Parallel Imports and Innovation in an Emerging Economy: The Case of Indian Pharmaceuticals*

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Abstract

This paper studies the impact of the re-importation of imitated pharmaceuticals as a by-product of an open policy towards parallel import (PI) on process innovation. Foreign investment by a firm to exploit a new unregulated market with weak intellectual property rights can give rise to imitation. These products can potentially re-enter the original country when PI is allowed influencing R&D incentives. In an emerging economy with technologically heterogeneous firms, trade costs shift PI-related market share losses from the more to the less R&D efficient firm, inducing the former to strategically increase R&D. PI accompanied by tariffs also induces higher R&D effort by the technologically inferior firm when it results in an expansion of its sales abroad. A tariff on PI is most likely to increase welfare when the technological gap between the two firms at home is sufficiently large.

Keywords: Parallel imports, Process innovation, Pharmaceutical industry, Trade costs, Welfare, Intellectual property rights, Imitation.

JEL Classification: F12, F13, O31, O34

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1 Introduction

Parallel Import (PI) is a process whereby commodities protected by intellectual property rights (IPR) are put into circulation in a foreign market, and re-imported back into the original market without the authorization of the original producer. The debate about PI and the views on its impact in an increasingly globalized world have become controversial in recent years. The issue has by and large been associated with price discrimination, vertical price control, and national price regulations.[1] When goods sold by a patent holder to a foreign market at a lower price are imported back to the original country, the producer faces competition with its own goods offered at a lower price.

Although PI does not include counterfeited products, authorizing PI could facilitate the entry of such goods into the original market (Arfwedson, 2004). We attempt to touch upon this issue by highlighting how asymmetric IPR protection between countries could lead to the re-importation of unlicensed copies of goods. We build a theoretical framework to study how this affects strategic innovation activities of technologically asymmetric firms when one moves to an unregulated market where IPR are not protected. This contributes to studying the features of developing markets such as asymmetric IPR protection and technologies to shed light on a number of policy insights.

While the strongest arguments against re-importation are probably the long-term effects on innovation, the literature on the impact of PI on innovation is rare and mostly focuses on the R&D decision of a monopolist when its distributor engages in PI (see literature review below). Our model adopts the concept of Leahy and Neary (1997) and Zigic (1998) to build a two stage game where firms invest in cost-reducing innovation and compete in quantity. We build a three country model with two heterogeneous firms located in the home market. The more technologically advanced firm serves a regulated foreign market, whereas the less efficient firm enters an unregulated one. By comparing the optimal R&D investment with and without re-importation from the unregulated market, we demonstrate that R&D investment by each type of firm crucially depends on the extent of firm heterogeneity and trade costs.

We find that for low trade costs, allowing PI results in less R&D effort by both firms. In addition, the large firm loses a relatively larger market share to re-imported goods. Increasing trade costs transfers this burden to the medium firm. This gives

[1] See Maskus and Chen (1994), Richardson (2002), Valletti (2006), Ganslandt and Maskus (2007) and Grossman and Lai (2008).

significance to competition in the home market, where PI creates a 'domino' effect that induces the technologically superior firm to strategically increase its R&D. On the other hand, it is the foreign market that plays the principal role in the R&D decision of the medium firm. PI encourages R&D investment by the technologically inferior firm when it increases its foreign sales, which is more likely to occur for low degrees of firm heterogeneity. We also show that tariffs can make the international exhaustion system welfare-enhancing, especially if the technology gap between firms is large. This could explain why allowing PI may be justified in India, but not in Europe or the US. Finally, we confirm the robustness of our results by extending the model to account for differences in market size across regions.

The paper is structured as follows. Section 2 reviews relevant literature on PI, innovation and the pharmaceutical industry in India. Section 3 describes the basics of the model. Section 4 solves the game with and without a ban on PI. Section 5 compares the two scenarios to analyze the incentives to innovate by each firm and derives implications for welfare. Section 6 discusses potential extensions of our basic model. Section 7 concludes.

2 Parallel Imports, Innovation, and the Indian Pharmaceutical Industry

Innovation in relation to PI has been modelled in several forms with mixed results. Valletti and Szymanski (2006) look at product innovation, where more R&D translates into higher quality products. They find the impact of PI to be negative on R&D incentives, even if the monopolist may introduce a new lower quality brand to compete with the generic drug. Li and Robles (2007) instead find the conditions under which PI increases incentives to innovate a new horizontally differentiated version of the product. Li and Maskus (2006) consider cost reducing process innovation and show that PI always inhibits R&D. Li (2006) adds to this by examining competition between two symmetric firms in the home country and finds ambiguous results on innovation that depend on transportation cost. The results in the above-mentioned theoretical work are derived under the implicit assumption that IPRs are perfectly enforced across the globe.

The importance of the intersection of trade and IPR in the strategic response of firms to PI have been emphasized in a recent study by Kyle (2009). Chaudhuri, Goldberg and Jia (2006) instead empirically study the impact of IPR on welfare specifically using data from the Indian pharmaceutical industry. The Patent Act

2005 of India created major concerns in the pharmaceutical industry, one of its greatest points of strength since decades. While generic drugs have been freely and skillfully produced in India, the Patent Act prohibited the production of generics whose patents have not expired. On the optimistic side, this has been perceived as a first step towards a leading role in innovating original medicine. However, there have been concerns about the withdrawal of domestic firms from the market and a sudden surge in the prices of pharmaceuticals in India and hence limited access to medicine by a great portion of the population. The findings in Chaudhuri, Goldberg and Jia (2006) indeed give validity to these potential adverse effects, providing a rationale in support of an international exhaustion system (permitting PI).

