South-South Parallel Import and Cost Reducing Innovation in the Pharmaceutical Industry: An Alternative Approach[*]

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Abstract

This paper studies how South-South parallel import (PI) affects cost reducing R&D effort by heterogeneous firms located in an emerging country. Specifically, when a technologically inferior firm moves to exploit a new unregulated Southern market, the impact of PI on innovation is determined by the degree of heterogeneity between firms and trade policy. Innovation by one or both firms may increase when the technological gap between firms is low and tariffs are sufficiently large. PI can also enhance social welfare by creating stimulus for innovation.

VERY PRELIMINARY AND INCOMPLETE

Keywords: Intellectual Property Rights, Parallel Imports, Innovation, Tariffs, Welfare

JEL Classification: F12, F13, L11

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[*] We are grateful to Maria Comune for valuable comments and insightful discussions.

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1 Introduction

The topic of parallel imports (PI) has been gaining great attention in recent international trade literature. PI is generally defined as unauthorized re-imports of genuinely produced commodities back to the original producer's country. It has mostly been linked with the issue of price discrimination. This arises when a producer sells its product in a second country for a lower price, which is then imported back to the original country. This creates competition with the original producer, who is then forced to lower its home price and loses profits. PI has also been linked with intellectual property rights (IPR), though less frequently, which involves exporting to a country that does not respect the protection of IPRs. Goods meant for a secondary market are then reproduced by a manufacturer established in a foreign market or through distributors, and part of the output could be sent back to the original market. This also increases competition in the home market, thus damaging the local patent holder. As this has been rather neglected in PI literature, we focus on this second concept of parallel trade, also known as the "gray market".[1] In particular, we aim to explain recent specific facts with regards to the so called catching up of "Southern" countries through technological advancement in a the context of PI and IPRs.[2] Contrary to conventional studies, we look at a South-South framework, where a home market such as India lacks strong customs at the border, and the foreign market such as Tanzania is unregulated in terms of IPRs.[3]

The importance of the link between PI and IPR protection in international trade has indeed re-emerged since the TRIPS agreement of the 1994. TRIPS gives the sovereignty to each individual member country of the WTO to choose whether or not to allow PI into their local market. EU for instance has chosen community exhaustion for all kinds of IPRs, while it does not allow PI from outside the community. US has also adopted a national exhaustion regime, which again does not allow PI into the US. The decision of a government whether to allow international exhaustion has gained particular importance in the past few years. This is partly due to emerging countries such as India growing to become key players in the global economy. After the Patent Act 2005, India was obliged to respect IPRs. The main concern for India has been the pharmaceutical industry, which has been a point of strength for the

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[1] One exception is a recent work by Matsushima and Matsumura (2008); they find that permitting PI from an imitator in a country that lacks IPR protection can be beneficial to all parties by serving as a commitment device to soften price competition.

[2] See Kremer (2002) for a thorough review on the pharmaceutical industry in developing countries.

[3] See below for more detailed explanation of the specific case of the pharmaceutical industry in India and Tanzania based on Chaudhuri (2008).

country since decades. While generics have been freely and skillfully produced in India, the Patent Act was to put an end to the production of generic drugs whose patents have not expired.[4] On the positive side, this can be seen as a move towards taking a leading role as innovator of original medicine. The fear on the other hand has been a sudden surge in prices of pharmaceuticals in India and hence limited access to necessary medication by a great portion of the population.

One possibility to go around this is thought to be the use of an international exhaustion PI regime to allow imports from a country, which still lacks IPR protection, in order to maintain access to affordable medicine. This has raised debates in the rapidly evolving Indian pharmaceutical industry, which is in transition from being an imitative to an innovative industry. Could allowing PI reduce R&D incentives by inventors in India, hence impeding the road it has taken towards the development of its own innovative pharmaceutical industry? Moreover, could consumer gains from PI outweigh its negative impact on profits when variations in R&D investment by firms in different industry categories are taken into account?

In our contribution, we separate the market in India by distinguishing between large scale companies, who are the key innovators, and medium firms, known to be specialized operators. They are both owners of patents and differ with respect to their efficiency in cost-reducing R&D, which in turn determines their position in the market. The medium is endowed with an inferior technology. It is therefore motivated to look for new unexploited markets to compensate for its missing competitive advantage.[5] Such markets are often unregulated with respect to IPRs. Therefore, local manufacturers could reproduce and sell the same good both locally, and also in the market of origin when PI is present. We seek to single out the direct and the indirect effects of PI that may occur as a result of this action on innovation performed by both types of firms.

Our modelling and assumptions are based on recent tendencies in South-South trade such as the case of the pharmaceutical industry in India and Tanzania. Large scale Indian firms such as Ranbaxy, Dr. Ready, or Cipla pursue a catch up strategy by engaging in innovation in order to challenge leading firms in developed countries.[6] These firms tend to establish in regulated markets, while smaller Indian firms such as Lincoln, Simrone, and Aurochem resort to new unexploited markets such as

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[4] All patents registered before 1995 cannot be protected in India despite being protected elsewhere. Therefore, they could still be produced as generics in India.

