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Trade liberalization and Quality Innovation: A Theory and Some Evidence[♦]

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Abstract

This paper examines whether trade liberalization affects quality innovation in an economy. First we construct a theoretical model with a quality-differentiated good with heterogeneous set of consumers and a local firm facing competitive imports from abroad. In this model we examine the private incentives for quality innovation. For a differential tariff regime, we show that the private gains generally increase with increasing tariff levels in the low-quality segment of the domestic market for any given tariff on high-quality imports. But for higher tariff levels on the low-quality segment private gain from quality innovation might fall leading to a non-monotonic relationship between tariff levels and innovation incentives. We test our theoretical model with Indian data but we do not find any relationship between trade liberalization and quality innovation. Therefore from a policy perspective more direct incentives should be given to firms if they undertake innovative activity (in terms of tax holidays or otherwise on expenditure on R&D) and that might have the desired effect we are searching for.

Key Words: Quality Innovation; Tariff, Trade Liberalization.

JEL Classification: F13, L12, L15.

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1. Introduction:

Does trade liberalization foster quality innovation in an economy? This has been a debated issue both theoretically and empirically. Desai (1980), Lall (1984), Marjit and Raychaudhuri (1997), in the Indian context, argued quite strongly that increased protection led to domestic firms becoming more inward looking during the 1970s and 1980 and eliminated innovation incentives whatsoever during that period. According to these papers whatever little innovation that took place were just minor innovations (process or cost innovation) instead of at the frontiers of technology i.e. product and/or quality innovation. Similar argument has often been put forward for other developing countries as well. On the other hand Aw and Roberts (1986), found that the 1977-81 quota on footwear imports from Korea and Taiwan led to the quality upgrading of most important bundles throughout the period in USA.

Theoretical analyses linking trade liberalization and innovation have also remained inconclusive. Porter (1990) and White (1974) argued that too much market power for the domestic firms is not conducive for innovation. Segerstorm et. al. (1990) have put forward similar argument in a dynamic general equilibrium North-South model. Clemenz (1990) and Reitzes (1991), on the other hand, captured the Schumpeterian idea that market power and innovation are positively related [see also Kamien and Schwartz (1982)]. In a similar spirit, Rodrik (1992) in a dynamic set up, demonstrated that liberalization slows down the pace of the productivity increase and delays technological catch up since it shrinks the domestic monopolist's sales and thus reduces incentives to invest in cost-reducing technology. Recently Acharyya and Banerjee (2012) in a vertical differentiation framework showed that increasing protection might lead to increased innovation incentives for firms.

In this paper we revisit the debate about whether trade liberalization leads to increased quality innovation (quality upgradation) both from a theoretical and empirical perspective. First we construct a theoretical model linking trade liberalization and quality innovation. Using a vertical differentiation structure similar to Mussa and Rosen (1978)[1] with two types of consumers (differing in their marginal willingness to pay for quality) we find situations where protection fosters (quality) innovation which is in some sense similar to the Schumpeterian idea. Also we find that for sufficiently high tariff levels increased protection leads to reduced innovation. Thus the relationship between trade liberalization and quality innovation might not be monotonic and straightforward as some of the earlier models have suggested. Here we focus on the positive aspect of innovation and abstract from the social desirability aspect of innovation.

Then we take Indian data and examine whether trade liberalization has some impact on overall expenditure on research and development. Unfortunately we do not find any evidence of liberalization affecting (positively or negatively) the overall research and development expenditure in India. To throw some light on the quality innovation situation in India we collect the world development indicators data on high technology exports[2] from 1988 to2013 and compare India with various leading developed and developing countries. Casual empiricism shows that India's performance is less satisfactory even compared to other major developing economies (like China and Brazil) although India is certainly doing better than Bangladesh. But again we do not find much evidence of an increased level of high-technology exports post liberalization. Therefore empirically we do not find any evidence that liberalization (or trade liberalization) affects level of innovation in an economy. Thus tinkering with economic variables might not have the desired

[1] In a similar framework, choice between innovation types has been examined for a closed economy by Bandyopadhyay and Acharyya (2004a) and Lambertini and Orsini (2000). For similar approach see papers by Acharyya (1998), Bandyopadhyay and Acharyya (2004), Acharyya and Banerjee (2012).
[2] We conjecture that high technology exports will be a decent proxy to quality innovation situation in an economy.

effect that we often expect. Therefore from a policy perspective we propose more direct incentives to firms (in terms of tax holidays or otherwise) on investments in R&D and that might have the desired effect that in increasing R&D activity in an economy.

The rest of the paper is organized as follows. In section 2 we spell out the theoretical framework of our analysis. Section 3 examines the innovation incentive and quality choice by the local firm when the high-quality good is completely protected from import competition. In section 4 we consider the case of non-prohibitive tariff on high quality product. In section 5 we provide some empirical evidence with Indian and World Development Indicators data. Finally, in section 6 we conclude our analysis.