Chaudhuri (2005a, 2005b) conducts a more detailed study of firms in the Indian pharmaceutical industry and classifies the major firms into two groups: *(i)* large scale companies such as Ranbaxy and Dr. Ready's, which have achieved comparable efficiency to challenge leading firms in developed countries;[2] *(ii)* medium firms such as Lincoln, Simrone, and Aurochem, less efficient and therefore more associated with the production of incremental drugs in the domestic market. While both types of firms are known to generally engage in the production of generics, they possess patents on their production process that differs with respect to their R&D capabilities. Today, the large scale companies are competent to enter less risky regulated markets such as the US or Europe. Medium firms, on the contrary, are technologically inferior and seek new unexploited markets to compensate for their competitive disadvantage. Such destination markets are often unregulated, where local manufacturers can reproduce and sell imitated products both in their local and the original market. Pertinently, Business Week writes: "In India, selling generics used to be so easy. Suddenly, drugmakers Dr.Reddy's and Ranbaxy have a host of copycat rivals."[3]

While the biggest markets for large firms such as Dr. Reddy's and Ranbaxy are US and Europe, smaller firms concentrate more on the domestic market, and have large investments in developing markets such as Africa, Asia, Latin America, and the Middle East. Tanzania is a good example of an attractive unregulated market not required to enforce IPR in pharmaceuticals until 2016.[4] Indian pharmaceuticals have a large representation of the market in Tanzania as India holds the highest number of registered patents in Tanzania. It accounts for 1315 drug products registered

[2] Generics consist a large share of Pharmaceutical sales, namely 44%-74% of total sales in developed and emerging markets alike (Danzon and Furukawa, 2008).

[3] Business Week, "In India, selling generics used to be so easy", February 27, 2006.

[4] Kenya is ranked second with 307 registered drugs.

there in 2007, which is more than one third of the total. Among these, medium firms such as Lincoln, Aurochem and Simrone hold a large number of products without regulatory approval in USA. At the same time, Tanzania is the only new frontier in Africa since 2002 with capabilities to replicate active pharmaceutical ingredients (API) besides Egypt (active since 1992). Other 32 African countries are only capable of producing pharmaceutical formulations (incorporating the drug into its final form as a medicinal product). As formulation manufacturing also exists in Tanzania, Indian pharmaceuticals moving there are prone to competition from local manufacturers using their absorptive capacity to reproduce the similar final good that contains the API. Shelys Pharmaceuticals and Tanzania Pharmaceutical Ind. are considered the top exporters in the industry, with export values that amount to approximately three billion and 200 million dollars respectively (Chaudhuri, 2008).

According to the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), each WTO member has the sovereignty to choose its own policy on PI. This could be seen as an opportunity to mitigate the negative effects of IPR protection on consumers, made possible by allowing imports of generic products from a market still unregulated in terms of IPR. There have been rather skeptic views with regards to PI in the international trade literature, precisely for cases such as the rapidly evolving Indian pharmaceutical industry. In particular, important questions raised are: Does allowing PI reduce R&D and thereby impede the road taken towards the development of an innovative industry? Under what conditions can PI be welfare enhancing? The model below endeavors to answer to these questions.

3 The Basic Framework

Consider a home country, H, and two foreign markets, the North and the South, labeled N and S respectively. A multinational from N and two local heterogeneous firms, L and M, compete in H. In our example of the Indian pharmaceutical industry, L represents a large-scale company while M represents a medium firm. Both firms invest in process (cost-reducing) innovation and produce a generic product.[5] The two firms differ with respect to their R&D efficiency, with L enjoying a superior production technology comparable to that of M due to prior experience or economies of scale. We abstract from product differentiation and assume full

[5] A detailed analysis of the Indian pharmaceutical industry before and after the Patent Act shows a remarkable increase in process innovation whereas no new product has been introduced in this period (Arora, Branstetter and Chatterjee, 2008).

homogeneity between the two goods in the eyes of consumers.[6]

The two foreign markets, N and S, are segmented.[7] IPR are protected in N and H, while S remains an unregulated market.[8] We assume that, in addition to the home market, each firm can invest in one foreign market. We can think of FDI as the mode of serving the foreign market. Given the characteristics of our model, firm L enters the preferred Northern market, where it does not face the threat of imitation and competes with the multinational. Firm M enters the (remaining) unexploited Southern market instead, where IPR are not recognized.[9] A local manufacturers in S could hence reproduce the drug and sell it not only in S, but also export to H at cost τ, giving rise to re-importation. We assume that the local firm in S does not possess the technology to engage in cost-reducing R&D.[10] Finally, the home government has the possibility to either ban or allow PI, depending on its impact on social welfare.

We adopt the familiar linear demand function for each country:

$$p_i = a - Q_i \qquad i = H, N, S. \tag{1}$$

For the sake of simplicity, markets are equal in size, captured by a. This assumption also assumes constant price sensitivity of consumers across geographies, which could otherwise vary as a function of competition and regulation in markets.[11] Depending on whether PI is allowed or not, either three or four firms operate in H. In addition, the L firm competes with the Northern multinational in N, while the M firm

[6] This is done so without a loss of generality as our main results hold when products are not fully homogeneous.