[5] In contrast, large scale firms do not have an interest in serving this second market as they tend to stay in less risky markets where IPR regulations are respected such as US or the EU.

[6] See Chaudhuri (2005a).

Tanzania, where India holds the highest number of registered patents.[7] Tanzania is also a good example of an unregulated market, as under the TRIPS agreement they are not required to introduce IPR protection in pharmaceuticals until 2016.[8] Finally, it is the only new frontier in Africa since 2002 with capabilities to replicate active principle ingredients (API) besides Egypt, which has been active since 1992. There are 32 other African countries, which are only capable of producing formulations. As formulation manufacturing already exists in Tanzania, workers in the Indian subsidiary may defect and disseminate information to local manufactueres. They can then use their absorptive capacity to produce the similar final good that contains the patented API and sent it back to India.

We build a two-stage game in a two-country model for each scenario (with or without PI) where the firms located in the home market decide first the investment level in cost-reducing innovation and then they compete à la Cournot in the market. By comparing the optimal investment levels, we show that PI does not necessarily reduce innovation. In particular, we demonstrate that the equilibrium investment level in cost-reducing R&D by each type of firm crucially depends on the combination between firm heterogeneity and the tariff rate. Strategic interaction creates a taxonomy of situations in which innovation by one or both firms can indeed increase through PI. We find that for sufficiently high tariff levels and small technological superiority by the large scale firm, PI increases R&D efforts by both firms. Alternatively, when both the tariffs and the degree of heterogeneity are sufficiently high, the presence of PI enhances R&D carried out by the large scale firm, while reducing that by the medium firm. For a higher degree of homogeneity across firms and low tariff levels the opposite holds. It follows that high tariffs are a more important factor for the decision of the large scale firm to increase R&D, while technological similarity is so for the medium firm. We further find that PI can only be socially optimal when it improves R&D by both firms. Trade policy in this case can be used as a complementary tool along with PI to benefit the society at large. Tariffs must be at a high enough level to make PI the favorable policy as the socially optimal outcome.

Related literature

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[7] India accounts for 1315 drug products registered in Tanzania in 2007, which is more than one third of the and by large higher than the following countries (Kenya is ranked second with 307 drugs registered). See Chaudhuri (2008) for more details.

[8] Even in industries where IPR protection has become mandatory, violations in Tanzania are not seriously investigated as courts lack experience and training in IPR issues (Index of Economic Freedom, 2008).

Li and Maskus (2006), Li (2005) and Li and Robles (2007) are among recent theoretical papers that deal with the debate over PI and innovation. Li and Maskus (2006) finds that PI reduces the producer's incentives to do cost-reducing innovation. Li (2005) and Li and Robles (2007) on the other hand show that PI may or may not discourage product innovation. All three works are however single-producer models, ruling out competition among firms. Li (2006) integrates competition into the PI model of Li and Maskus (2006) to explore how competition and PI affect producer's incentives to innovate. They find that PI may stimulate manufacturers to invest in cost-reducing innovations. What they do not take into account is the interaction of the IPR regime of the foreign country and firm heterogeneity with respect to technological efficiency in the impact of PI on innovation. Instead, as in Maskus and Li (2006), they focus on the effect of PI for different levels of of trade costs.

The interaction of tariff policy and parallel imports has also taken its own direction as a branch of literature. Knox and Richardson (2002) show how the optimal tariff decreases when parallel imports are permitted as a monopolist can bneefit from PI. They further show that PI is always optimal whether or not a country sets an optimal tariff rate. Hur and Riyanto (2006) also study the interaction between trade and PI policy to show that again PI is beneficial for the host country in the presence of a tariff policy, which can be set optimally to induce the foreign manufactuere to impose a price discrimination policy. Their analysis is limited to one monopoly firm in the original country and innovation has not been considered in their models.

Our model adopts the Leahy and Neary (1997) framework, where firms first engage in R&D and then compete in output. Unlike the above strands of literature however, our paper does not take into account vertical pricing because our main focus is more on the heteregoeneity of firms and their interests, and the interaction between the PI and the lack of an IPR regime in a secondary market. In doing so, we use a modified version of the strategic IPR models of Chen and Grossman (1991), Zigic (1998), and Naghavi (2007). Using such framework, we reproduce the scenario for the pharmaceutical industry in India, where a medium firm moves into a new unregulated market, hence making possible the PI of its goods. Also note that IPRs are fully protected in the home country, i.e. India after the Patent Act 2005, giving firms full rights to their technology in the home country. The same argument can be applied to countries such as the EU and the US to assess the costs and benefits of an international exhaustion system, and for others who have switched to a PI regime such as Australia, New Zealand, and Singapore, who relaxed their restriction on PI in late 1990s.

