a take-it-or-leave-it offer to the patent-holder, it has an incentive to provide patent protection even if the patent-holder is willing to enter *without* it. This is because the price needed to induce entry is higher under imitation since competition from imitators reduces the patent-holder's sales in the South. This adverse effect of imitation on the price required to induce entry dominates the benefit of making the low quality product available to local consumers.

5 Mathematical appendix

5.1 Proof of Proposition 2

(i) We need to show $w_I(p_I^m;\gamma) \geq w_E(p^m)$. Using

$$w_I(p_I^m;\gamma) = (1+\Omega)s_I(p_I^m) + v_I(p_I^m) - \varphi \tag{18}$$

and

$$w_E(p^m) = (1+\Omega)s_E(p_I^m) + v_E(p^m) - \varphi \tag{19}$$

we have

$$w_I(p_I^m;\gamma) - w_E(p^m) = q\gamma\left(1+\Omega\right)/8 \geq 0$$

(ii) We need to show that $w_I(p_I^m;\gamma) \geq w_N(\gamma)$ iff $\varphi \leq \varphi_I^w$. Using

$$w_N(\gamma) = (1+\Omega)s_N(\gamma) \tag{20}$$

and equation (18) we have

$$w_I(p_I^m;\gamma) \geq w_N(\gamma) \text{ iff } \varphi \leq \varphi_I^w = 3q\left(1-\gamma\right)\left(1+\Omega\right)/8$$

i.e. given imitation, entry raises joint welfare iff $\varphi \leq \varphi_I^w$.

(iii) We need to show that $w_E(p^m) \geq w_N(\gamma)$ *iff* $\varphi \leq \varphi_E^w$. Using equation (19) and equation (20) we have:

$$w_E(p^m) \geq w_N(\gamma) \text{ iff } \varphi \leq \varphi_E^w = q\,(3-4\gamma)\,(1+\Omega)\,/8$$

5.2 Proof of Proposition 7

(i) For $\varphi \leq \varphi_I$, the South offers patent protection iff

$$s_E(p_E^{\min}(\varphi)) \geq s_I(p_I^{\min}(\varphi,\gamma))$$

which is the same as

$$\int_{p_E^{\min}(\varphi)/q}^{1} [q\theta - p_E^{\min}(\varphi)]d\theta \geq \int_{0}^{\theta_I^{\min}} \gamma q\theta d\theta + \int_{\theta_I^{\min}}^{1} [q\theta - p_I^{\min}(\varphi,\gamma)]d\theta$$

where $\theta_I^{\min} = p_I^{\min}(\varphi,\gamma)/q(1-\gamma)$. Substituting for $\theta_I^{\min}$, $p_E^{\min}(\varphi)$, and $p_I^{\min}(\varphi,\gamma)$ allows us to rewrite the above inequality as

$$G(\gamma) \geq 0 \text{ where } G(\gamma) = \left[q\left(q - \frac{4\phi}{1+\Omega}\right)\right]^{1/2} - q\gamma - \left[q(1-\gamma)\left(q(1-\gamma) - \frac{4\phi}{1+\Omega}\right)\right]^{1/2} \geq 0$$

Straightforward differentiation shows that for all $\varphi < \varphi_I$, we have $G'(\gamma) > 0$ and $G(\gamma)_{\gamma=0} = 0$ so that it must be that $G(\gamma) \geq 0$ for all γ when $\varphi < \varphi_I$.

(ii) For $\varphi \in [\varphi_I, \varphi_E)$, patent protection is preferred by the South iff

$$s_E(p_E^{\min}(\varphi)) \geq s_N(\gamma) \Longleftrightarrow \int_{p_E^{\min}(\varphi)/q}^{1} (q\theta - p_E^{\min}(\varphi))d\theta \geq \int_{0}^{1} \gamma q\theta d\theta,$$

which is the same as

$$p_E^{\min}(\varphi) \leq q(1-\sqrt{\gamma}) \tag{21}$$

Using (15), the South is indifferent between patent protection at $p_E^{\min}(\varphi)$ and no patent protection for fixed costs satisfying the following inequality:

$$\varphi \leq \varphi^B(\gamma) \equiv q(\sqrt{\gamma} - \gamma)(1+\Omega) \tag{22}$$

where $\varphi^B(\gamma) \geq \varphi_E^m$ iff $\gamma \geq \gamma^S$.

(*iii*) For $\varphi > \varphi_E$, the patent-holder will not enter with patent protection. The South does not offer patent protection.