[7] While introducing a Northern market and adding a multinational do not play a key role in explaining our hypothesis, they serves to avoid creating an unplausible bias in favor of the M firm in terms of their market share or total production.

[8] This setting with IPR enforcement in H aims to capture the post-2005 scenario mentioned in Section 2 that applies to emerging markets such as India. It is however worth noting that the protection of IPRs has been substantially relaxed in the last few years even in North with the advent of Acts, such as the Hatch-Waxman Act that facilitates generic entry into the US market. We assume away these shifts in IPR regulations and their effects on firm-behavior if any.

[9] Adding a symmetric fixed cost of FDI will not alter the framework as both L and M have an additional foreign market under PI and no PI.

[10] This could reflect the fact that foreign goods in less developed countries comprise a large fraction of sales compared to local production (for evidence in Tanzania, see Chaudhuri, 2008). In our model, this comes due to the cost advantage of the medium firm with respect to the less efficient local firm.

[11] We abstract from the discussion of price controls although they are also an important factor in the strategy of firms, especially those that engage in 'product' innovation. See Danzon, Wang, and Wang (2005) and Kyle (2007) for more on the impact of price controls on the extent (lower quality) and timing (delay in launch) of new drugs.

competes with a local firm in S. More precisely, total output in each market is

$$\begin{aligned} Q_H &\equiv \begin{cases} Q_H^{NP} = q_{L_H} + q_{M_H} + q_{N_H} \\ Q_H^{PI} = q_{L_H} + q_{M_H} + q_{N_H} + q_{S_H} \end{cases}, \\ Q_N &= q_{N_N} + q_{L_N}, \\ Q_S &= q_{M_S} + q_{S_S}, \end{aligned} \tag{2}$$

where quantity produced by firms is indicated by q, with the first subscript representing the firm, and the second denoting the market it serves. Superscripts NP and PI specify the scenario in which PI is either banned or allowed, respectively.

The cost function for each firm is:

$$\begin{aligned} c_j &= c - \frac{1}{2}\sqrt{x_j}\,,\ j = L, N, \\ c_M &= c - \frac{\beta}{2}\sqrt{x_M}, \\ c_S &= c, \end{aligned} \tag{3}$$

where investment in cost-reducing R&D is indicated by x. Parameter c is the pre-innovation production cost equal across firms. We assume that the lack of IPR protection in S allows the Southern firm to imitate the product, but not the production process. Parameter $\beta \in [0,1]$ captures the technological difference between the large-scale and the medium firm.[12] Finally, we assume $a > c$, and $c \geq \max[\frac{\beta}{2}\sqrt{x_M}, \frac{1}{2}\sqrt{x_j}]$ must hold throughout the paper to assure non-negative marginal costs after innovation.[13]

The profit function for the L and M firms located in H are:

$$\pi_L = (p_H - c_L)q_{L_H} + (p_N - c_L)q_{L_N} - x_L, \tag{4}$$

$$\pi_M = (p_H - c_M)q_{M_H} + (p_S - c_M)q_{M_S} - x_M, \tag{5}$$

while those of the Northern and the Southern firms are:

$$\begin{aligned} \pi_N &= (p_N - c_N)q_{N_N} + (p_H - c_N)q_{N_H} - x_N, \\ \pi_S &\equiv \begin{cases} \pi_S^{NP} = (p_S - c_S)q_{S_S} \\ \pi_S^{PI} = (p_S - c_S)q_{S_S} + (p_H - c_S - \tau)q_{S_H} \end{cases}, \end{aligned} \tag{6}$$

with τ indicating trade costs, or tariffs on imports from the South.

[12] Alternatively, one can think of $(1-\beta)$ as the technology gap between the two firms.

[13] Here, following d'Aspremont and Jacquemin (1988) and Kamien et al. (1992) among others we impose a simple linear-quadratic functional form in order to get explicit closed solutions.

4 Solving the Game

The two firms in H play a two-stage game: in the first stage they invest in process R&D and in the second stage they compete in quantity *à la* Cournot.

4.1 No Parallel Import

We start by considering the case in which PI is banned. Using backward induction, second stage optimal quantities as a function of R&D investment can be computed by taking the first order conditions of (4)-(6) using (1)-(3):

$$\begin{aligned}
q_{N_N}(x_L, x_M, x_N) &= \frac{a-c}{3} + \frac{2\sqrt{x_N} - \sqrt{x_L}}{6}, \\
q_{L_N}(x_L, x_M, x_N) &= \frac{a-c}{3} + \frac{2\sqrt{x_L} - \sqrt{x_N}}{6}, \\
q_{N_H}(x_L, x_M, x_N) &= \frac{a-c}{4} + \frac{3\sqrt{x_N} - \beta\sqrt{x_M} - \sqrt{x_L}}{8}, \\
q_{L_H}(x_L, x_M, x_N) &= \frac{a-c}{4} + \frac{3\sqrt{x_L} - \beta\sqrt{x_M} - \sqrt{x_N}}{8}, \\
q_{M_H}(x_L, x_M, x_N) &= \frac{a-c}{4} + \frac{3\beta\sqrt{x_M} - \sqrt{x_L} - \sqrt{x_N}}{6}, \\
q_{M_S}(x_L, x_M, x_N) &= \frac{a-c}{3} + \frac{\beta\sqrt{x_M}}{3}, \\
q_{S_S}(x_L, x_M, x_N) &= \frac{a-c}{3} - \frac{\beta\sqrt{x_M}}{6}.
\end{aligned} \tag{7}$$

Note that Northern multinational and the L firm are symmetric, resulting in identical expressions for the two firms. For the sake of exposition, we reduce the presentation of the outcomes to those for the two home firms under study.