The paper is structured as follows. Section 2 describes the basics of the model and introduces the case with no PI (duopoly). PI and the trade policy is then discussed in section 3 and two scenarios are studied: we distinguish beween effects of PI on cost-reducing innovation by the large scale innovator firm and that by the medium firm. Section 4 studies welfare and section 5 concludes.

2 The Basic Framework

Consider two Southern countries, labeled as H and F for home and foreign. In the home market there are two heteregeneous firms, M and L, both of which are owners of patents. In our example of the Indian pharmaceutical industry, L represents a large-scale company while M represents a medium firm, which obtains its patent through the so called "me-too" drugs, i.e. drugs that imitate existing products and consist of only minor modifications.[9] We abstract from product differentiation and assume full homogeneity between the two goods in the eyes of consumers.[10] This is done so without the loss of generality as the results remain the same even when products are not fully homogeneous.

Both firms can invest in cost-reducing R&D activity but they differ in their ability to perform R&D, with L endowed with a superior efficiency. We assume that L has an edge on the process innovation activity due to prior investments in the field or better team organization. Based on the case study reported in the introduction, firm M decides therefore to export to an unregulated foreign market with no IPR protection (Tanzania, for example).[11] Firm L, on the contrary, continues to serve only the home market. The newly available foreign market represents an opportunity in terms of sales' expansion. Nonetheless, as IPR protection is not guaranteed, local manufacturers could freely reproduce and sell the drug not only in the F market, but also reintroduce it in the H market of origin, thus giving rise to PI. We consider only one firm in the foreign market and assume that its technological endowment does not suffice to engage in R&D.[12] The home government has the possibility to ban PI

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[9] This is for instance incremental innovation to the product, which has already been invented by the big firm. Thus, no initial large fixed cost are involved.

[10] An example is incremantal innovation on Viagra to make it last 36 hours, which can also be patented. This competes with the initial version of Viagra and is viewed by consumers just as important as the original.

[11] In the example of Viagra, when the original firm has an advantage, the second firm has an incentive to go to a new market and exploit its incremental patent.

[12] This reflects the fact that foreign goods in less developed countries comprise a large fraction of sales compared to local production (see Chaudhuri, 2008 for evidence in Tanzania). In our model,

if it considers that social welfare is damaged by such a practice. Alternatively, it can allow PI while imposing a tariff duty on all imports from the foreign country.

We adopt the well known linear demand function for both the H and the F market:

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

For the sake of simplicity, markets are equal in size, captured by a. In the H market, depending on whether PI is allowed or not, either two or three firms operate, while in the F market there are always two firms. More precisely,

$$\begin{aligned} Q_H &\equiv \left\{ \begin{array}{c} Q_H^{NP} = q_{_L} + q_{_{M_H}} \\ Q_H^{PI} = q_{_L} + q_{_{M_H}} + q_{_{F_H}} \end{array} \right. ; && (2) \\ Q_F &= q_{_{M_F}} + q_{_{F_F}}. && (3) \end{aligned}$$

Following our previous labeling, subscripts L and M indicate respectively the large scale firm and the medium firm, both based in H, while subscript F stands for the foreign firm. Superscripts PI and NP obviously specify whether parallel import is allowed or not. As the medium firm serves both markets, $q_{_{M_H}}$ is the quantity sold at H and $q_{_{M_F}}$ that sold in F. The foreign firm sells $q_{_{F_F}}$ in its market; moreover, if PI is permitted, it may sell $q_{_{F_H}}$ in the H market conditional to the payment of a tariff τ set by the home government.

Profit functions in the home country are given by:

$$\pi_L = (p_H - c_L)q_L - x_L, \tag{4}$$

$$\pi_{_M} = (p_H - c_M)q_{M_H} + (p_F - c_M)q_{_{M_F}} - x_M \ ; \tag{5}$$

The profit of the firm based in the foreign country depends on the decision of the home government regarding PI. It follows that:

$$\pi_{_F} \equiv \left\{ \begin{array}{c} \pi_{_F}^{NP} = (p_F - c_F)q_{_{F_F}} \\ \pi_{_F}^{PI} = (p_F - c_F)q_{_{F_F}} + (p_H - c_F - \tau)q_{_{F_H}} \end{array} \right. \tag{6}$$

The firm in the foreign market does not invest in R&D, while both firms in the home market invest in cost-reducing R&D, with the L firm enjoying a superior technological capabilities. The investment efforts are indicated by x_L and x_M and their effect on the cost functions is represented as follows:

$$c_L = c - \gamma\sqrt{x_L} \tag{7}$$

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this comes due to the cost advantage of the medium firm with respect to the less efficient local firm.

$$c_M = c - \beta\gamma\sqrt{x_M} \tag{8}$$

$$c_F = c \tag{9}$$

where c is the pre-innovation production cost, assumed to be equal across firms, while γ measures the overall R&D efficiency. Moreover, $a > c$, $x_L \leq \left(\frac{c}{\gamma}\right)^2$ and $x_M \leq \left(\frac{c}{\beta\gamma}\right)^2$ to assure non-negative marginal cost after innovation. Parameter $\beta \in [0,1]$ captures the technological difference between the large-scale and the medium firm, with the former benefiting from superior cost-reducing technology than the latter.[13] Due to full protection of IPR in the home country, firms can save their technology from being copied at home.