5.3 Proof of Proposition 8

In region **D** we have $\varphi > \varphi_E$, so entry would not have occurred without CL and both players receive 0. When the option of CL exists, the South obtains the product under CL and both parties receive a positive payoff. Thus, both parties gain from CL.

In regions **Y** and **Z**, $\varphi < \min\{\varphi_E(R), \varphi_B^{CL}(\gamma, R)\} < \varphi_E$, so entry occurs with or without the threat of CL. If the patent-holder has all of the bargaining power, it enters at a price of p^m if there is no option of CL. The threat of CL is not credible in **Y**, since $\gamma < \gamma_{CL}$, so it has no effect on the payoffs. For region **Z** with $\gamma > \gamma_{CL}$, CL is a credible threat and the patent-holder enters at a price $p_E^{\max} < p^m$. This benefits the South and harms the patent-holder. If the South has all of the bargaining power, the patent-holder enters at a price of $p_E^{\min}(\varphi)$ when the option of CL does not exist and a price of $p_E^{\min}(\varphi + \Omega R)$ when it does. The South is harmed by the increase in price caused by the option of CL whereas the patent-holder benefits.

It remains to consider regions **V**, **W,** and **X,** where the threat of CL results in a switch from entry to the issuance of a compulsory license. Let p^B denote the price determined by the bargain if the patent-holder enters when there is no threat of CL. The South gains from a switch from entry to CL if $(1+\Omega)s_E(p^B) > \Omega s_N(\gamma)$, which is equivalent to $p^B > p_E^{\max}(\gamma, R)$.

The patent-holder gains from a switch from entry to CL if $v_E(p^B) < \varphi + \Omega R$, which is equivalent to $p^B < p_E^{\min}(\varphi + \Omega R)$. In the case where the patent-holder has all of the bargaining power, the bargained price under entry equals the monopoly price ($p^B = p^m$) and the South benefits from the threat of CL if $p_E^{\max}(\gamma, R) < p^m$. This condition is satisfied iff $\gamma > \gamma_{CL}$, so the South benefits in regions **W** and **X** whereas it loses in region **V**. In

regions **V** and **W**, the patent-holder benefits from the switch from entry to CL because $v_E(p^m) < \varphi + \Omega R$**.**

In the case where the South has all of the bargaining power, in the absence of the threat of CL we have $p^B = p_E^{\min}(\varphi) < p_E^{\min}(\varphi + \Omega R)$. Since the patent-holder is driven to zero profits under bargaining, the patent-holder must gain from the switch to CL for all $R > 0$. For the South, welfare is increased by this switch for all parameter values such that $p_E^{\min}(\varphi) > p_E^{\max}(\gamma, R)$. In region **V** where $\gamma < \gamma_{CL}$ and $\varphi \leq \varphi_E$, the South cannot gain because $p_E^{\max}(\gamma, R) \geq p^m \geq p_E^{\min}(\varphi)$. The South gains for the set of $\{\gamma, \varphi\}$ in regions **W** and **X** such that $p_E^{\min}(\varphi) > p_E^{\max}(\gamma, R)$, is a non-empty set if $p_E^{\min}(\varphi) > p_E^{\max}(1, R)$.