By substituting the above expressions into the original home profit functions, we solve for the optimal R&D investments and get:[14]

$$x_L^* = x_N^* = \left[\frac{118(144 - 43\beta^2)}{70560 - 18127\beta^2}\right]^2, \tag{8}$$

$$x_M^* = \left[\frac{12862\beta}{70560 - 18127\beta^2}\right]^2. \tag{9}$$

Substituting (8) and (9) in (7), optimal quantities can be calculated:

$$\begin{aligned}
q_{L_H}^* &= \frac{16(1368 - 463\beta^2)}{70560 - 18127\beta^2}, \; q_{L_N}^* = \frac{8(3294 - 861)\beta^2}{70560 - 18127\beta^2}, \\
q_{M_H}^* &= \frac{24(558 + 65\beta^2)}{70560 - 18127\beta^2}, \; q_{M_S}^* = \frac{15(1568 - 117\beta^2)}{70560 - 18127\beta^2}.
\end{aligned} \tag{10}$$

[14] Hereafter we normalize the market size $(a - c)$ to unity as it appears as a multiplicative term in all upcoming values of optimal R&D investment, output, and profits.

Moreover, $q^*_{N_H} = q^*_{L_H}$ and $q^*_{N_N} = q^*_{L_N}$ by symmetry.

Plugging the optimal R&D investments and quantities back into (4) and (5) yields optimal profits:[15]

$$\pi^*_L = (q^*_{L_H})^2 + (q^*_{L_N})^2 - x^*_L, \tag{11}$$

$$\pi^*_M = (q^*_{M_H})^2 + (q^*_{M_S})^2 - x^*_M, \tag{12}$$

whereas consumer surplus in the home country without PI amounts to

$$CS^*_H = \frac{(q^*_{N_H} + q^*_{L_H} + q^*_{M_H})^2}{2}. \tag{13}$$

4.2 Parallel Import

We now look at the case in which PI is allowed into the home country. As in the previous scenario, second stage optimal quantities can be calculated:

$$\begin{aligned}
q_{N_H}(x_L, x_M, x_N) &= \frac{1+\tau}{5} + \frac{4\sqrt{x_N} - \beta\sqrt{x_M} - \sqrt{x_L}}{10}, \\
q_{L_H}(x_L, x_M, x_N) &= \frac{1+\tau}{5} + \frac{4\sqrt{x_L} - \beta\sqrt{x_M} - \sqrt{x_N}}{10}, \\
q_{M_H}(x_L, x_M, x_N) &= \frac{1+\tau}{5} + \frac{4\beta\sqrt{x_M} - \sqrt{x_L} - \sqrt{x_N}}{10}, \\
q_{S_H}(x_L, x_M, x_N) &= \frac{1-4\tau}{5} - \frac{\beta\sqrt{x_M} + \sqrt{x_L} + \sqrt{x_N}}{10},
\end{aligned} \tag{14}$$

while $q_{N_N}(x_L, x_M, x_N)$, $q_{L_N}(x_L, x_M, x_N)$, $q_{M_S}(x_L, x_M, x_N)$, and $q_{S_S}(x_L, x_M, x_N)$ take the same form as in (7).

Next, we derive the optimal R&D investments:

$$x^{**}_L = x^{**}_N \left[\frac{2(43+18\tau)(45-14\beta^2)}{16695-4591\beta^2}\right]^2, \tag{15}$$

$$x^{**}_M = \left[\frac{67\beta(43+18\tau)}{16695-4591\beta^2}\right]^2. \tag{16}$$

Innovation by both firms is always increasing in trade costs τ, as a larger potential market share stimulates R&D efforts.

Optimal quantities for the firms located in H are:

$$\begin{aligned}
q^{**}_{L_H} &= \frac{15(600-209\beta^2) + 170\tau(45-14\beta^2)}{2(16695-4591\beta^2)}, \; q^{**}_{L_N} = \frac{3[2070-577\beta^2+2\tau(45-14\beta^2)]}{16695-4591\beta^2}, \\
q^{**}_{M_H} &= \frac{5[19(27+5\beta^2)+67\tau(9-\beta^2)]}{16695-4591\beta^2}, \; q^{**}_{M_S} = \frac{3[5(371-38\beta^2)+134\tau\beta^2]}{16695-4591\beta^2}.
\end{aligned} \tag{17}$$

[15] All explicit expressions for both regimes are omitted for brevity. They are available upon request.