3 Solving the Model

Firms in the H market are engaged in a two-stage game: in the first stage they invest in process innovating R&D and in the second stage they compete in quantity *à la* Cournot. We solve the game both first in the case where PI is forbidden and then in the case where PI is allowed.

3.1 No Parallel Import

We start by considering the case in which PI is banned. In the home market, the total quantity is given by $Q^{NP} = q_L + q_{M_H}$ and profit functions are:

$$\pi_L = (a - c - q_L - q_{M_H} + \gamma\sqrt{x_L})q_L - x_L, \tag{10}$$

$$\pi_M = (a-c-q_L-q_{M_H}+\beta\gamma\sqrt{x_M})q_{M_H}+(a-c-q_F-q_{M_F}+\beta\gamma\sqrt{x_M})q_{M_F}-x_M\ . \tag{11}$$

while the profit function for the foreign firm is

$$\pi_F^{NP} = (a - c - q_{M_F} - q_{F_F})q_{F_F}.$$

Using backward induction, second stage optimal quantities can be easily computed and are given by:

$$q_L\left(x_L, x_M\right) = \frac{a - c + 2\gamma\sqrt{x_L} - \beta\gamma\sqrt{x_M}}{3}, \tag{12}$$

$$q_{M_H}\left(x_L, x_M\right) = \frac{a - c + 2\gamma\beta\sqrt{x_M} - \gamma\sqrt{x_L}}{3}, \tag{13}$$

$$q_{M_F}\left(x_L, x_M\right) = \frac{a - c + 2\gamma\beta\sqrt{x_M}}{3} \tag{14}$$

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

$$q_{F_F}\left(x_L, x_M\right) = \frac{a-c-\gamma\beta\sqrt{x_M}}{3} \tag{15}$$

By substituting the above expressions into the original home profit functions, we obtain first stage profits as a function of R&D investment levels:

$$\pi_L\left(x_L, x_M\right) = \left[q_L\left(x_L, x_M\right)\right]^2 - x_L, \tag{16}$$

$$\pi_M\left(x_L, x_M\right) = \left[q_{M_H}\left(x_L, x_M\right)\right]^2 + \left[q_{M_F}\left(x_L, x_M\right)\right]^2 - x_M, \tag{17}$$

Taking First Order Conditions (FOCs) w.r.t x_L and x_M , optimal R&D investments can be easily computed and are given by:

$$x_L^* = \frac{36\gamma^2(3-4\gamma^2\beta^2)^2}{\Phi^2} \tag{18}$$

$$x_M^* = \frac{16\gamma^2\beta^2(9-5\gamma^2)^2}{\Phi^2}, \tag{19}$$

where $\Phi = 81 - 4\gamma^4[9+\beta^2(18-7\gamma^2)]$.[14] We assume that $\gamma \leq \min[\frac{3\sqrt{5}}{5}, \frac{\sqrt{3}}{2\beta}]$ for the optimal R&D investment levels to be admissable. Comparative statics reveal that innovation by both firms is always positively related to the overall R&D efficiency of the industry γ. Innovation by the L firm is decreasing, while that of M is increasing in β, i.e. with a lower technological gap. Comparing the R&D levels by the two firms, there exists a critical level

$$\beta^{NP} = \frac{5\gamma^2 - 9 + \sqrt{81+18\gamma^2+25\gamma^4}}{12\gamma^2} \in (0,1), \tag{20}$$

above which $x_M^* > x_L^*$. Note that in the absence of an additional market for the M firm, R&D effort by the L firm would always be higher due to its technological superiority. The market opportunity for the M firm works as a force against their technological inferiority to have M engage in more innovation for sufficiently high levels of β.