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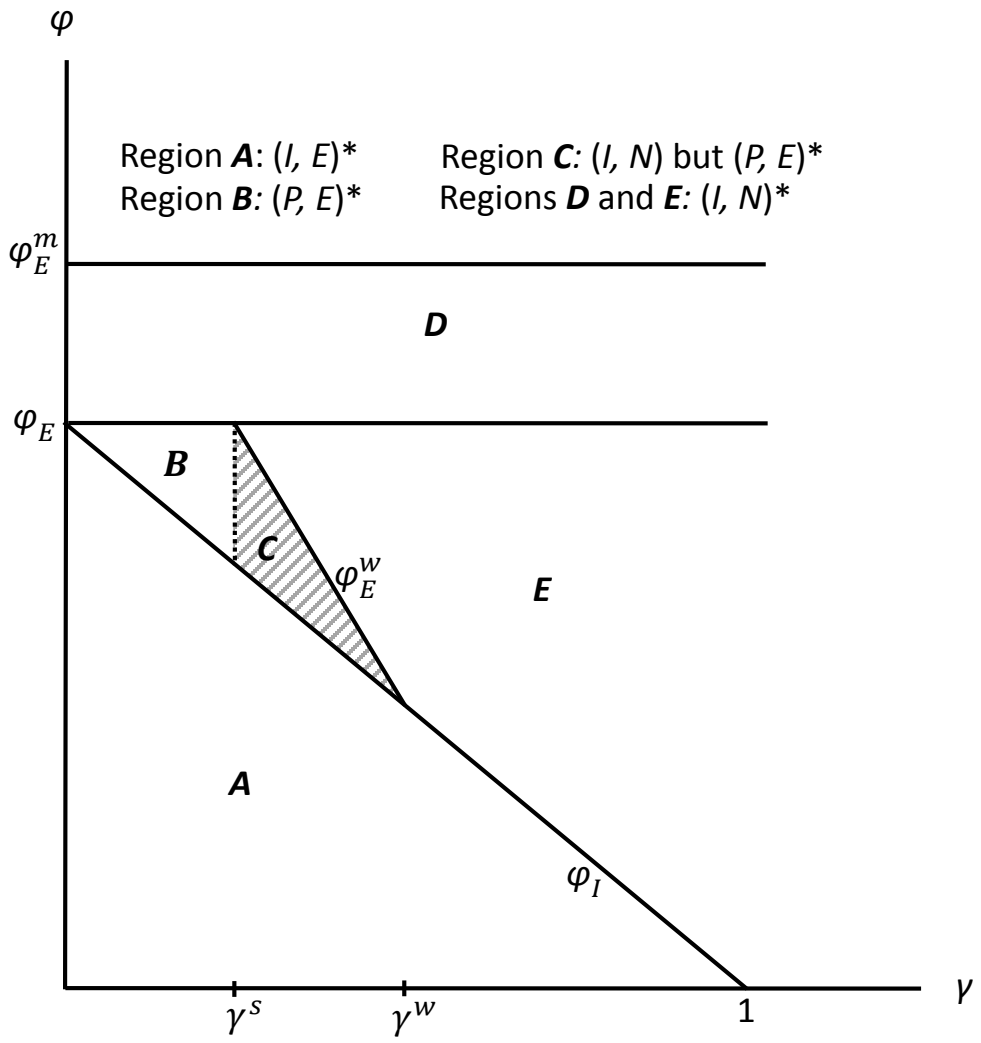