In addition, $q^{**}_{N_H} = q^{**}_{L_H}$, $q^{**}_{N_N} = q^{**}_{L_N}$ and

$$q^{**}_{S_H} = \frac{5130 - 1931\beta^2 - 2\tau(13680 - 3653\beta^2)}{2(16695 - 4591\beta^2)}. \quad (18)$$

Notice that there is a prohibitive level of trade costs that blocks PI by making $q^{**}_{S_H} = 0$, which is:

$$\hat{\tau} = \frac{5130 - 1931\beta^2}{2(13680 - 3653\beta^2)}. \quad (19)$$

This threshold level of trade costs starts at $\hat{\tau}|_{\beta=0} \simeq 0.19$ and monotonically falls to $\hat{\tau}|_{\beta=1} \simeq 0.16$. Clearly, we are only interested in the parameter region in which PI is a feasible option, and therefore we assume that $\tau \in (0, \hat{\tau})$.

Optimal profits for L and M in the presence of PI are:

$$\pi^{**}_L = (q^{**}_{L_H})^2 + (q^{**}_{L_N})^2 - x^{**}_L, \quad (20)$$

$$\pi^{**}_M = (q^{**}_{M_H})^2 + (q^{**}_{M_S})^2 - x^{**}_M, \quad (21)$$

and consumer surplus in the home country is:

$$CS^{**}_H = \frac{(q^{**}_{N_H} + q^{**}_{L_H} + q^{**}_{M_H} + q^{**}_{S_H})^2}{2}. \quad (22)$$

5 Analysis and Policy Implication

5.1 The Impact on Innovation

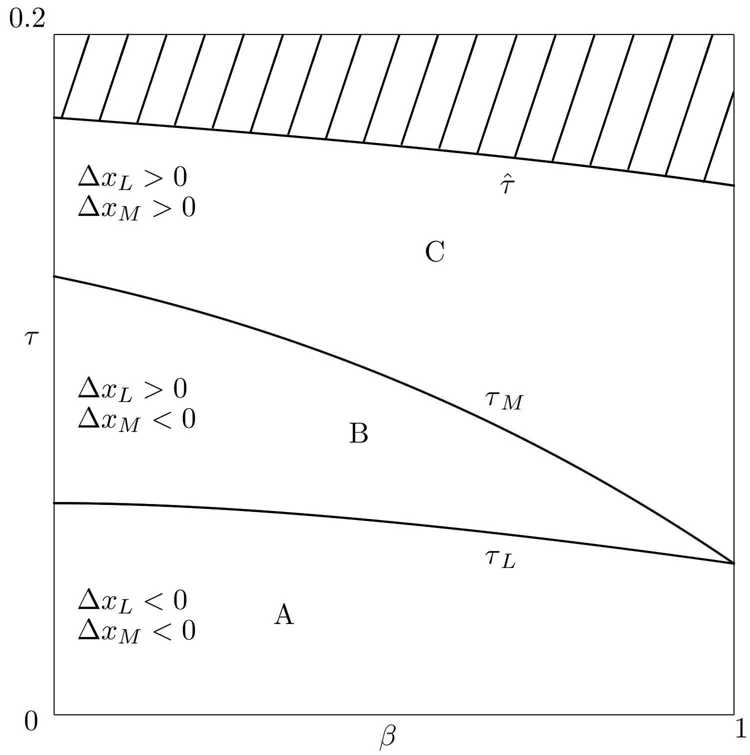
Taking into account the role of both technological heterogeneity between firms and trade costs, we compare the innovation effort carried out by firms across the two regimes. The critical levels of τ above which PI increases cost-reducing R&D by L ($\Delta x_L = x^{**}_L - x^*_L > 0$) and M ($\Delta x_M = x^{**}_M - x^*_M \geq 0$) can be found using (8), (9), (15) and (16), and are respectively:

$$\tau_L = \frac{9(65520 - 47006\beta^2 + 9073\beta^4)}{2(70560 - 18127\beta^2)(45 - 14\beta^2)}, \quad (23)$$

$$\tau_M = \frac{5(254394 - 151679\beta^2)}{134(70560 - 18127\beta^2)}, \quad (24)$$

where $\tau_L \leq \tau_M < \hat{\tau}$ for $\beta \in [0, 1]$. Hence, allowing PI is more likely to stimulate innovation by the more technologically advanced firm. These threshold values of τ determine the partition of the parameter space in Figure 1, which can be divided into three regions: A, B, and C. Recall that above $\hat{\tau}$ the foreign firm does not export to the H market.

Figure 1: Innovation



Starting from the bottom, Region A depicts a situation of free trade or low values of τ. PI decreases R&D by both firms due to added competition coming from imports of the Southern firm. Introducing PI reduces the market share of L and M in the home market ($\Delta q_{L_H} = q^{**}_{L_H} - q^{*}_{L_H} < 0$ and $\Delta q_{L_M} = q^{**}_{M_H} - q^{*}_{M_H} < 0$), more so the lower the value of β. This is the case because imports from the South are at their highest level when the M firm is relatively inefficient.