Optimal quantities are in turn

$$q_L^* = \frac{9(3-4\gamma^2\beta^2)}{\Phi}, \tag{21}$$

$$q_{M_H}^* = \frac{4\gamma^4\beta^2 - 18\gamma^2 + 27}{\Phi}, \tag{22}$$

$$q_{M_F}^* = \frac{27 - 4\gamma^4\beta^2 - 12\gamma^2}{\Phi}, \tag{23}$$

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[14] For the sake sake of exposition, we can set $(a-c)$ to unity as it appears in a multiplicative form in front of optimal R&D investments, quanitites, and profits.

$$q^*_{F_F} = \frac{(3-2\gamma)(3+2\gamma)(3-4\gamma^2\beta^2)}{\Phi}. \tag{24}$$

The derivatives of the optimal quantities w.r.t. β convey the expected results that $\partial q^*_L/\partial\beta < 0, \partial q^*_{F_F}/\partial\beta < 0$ and $\partial q^*_{M_i}/\partial\beta > 0$. When considering the effect of a change in γ, we get $\partial q^*_L/\partial\gamma > 0$, $\partial q^*_{M_F}/\partial\gamma > 0$ and $\partial q^*_{F_F}/\partial\gamma < 0$; however, the sign of $\partial q^*_{M_H}/\partial\gamma$ depends on β. In particular

$$\partial q^*_{M_H}/\partial\gamma > 0 \text{ iff } \beta > \tilde{\beta}, \tag{25}$$

where $\tilde{\beta} = \frac{\sqrt{2}\sqrt{27+5\gamma^4-12\gamma^2-\sqrt{729+306\gamma^4-648\gamma^2+25\gamma^8-120\gamma^6}}}{4\gamma^2} \in (0,1)$. The output by the M firm is positively related to the overall R&D efficiency in the industry only when the technological gap between the two firms is small, i.e. when expression (25) holds.

Finally, optimal profits are in turn:

$$\pi^*_L = \frac{9(3-2\gamma)(3+2\gamma)(3-4\gamma^2\beta^2)^2}{\Phi^2}, \tag{26}$$

$$\pi^*_M = \frac{2(729-810\gamma^2+234\gamma^4+16\gamma^8\beta^4-224\gamma^6\beta^2+720\gamma^4\beta^2-648\gamma^2\beta^2)}{\Phi^2}. \tag{27}$$

As with the innovation efforts, profit of the L firm is decreasing , while that of the M firm is increasing in β. More interestingly, comparative statics with respect to the overall R&D efficiency γ reveal that:

Lemma 1 *$\partial\pi^*_L/\partial\gamma < 0$ and $\partial\pi^*_M/\partial\gamma > 0$ for high values of β, while the opposite holds for low values of β.*

Proof: see the Appendix ■.

When firms are relatively homogeneous in terms of technology, an increase in γ boosts investments in cost-reducing R&D and quantities produced by both firms. Consequently, the price in the domestic market falls reducing firms' home revenues net of R&D costs. This is driven by over-investment in R&D explaining why the profit of L shrinks. Since the M firm enjoys revenues from a second market where there is no R&D competition, the gains coming from such a market overcompensates the loss in the home market, thus explaining the sign of $\partial\pi^*_M/\partial\gamma > 0, \partial\pi^*_L/\partial\gamma < 0$. For lower values of β, on the other hand, the efficiency gap is enough to give L an edge to enjoy a greater market share and yield higher profits when the overall technological level advances, $\partial\pi^*_L/\partial\gamma > 0, \partial\pi^*_M/\partial\gamma < 0$.

3.2 Parallel Import

We now assume that PI is allowed into the home country; the foreign firm can enter the home market, whose total quantity becomes $Q^{PI} = q_{L} + q_{M_H} + q_{F_H}$. As a consequence, profit functions are given by:

$$\pi_L = (a - c - q_L - q_{M_H} - q_{F_H} + \gamma\sqrt{x_L})q_L - x_L, \tag{28}$$

$$\pi_M = (a-c-q_L-q_{M_H}-q_{F_H}+\beta\gamma\sqrt{x_M})q_{M_H}+(a-c-q_F-q_{M_F}+\beta\gamma\sqrt{x_M})q_{M_F}-x_M\ , \tag{29}$$

$$\pi_{F}^{PI} = (a - c - q_{M_F} - q_{F_F})q_{F_F} + (a - c - q_L - q_{M_H} - q_{F_H} - \tau)q_{F_H}, \tag{30}$$

where $\tau = t(a - c)$ is the tariff rate normalized by the size of the market. Using backward induction, second stage optimal quantities can be computed and are given by:

$$q_L\left(x_L, x_M\right) = \frac{a - c + 3\gamma\sqrt{x_L} - \beta\gamma\sqrt{x_M} + \tau}{4}, \tag{31}$$

$$q_{M_H}\left(x_L, x_M\right) = \frac{a - c - \gamma\sqrt{x_L} + 3\beta\gamma\sqrt{x_M} + \tau}{4}, \tag{32}$$

$$q_{M_F}\left(x_L, x_M\right) = \frac{a - c + 2\gamma\beta\sqrt{x_M}}{3} \tag{33}$$

$$q_{F_F}\left(x_L, x_M\right) = \frac{a - c - \gamma\beta\sqrt{x_M}}{3} \tag{34}$$

$$q_{F_H}\left(x_L, x_M\right) = \frac{a - c - \gamma(\sqrt{x_L} + \beta\sqrt{x_M}) - 3\tau}{4} \tag{35}$$