Figure 1: Efficiency of equilibrium outcomes

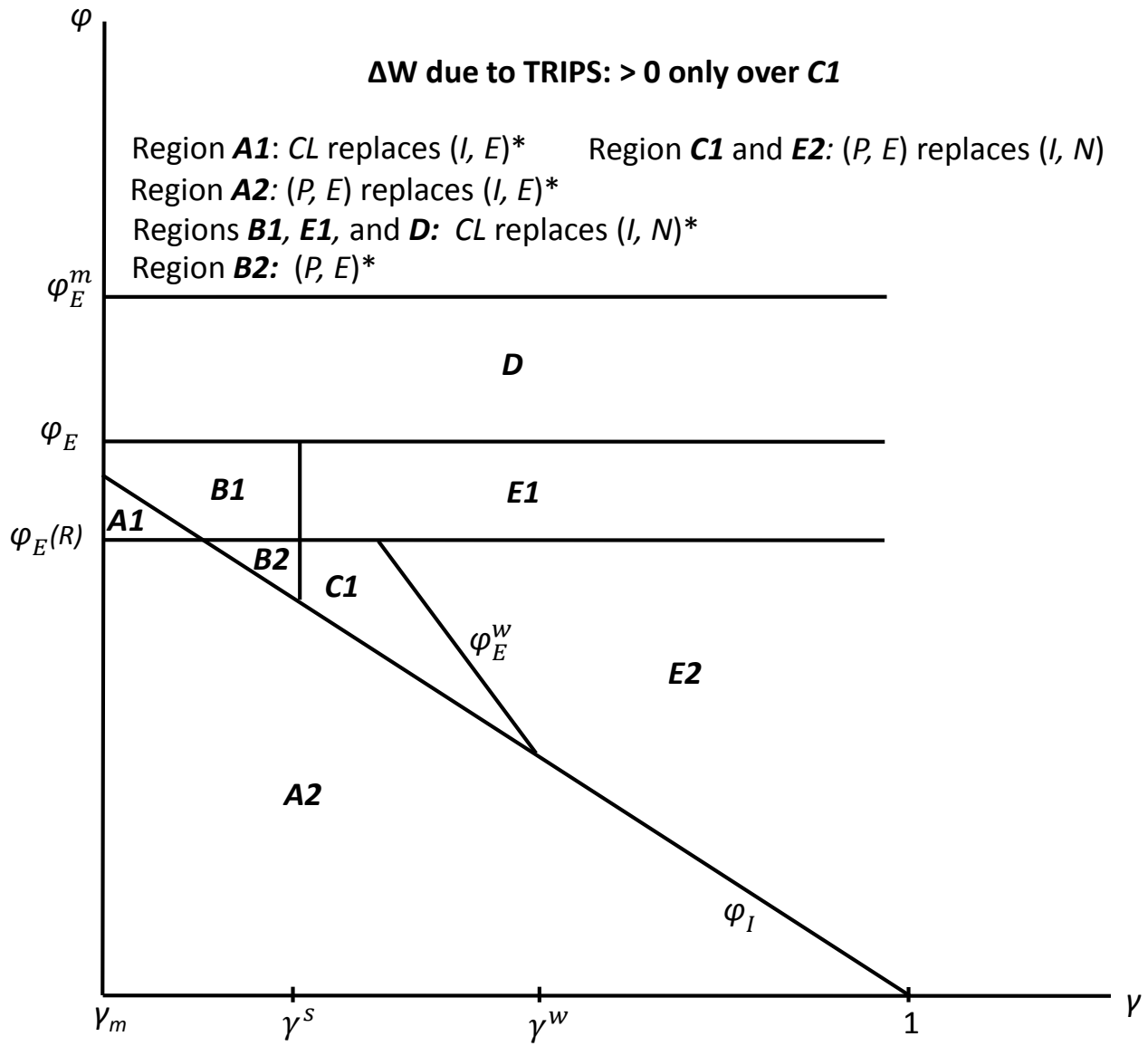

Figure 2: How TRIPS affects equilibrium and welfare

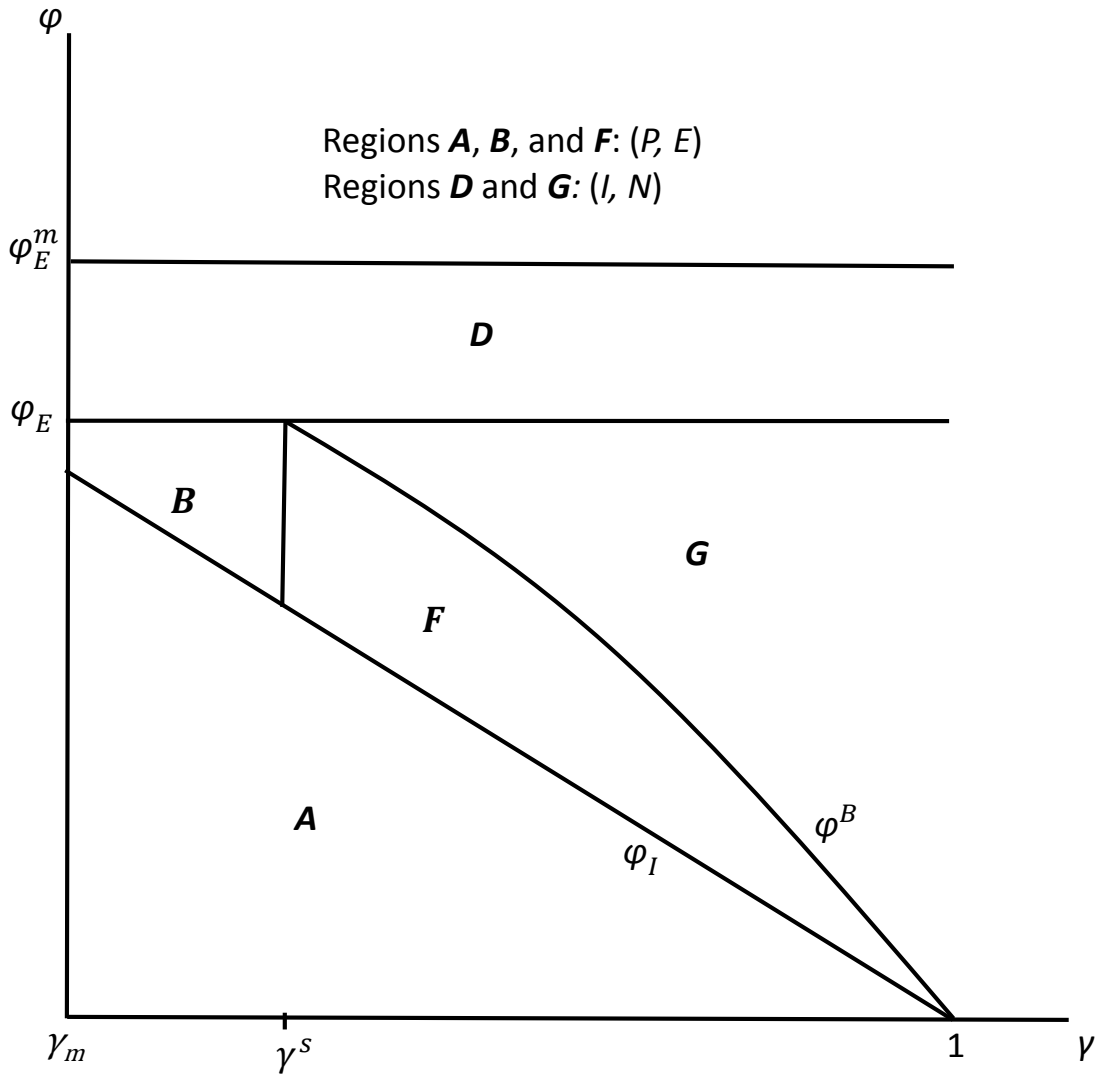