Imports tend to absorb more market share from the L firm as long as

$$\tau < \tilde{\tau} \equiv \frac{65520 - 48511\beta^2}{10(70560 - 18127\beta^2)} \iff |\Delta q_{L_H}| > |\Delta q_{M_H}|, \tag{25}$$

with $\tilde{\tau} < \tau_L$ in $\beta \in [0, 1]$.[16] Increasing trade costs shifts the burden of PI from the L to the M firm and this is confirmed by:

$$\frac{\partial(|\Delta q_{L_H}| - |\Delta q_{M_H}|)}{\partial \tau} = -\frac{45(18 - 19\beta^2)}{16695 - 4591\beta^2} < 0. \tag{26}$$

Equation (26) explains how trade costs affect the market size perceived by each firm, which in turn determines the incentives to engage in process innovation. When

[16] The threshold value $\tilde{\tau}$ goes from $\tau|_{\beta=0} \simeq 0.09$ to $\tau|_{\beta=1} \simeq 0.03$.

trade costs protect L to give it a sufficiently large edge over M, the former invests more than under the no PI case. This entails a shift from region A to region B in Figure 1, and occurs when trade costs reach $\tau = \tau_L$.

While allowing PI results in more R&D investment by L in region B, it reduces that by M. Here, the foreign entrant steals more market share from the 'vulnerable' M creating a "domino effect" by making L more aggressive and stimulating its innovation effort.[17] In region B, the Southern market starts to play a crucial role in the R&D decision of M. Interestingly, solving $\Delta q_{M_S} = q^{**}_{M_S} - q^{*}_{M_S}$ for τ unveils that PI induces M to increase its output destined to the South exactly when $\tau > \tau_M$, after which point PI encourages also M to devote more resources to R&D. This is more likely to occur when the technology gap between L and M is not significant, since $\partial\tau_M/\partial\beta < 0$. One can notice that the distance between τ_M and τ_L decreases with the reduction of the technological gap, and $\tau_M = \tau_L$ when $\beta = 1$. This suggests that PI instigates M to increase its production for the South when it is sufficiently protected by tariffs in the home market, and enjoys a large cost advantage in the Southern market. In this case, we move to region C, where a combination of sufficiently high values of β and τ induces more process R&D by both firms under PI.

We can therefore state:

Proposition 1 *Trade costs τ transfer the market share loss brought about by PI from the L to the M firm so that PI increases R&D by L for $\tau > \tau_L$. On the other hand, allowing PI from the South to the home market increases the output of the M firm for the Southern market along with its R&D effort for $\tau > \tau_M$. Inequality $\tau_M \geq \tau_L$ suggests that PI is more likely to stimulate innovation by the more technologically advanced firm.*

Proof Directly follows from (23) - (26) and Δq_{M_S}.■

In line with recent PI literature, our results reinforce the claim that PI may enhance incentives to innovate by home firms. It remains to evaluate whether PI can improve aggregate welfare in the home country.

[17] This result is in line with asymmetric Cournot oligopoly models such as Ishida, Matsumura and Matsushima (2010), who show that an inefficient entrant can boost R&D incentives of dominant firms through a strategic effect.

5.2 The Impact on Welfare

Social welfare in H amounts to the sum of consumer surplus, producer surplus, and tariff revenues:

$$W_H = CS_H + \Pi_H + T, \tag{27}$$

where $\Pi_H = \pi_L + \pi_M$, and

$$T = \tau \cdot q^{**}_{S_H}. \tag{28}$$

In the admissible range of trade costs $\tau \in [0, \hat{\tau}]$, we can demonstrate that

$$\Delta CS_H = CS^{**}_H - CS^{*}_H > 0, \tag{29}$$

as the entry of a fourth firm into the home market always makes consumers better off.[18] Together with the results from the previous section on R&D, PI may eliminate the conventional trade-off between consumers' well-being and firms' incentive to innovate (area C in Figure 1). Nevertheless, looking at the supply side yields that PI harms both firms L and M, thus lowering home industry profit:[19]

$$\Delta\Pi_H = (\pi^{**}_L + \pi^{**}_M) - (\pi^{*}_L + \pi^{*}_M) < 0. \tag{30}$$

PI hence benefits consumers, but always at the expense of local firms, regardless of their resulting innovative activities. Weighing the magnitude of consumer gains against producer losses using the calculated values from Sections 4.1 and 4.2 in (29) and (30) reveals that $\Delta CS_H + \Delta\Pi_H < 0$.

Tariffs levied on imports whose legitimacy is the object of our discussion create revenue, but reduce the total quantity of imports from the South ($\partial q^{**}_{S_H}/\partial\tau < 0$).[20] Additionally, $\partial q^{**}_{S_H}/\partial\beta < 0$ implies that tariff revenue is higher the lower the value of β ($\partial T/\partial\beta < 0$). For PI to increase home welfare it must be true that