By substituting the above expressions into the original home profit functions, we obtain first stage profits as a function of R&D investment levels:

$$\pi_L\left(x_L, x_M\right) = \left[q_L\left(x_L, x_M\right)\right]^2 - x_L, \tag{36}$$

$$\pi_M\left(x_L, x_M\right) = \left[q_{M_H}\left(x_L, x_M\right)\right]^2 + \left[q_{M_F}\left(x_L, x_M\right)\right]^2 - x_M, \tag{37}$$

Taking First Order Conditions (FOCs) w.r.t x_L and x_M , optimal R&D investments are:

$$x_L^{**} = \frac{9\gamma^2\left[\gamma^2\beta^2(51 + 43\tau) - 36(1 + \tau)\right]^2}{4\Omega^2}, \tag{38}$$

$$x_M^{**} = \frac{\gamma^2\beta^2\left[3\gamma^2(51 + 27\tau) - 236 - 108\tau\right]^2}{4\Omega^2}, \tag{39}$$

where $\Omega = 288 - \gamma^2[162 + 290\beta^2 - 153\gamma^2\beta^2]$. Moreover, we assume that $\gamma \leq \min[\frac{6\sqrt{(43\tau+51)(1+\tau)}}{\beta(43\tau+51)}, \frac{6\sqrt{(9\tau+17)(59+27\tau)}}{153+81\tau}]$ for (38) and (39) to be feasible.

Innovation by both firms is always increasing in the overall technology efficiency γ and in tariffs τ. Similar to the NP case, innovation by the L firm is decreasing, while that of M is increasing in β. We can identify the threshold value

$$\begin{aligned} \beta^{PI} &= \frac{9\gamma^2\left(9\tau+17\right)-108\tau-236+\sqrt{\digamma}}{6\gamma^2\left(51+43\tau\right)} \in (0,1)\,, \\ \digamma &= 9\gamma^2\left[9\gamma^2\left(9\tau+17\right)^2+4248\tau^2+5616\tau-680\right]+16\left(27\tau+59\right)^2 \end{aligned} \tag{40}$$

above which $x_M^{**} > x_L^{**}$.

Optimal quantities can be calculated and are given by:

$$q_L^{**} = \frac{-2(51g^2\beta^2+43g^2\beta^2\tau-36-36\tau)}{\Omega}, \tag{41}$$

$$q_{M_H}^{**} = \frac{2(8g^2\beta^2-27g^2+36+12g^4\beta^2\tau-27g^2\tau-16g^2\beta^2\tau+36\tau)}{\Omega}, \tag{42}$$

$$q_{M_F}^{**} = \frac{-3(6g^2\beta^2+18g^2-32-12g^2\beta^2\tau+9g^4\beta^2\tau)}{\Omega}, \tag{43}$$

$$q_{F_F}^{**} = \frac{(153g^4\beta^2-272g^2\beta^2-108g^2+192-36g^2\beta^2\tau+27g^4\beta^2\tau)}{2\Omega}, \tag{44}$$

$$q_{F_H}^{**} = \frac{-3(68g^2\beta^2-136g^2\beta^2\tau-51g^4\beta^2+59g^4\beta^2\tau+36g^2-48-72g^2\tau+144\tau)}{2\Omega} \tag{45}$$

Comparative statics with respect to β and γ replicate the mechanism obtained in the case with no PI. More precisely, the sign of $\partial q_{M_H}^{**}/\partial\gamma$ also depends on β and

$$\partial q_{M_H}^{**}/\partial\gamma > 0 \text{ iff } \beta > \hat{\beta}, \text{ where } \hat{\beta} < \tilde{\beta}$$

holds at all time.[15] These results imply that under a PI regime, a lower threshold β is necessary for the M firm to increase output when overall technology efficiency improves. In other words, PI tends to be a positive factor for the home market of the M firm in a country where overall R&D efficiency is growing. Additionally, output by home firms increases and that by the foreign firm decreases in tariffs. There is a level of prohibitive tariffs that blocks PI by making $q_{F_H}\left(x_L, x_M\right) = 0$, which is

$$\hat{\tau} = \frac{(4-3\gamma^2)(12-17\gamma^2\beta^2)}{144-72\gamma^2+59\gamma^4\beta^2-136\gamma^2\beta^2}.$$

Finally, optimal profits are:

$$\pi_L^{**} = \frac{(4-3\gamma)(4+3\gamma)\left[\gamma^2\beta^2(51+43\tau)-36(1+\tau)\right]^2}{4\Omega^2}, \tag{46}$$

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[15] See appendix for details.

$$\pi_M^* = \frac{\Psi}{4\Omega^2}. \tag{47}$$

where Ψ is to be simplified and defined in the appendix. The comparative statics of the PI case works in the same direction as the NP case, with the addition that profits of both firms are increasing in tariffs τ.