Figure 3: Equilibrium with price bargaining and w/o CL

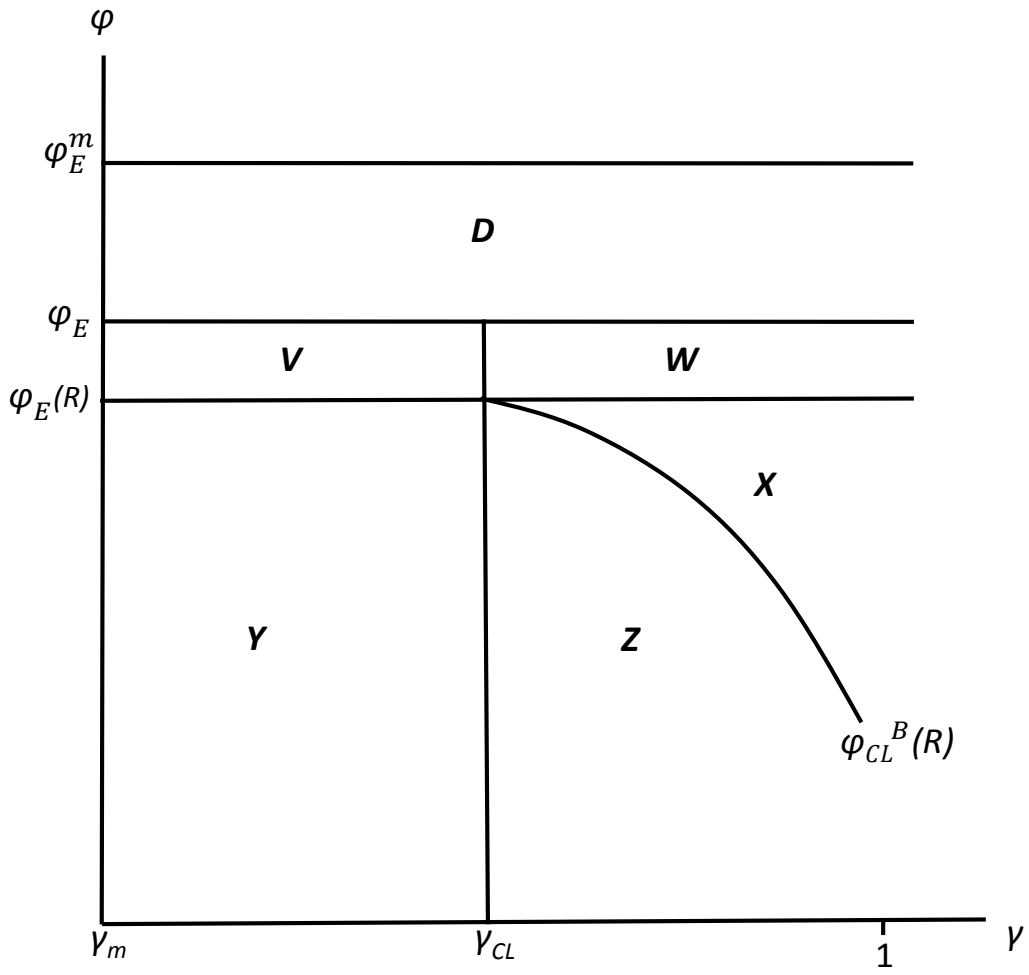

Figure 4: Effects of CL with price negotiations