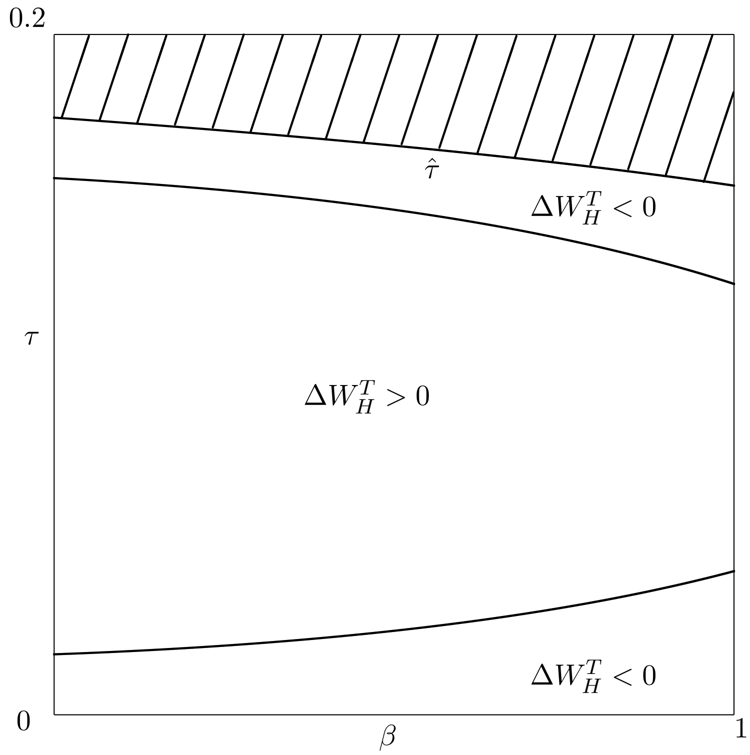
$$\Delta W_H = \Delta CS_H + \Delta\Pi_H + T > 0. \tag{31}$$

[18] All explicit formulation for the welfare comparison are omitted for brevity.

[19] In a different context under demand uncertainty, Raff and Schmitt (2007) show how PI may increase the profit of manufacturers.

[20] Hur and Riyanto (2006) also use trade costs to show how PI can be beneficial for the host country in the presence of a tariff policy. Their analysis however abstracts from the role of innovation.

Figure 2: Welfare



On the one hand, only a high tariff rate can create sufficient revenue to overturn industry losses from PI and make the inequality in (31) viable. On the other hand, T is hump-shaped in τ as it discourages imports from the South. Moreover, as $\partial T/\partial\beta < 0$, tariffs are more effective in making PI beneficial when the degree of heterogeneity between firms is large. We can deduce that

Proposition 2 *Tariff are more likely to make the international exhaustion system welfare improving when technology gap between home firms is large.*

Proof Directly follows from (27) - (31). ■

The intuition behind Proposition 2 is that social welfare is higher in H under PI when it is possible to simultaneously mitigate the damage to home firms and collect a relatively high tariff revenue. The enforcement of tariffs by the home government is essential to reduce the profit loss ($\partial\left|\Delta\Pi_H\right|/\partial\tau < 0$). However, as noted above, an additional earning is necessary to make PI welfare improving. The tariff revenues are more likely to satisfy $\Delta W_H > 0$ when the Southern firm has a strong position, *i.e.* for lor low values of β. The truncated cone-shaped area in Figure 2 represents the parametric region in which social welfare is higher under PI when tariff revenues are taken into account. This result suggests that an international exhaustion system accompanied by tariffs is more likely to be beneficial for emerging economies, where the technology gap between firms is considerable.

6 Extension: Heterogeneous Market Sizes

The aim of this section is to show that our main results are robust against a variation in the market size of foreign destination markets. Coherent with the case of Indian pharmaceuticals under consideration, we do this by assuming a larger market in the North and a smaller market in the South. In particular, while demand at home remains $p_H = a - Q_H$, the foreign destination markets turn to:

$$p_N = a + \gamma - Q_N, \tag{32}$$

$$p_S = a - \gamma - Q_S. \tag{33}$$

Parameter γ capture the degree of size heterogeneity, which is assumed to change symmetrically between the three markets.

Second stage optimal quantities as a function of R&D investment can be solved for in a similar manner as the baseline model. As we continue to use the normalization $a - c = 1$, quantities produced by firms for the H market without and with PI remain similar to their corresponding expressions in (7) and (14), while output for the Northern and the Southern markets change to:

$$\begin{aligned} q'_{N_N}(x_L, x_M, x_N) &= \frac{1+\gamma}{3} + \frac{2\sqrt{x_N} - \sqrt{x_L}}{6}, \\ q'_{L_N}(x_L, x_M, x_N) &= \frac{1+\gamma}{3} + \frac{2\sqrt{x_L} - \sqrt{x_N}}{6}, \\ q'_{M_S}(x_L, x_M, x_N) &= \frac{1-\gamma}{3} + \frac{\beta\sqrt{x_M}}{3}, \\ q'_{S_S}(x_L, x_M, x_N) &= \frac{1-\gamma}{3} - \frac{\beta\sqrt{x_M}}{6}, \end{aligned}$$

where the prime superscripts indicate the case with market size heterogeneity.

We next compute equilibrium values for investment levels, quantities and profits.[21] In particular, R&D investment levels by each firm without and with PI are

[21] All equilibrium results remain analytically tractable, but are omitted for brevity.

respectively given by:

$$x_L'^* = \left\{ \frac{2\left[59\beta^2(43+16\gamma) - 144(59+32\gamma)\right]}{70560 - 18127\beta^2} \right\}^2, \tag{34}$$

$$x_M'^* = \left[\frac{2\beta(6431 - 4352\gamma)}{70560 - 18127\beta^2} \right]^2; \tag{35}$$

$$x_L'^{**} = \left\{ \frac{2\left[(43+18\tau)(14\beta^2 - 45) + 5(52\beta^2 - 225)\gamma\right]}{16695 - 4591\beta^2} \right\}^2, \tag{36}$$

$$x_M'^{**} = \left[\frac{\beta(2881 + 1206\tau - 2035\gamma)}{16695 - 4591\beta^2} \right]^2. \tag{37}$$