4 Analyzing the Model

4.1 The Impact on Innovation

The aim of this section is to compare the innovation effort carried by the firms L and M in the two regimes, by taking into account the effect of the tariff levied by the home government.

We start by analyzing (20) and (40) and use parameter τ as a discriminant. It is easy to verify that under free trade (i.e. when $\tau \longrightarrow 0$) it always holds that $\beta^{NP} > \beta^{PI}$. This indicates that allowing PI would induce M to perform more R&D than L for a larger range of β than in absence of PI. In other words, absent tariffs, PI tends to push the M firm to do R&D relative to the L firm. Yet, there exists a threshold level of tariffs

$$\bar{\tau} = \frac{\gamma^2(255\gamma^2 - 686) + 117 + (51\gamma^2 - 13)\sqrt{\Theta}}{\gamma^2(265\gamma^2 - 1602) + 1539 + (53\gamma^2 - 171)\sqrt{\Theta}}$$

with $\Theta = 81 + 18\gamma^2 + 25\gamma^4$, above which $\beta^{NP} < \beta^{PI}$. The effect of PI in this situation is to push the L firm to invest more in R&D than the M firm, i.e. $x_L > x_M$ for a larger spectrum of β than without PI. As a result, a policy of PI with a sufficiently high tariff rate ($\tau > \bar{\tau}$) reinforces the position of the L firm as the innovative leader in the market.

We can now evaluate the R&D effort exerted by firms across the two regimes. This reveals whether PI can bring out a stimulus to invest in cost-reducing activities. Comparing the optimal R&D investment by each firm, there exists a critical value of τ above which PI increases R&D: $x_L^{**} > x_L^*$ if $\tau > \tau_L$ and $x_M^{**} > x_M^*$ if $\tau > \tau_M$, where

$$\tau_L = \frac{1020\gamma^6\beta^4 + 3\gamma^2(216 + 455\beta^2) - 88\gamma^2\beta^2(18 + 11\beta^2) - 540}{(43\gamma^2\beta^2 - 36)\left\{81 + 4\gamma^2\left[(7\gamma^2 - 18)\beta^2 - 9\right]\right\}}, \tag{48}$$

$$\tau_M = \frac{\gamma^2\left[765 - 324\gamma^2 + 4\beta^2(324 - 416\gamma^2 + 153\gamma^4)\right] - 540}{9(3\gamma^2 - 4)\left\{81 + 4\gamma^2\left[(7\gamma^2 - 18)\beta^2 - 9\right]\right\}}. \tag{49}$$

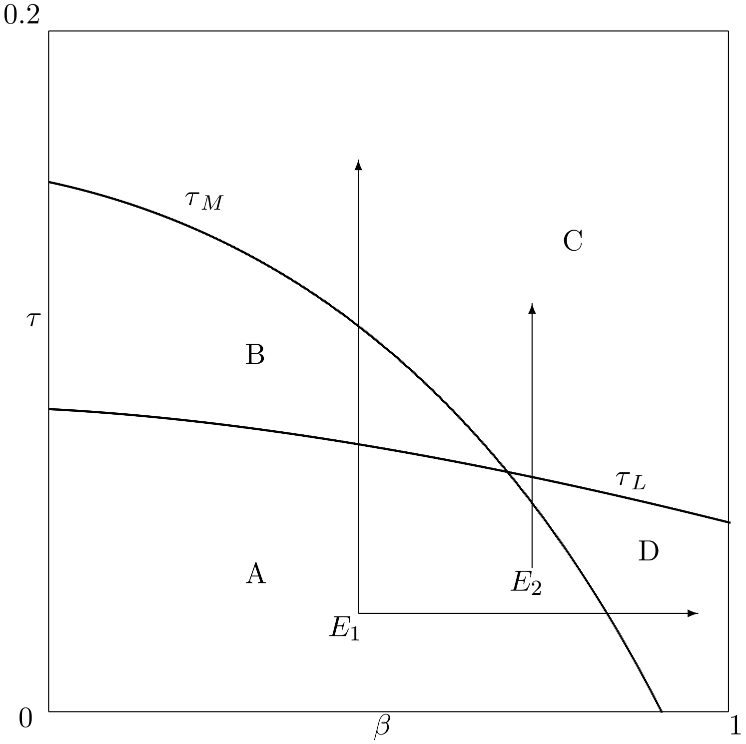
When comparing τ_L and τ_M, we find that they only cross once in $\beta \in (0, 1)$ and

$$\tau_M > \tau_L \text{ when } \beta < \breve{\beta} = \frac{3}{2}\sqrt{2}(9 + \gamma^2)^{-(1/2)}.$$

Lemma 2 *$x_L^{**} > x_L^*$ when $\tau > \tau_L$ and $x_M^{**} > x_M^*$ when $\tau > \tau_M$, with τ_M and τ_L crossing only once in $0 < \beta < 1$.*

In Figure 1 we represent τ_M and τ_L as a function of β.[16] We find four parameter regions, labelled A, B, C and D; in each of them we can easy compare the R&D levels of the two firms with and without PI.