As before, we can find the critical levels of τ above which PI increases R&D efforts by L and M:

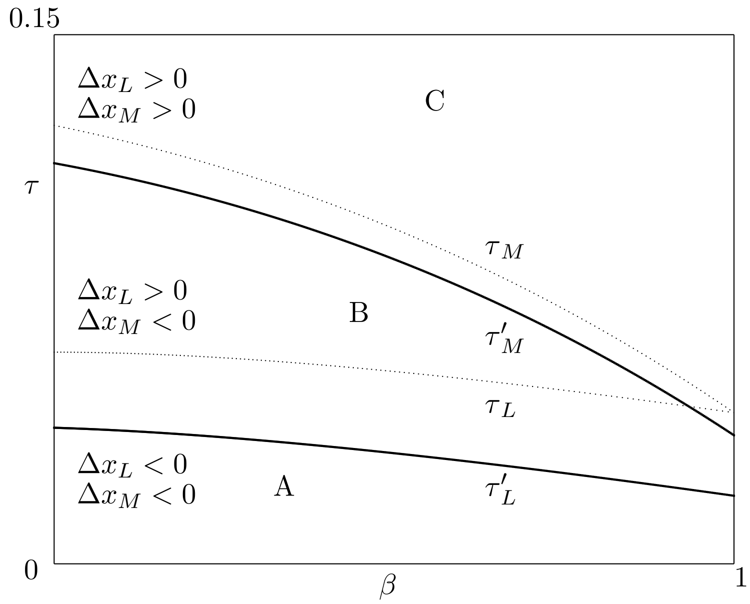
$$\tau_L' = \frac{\beta^4(81657 - 42124\gamma) + 9\beta^2(22507\gamma - 47006) + 45124(13 - 6\gamma)}{2(18127\beta^2 - 70560)(14\beta^2 - 45)}, \tag{38}$$

$$\tau_M' = \frac{\beta^2(341291\gamma - 758395) + 630(2019 - 304\gamma)}{134(70560 - 18127\beta^2)}, \tag{39}$$

and the same ranking applies in our interval region for all feasible values of γ, *i.e.* $\tau_L' \leq \tau_M'$.

In order to highlight the impact of γ on the main results of our paper, we represent in Figure 3 the case where $\gamma = 0.6$ with a solid line, and the previous symmetric market size case with a dotted line. It can be observed that our results remain robust when the Northern market is larger and the Southern market smaller with respect to the home market, with the difference that the B region expands. Revisiting Proposition 1, we can infer that this occurs for two reasons: On the one hand, a larger North and a smaller South work as a bias in favor of the L firm when passing the costs of PI to the M firm. This expands the region in which only the L firm increases its R&D expenditure as a consequence of PI. On the other hand, a smaller market opportunity in the South reduces the positive impact of PI on firm M's production for this market and therefore its R&D. This is most obvious in the figure for high levels of β, where this effect was at its strongest under symmetric market size (note that now $\tau_L' \neq \tau_M'$ for $\beta = 1$).

Figure 3: The effect of γ



7 Conclusion

In this paper we have examined the consequences of an international exhaustion system in an emerging economy. In so doing, we have based our model on the Indian pharmaceutical industry, which after the Patent Act 2005 has experienced a surge in re-imports arriving from markets not yet obliged by TRIPS to enforce IPR protection. A good example is Tanzania, inferior both in terms of technology and IPR enforcement. Such unexploited markets can serve as interesting destinations for relatively less technologically endowed firms in the industry.

We find that competition in the home market plays a major role in the R&D decision of the large (more R&D efficient) firm. Trade costs transfer the loss brought about by PI from the large to the medium (less R&D efficient) firm. This results in a less aggressive medium firm, which then increases the incentives of the dominant competing firm to innovate. For the medium firm, sales in the foreign market play the decisive role in their R&D investment. Re-importation of imitated goods that can occur through allowing PI paradoxically gives the medium firm a lead in the Southern market and stimulates its R&D efforts when trade costs are sufficiently large. This is more likely for low degrees of firm heterogeneity, which also implies a larger cost advantage over the Southern firm.

As for welfare, PI always benefits consumers through lower prices and can increase innovation by both firms. This however comes at the expense of profits of both firms. Tariffs could make PI welfare-enhancing for the home country by simultaneously creating a form of protection for the domestic firms again PI and generating government revenues. This is more likely in the presence of large technological asymmetry between firms, which in turn assures sufficient revenues to result in a welfare gain.

We can conclude from our findings that in an emerging industry where the technology gap between firms is large, an international exhaustion system accompanied by tariffs can increase innovation and welfare in the home country. These are the actual conditions that apply to the pharmaceutical industry in India, but not in fully developed economies such as the US or Europe, justifying assorted policies observed with regards to PI in different parts of the world.

Our model can be extended in many interesting directions as is a simplified version of the reality and does not capture important dynamic aspects such as the implications for firm innovation in future periods.[22] For instance, less efficient firms who initially move to unexploited markets can at a later period be competent to also enter US and Europe. Our results are, in other words, limited to the initial impact of allowing PI on innovation and welfare in an emerging economy, when firms are heterogeneous and exploit different foreign markets.

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