Figure 1



Recall, introducing PI reduces the market share of L and M in the home market. A lower market share would imply less incentives to invest in cost-reducing R&D. While the L firm only serves the home market, M also competes in the foreign country with a local firm, which has no R&D capabilities. It follows that the M firm balances out gains and losses in the two markets when deciding its R&D expenditure.

Let us now examine the four different regions in the figure:

In region A, we observe a combination of low values of β and τ. PI decreases R&D by both firms due to the competition added from the imports of the foreign firm. In this zone, the foreign firm is very competitive in H because of the absence

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[16] Figure 1 has been plotted by fixing $\gamma = 0.7$.

of protection through tariffs, and because of the lack of a technological advantage by M over the entrant that could hamper progress by the latter into the home market.

In region B, where τ is sufficiently high, but β takes on a low value, PI increases R&D efforts by the L firm while reducing that by M. As the L firm has a dominant position in the market with respect to M, the foreign entrant steals market share from the more vulnerable M firm. The L firm hence turns more aggressive and increases innovation when protected by sufficienty high tariffs.

Region C illustrates a combination of high values of β and τ, where PI increases R&D by both firms. In this situation both firms gain from large tariff levels and the M firm enjoys a large advantage in both markets.

Finally, region D depicts low values of τ with high values of β. The L firm here reduces its R&D efforts when PI is introduced, while M increases his. The M firm is approximately as efficient as L at home, while enjoying a large technological advantage in the foreign market. Having an extra market increases R&D by M, which in turn also gives it an edge in the home market. As it can be seen in the figure, the rise in R&D by M creates the need for a a higher τ for L to increase its efforts.

Some illustrative examples of movements from one zone to another will clarify the role played by our relevant parameters on innovation. First, we start from point E_1 belonging to region A. A righward move towards region D driven by an increase in β, makes firm M more efficient in cost-reducing R&D. The advantage over the foreign firm in its second market outweighs the R&D disincentives in the home market created by the presence of a though third competitor. Higher R&D efficiency (large enough values of β and γ), induces innovation due to the large advantage in the foreign market, which also gives M an edge in the home market.

An upward move from E_1 (low β) instead by increasing τ implies a shift from zone A to B to C. (low β). Higher tariffs protect the two firms against the foreign entrant. Initially, increasing tariffs stimulates the L firm, which dominates the home market. A higher τ is required for the less efficient M firm to also increase R&D after opening to PI. Alternatively, starting from E_2 (high β) and moving upwards, we experience a shift from zone A to D to C. As the M firm is relatively more efficient, it is the first one to engage in more R&D under PI for a more protectionist trade policy. When tariffs rise further, L also finds it more attractive to invest a higher amount of resources in R&D than in the absence of PI.

4.2 Welfare implication

For future reference, consumer surplus in the home country amounts to:

$$CS_H^* = \frac{2(2\gamma^4\beta^2 - 9\gamma^2 + 27 - 18\gamma^2\beta^2)^2}{\Phi^2}, \tag{50}$$

Finally, consumer surplus in the home country is:

$$CS_H^{**} = \frac{(216\gamma^2 + 376\gamma^2\beta^2 - 432 + 129\gamma^4\beta^2 t - 108\gamma^2 t - 172\gamma^2\beta^2 t + 144\tau - 153\gamma^4\beta^2)^2}{8\Omega^2}, \tag{51}$$

5 Conclusion

We based our paper on a stylized fact that concerns the surge of parallel import between countries belonging to the so called South of world. The case study we had in mind was the emergence of PI between India and Tanzania in the pharmaceutical industry. India is more advanced in terms of technology and intellectual property rights protection, while Tanzania could represent an interesting destination market for Indian firms. We considered two firms located in India that differ in their efficiency to perform a process-innovative activity. The less endowed may therefore look for new countries to expand its final market. However, if it decides to export, its product can be copied and reintroduced back to the initial market.

We aimed at studying the effect of PI on the R&D effort undertaken by Indian firms. To this aim, we solved the two-stage game played by these firms both in presence and in absence of PI. We compared the optimal investment levels, showing that PI can drive up the R&D activity level by both firms, when tariffs on the reintroduced product are sufficiently high and when firms are not too different. Lastly, we investigated social welfare and discovered that PI is socially optimal when both firms' investestment levels are higher than in absence of PI. A social planner should therefore allow PI when this leads to higher investment effort by both firms. Trade policy in this case can be used as a complementary tool along with PI to benefit the society at large.

Appendix

Proof of Lemma 1

to be added

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