2. A Vertical Differentiation Framework:

Consider a vertically differentiated good with observable quality indexed by $q \in \left[0, \bar{q}\right]$ and suppose the domestic production is monopolized by a single firm. Though the present state of scientific knowledge makes it possible to produce the good elsewhere over such a range of qualities, we assume that the domestic monopolist is technologically constrained and can only produce qualities within the range $\left[0, \tilde{q}_1\right]$ but not beyond that, where $\tilde{q}_1 < \bar{q}$. However by investing an exogenously given sum of F_q, the firm can learn the technical know-how to produce all $q \in \left[\tilde{q}_1, \bar{q}\right]$ which we term as quality innovation. Assume that the marginal cost of production is invariant with respect to output level but increases at an increasing rate with the quality level. Therefore the unit cost function in the pre-innovation stage for this domestic monopolist is given as,

$$C = \bar{c}q^2 \quad \forall q \in \left[0, \tilde{q}_1\right]$$
$$= \propto \quad \text{otherwise} \tag{1}$$

In the home country there are two types of consumers who differ in respect of their taste parameters: α_2 high type and α_1 low type where $\alpha_2 > \alpha_1$. α_2-type consumers have higher willingness to pay for quality than the α_1-type. In addition to this we assume that the high type is sufficiently high such that $\alpha_2 > 2\alpha_1$ which is nothing but a technical restriction and help solve our model better. Suppose there are n_2 number of high type consumers and n_1 number of low type consumers. Each consumer buys, if at all, only one unit of the good. Also we assume that a consumer gets zero utility from not purchasing anything. The net utility that type-α_j consumer derives from purchasing the menu *(q, P)* is assumed to follow the Mussa and Rosen (1978) type preference structure and therefore is given as:

$$U_j = \alpha_j q - P, \quad j = 1,2 \tag{2}$$

The above preference function satisfies the single crossing property. A representative type-α_j consumer participates in the market if $\alpha_j q \geq P$ holds and the α_2-type selects the menu (q_2,P_2) over (q_1,P_1) if the self-selection constraint $\alpha_j q_2 - P_2 \geq \alpha_j q_1 - P_1$ is satisfied where $q_2 > q_1$ and $p_2 > p_1$. First we look at the quality choice of the home firm had it not been technologically constrained, and faced no competition from abroad whatsoever. This exercise will help us understand the technological constraint and the potential gains from quality innovation. Under a completely protected trade regime, the unconstrained home firm would have chosen a separating menu with the following qualities that maximize its profit, $\pi = n_1(\alpha_1 q_1 - \bar{c}q_1^2) + n_2\{\alpha_2(q_2 - q_1) + \alpha_1 q_1 - \bar{c}q_2^2\}$ and the optimal qualities offered will be

$$\tilde{q}_1 = \frac{n_1\alpha_1 - n_2(\alpha_2 - \alpha_1)}{2n_1\bar{c}}, \quad \tilde{q}_2 = \frac{\alpha_2}{2\bar{c}} \tag{3}$$

It is a standard result that $\tilde{q}_1$ is socially suboptimal but $\tilde{q}_2$ is optimal. This is the well-known quality-distortion-at-the-bottom result first established by Mussa and Rosen (1978)[3]. For the above separating quality choice to be profitable we need the lower end of the market to be sufficiently large, i.e.

$$\frac{n_1}{n_2} > \frac{(\alpha_2 - \alpha_1)}{\alpha_1} \tag{4}$$

Otherwise the monopolist will offer $\tilde{q}_2$ at price $\alpha_2 \tilde{q}_2$ to the α_2-consumers and will exclude the α_1-type from the market. In rest of our analysis we will assume that (4) holds.

It is immediate that the technological constraint defined above, is assumed to be binding in the sense that without investing in R&D, the home firm can offer at most $\tilde{q}_1$ level of quality. Pre-innovation, therefore the problem simply boils down to whether to extract all surplus from the high-type by charging their reservation price which, of course, drives low-type consumers out of the market, or to offer a pooling menu by charging the reservation price of the low-types which leaves high-types with some surplus. The same restriction on the distribution pattern mentioned above, however, implies that the pooling menu, $\tilde{q}_1, P_1 = P_2 = \alpha_1 \tilde{q}_1$, is relatively profitable.

Suppose the world market for this quality-differentiated good is perfectly competitive and there is per unit tariff on imports. We assume that producers abroad have identical cost of quality as the home firm with the exception that they face no technological constraint. Therefore, $C^* = \bar{c}q^2 \ \forall q \in \lfloor 0, \bar{q} \rfloor$ will be the cost function for the foreign producers. These simplifying assumptions imply that competitive foreign producers will offer the quality $q_j{}^* = \frac{\alpha_j}{2\bar{c}} \ \forall \ j = 1, 2$ to the α_j-type home consumers. Note, since the indifference curves generated by the utility functions

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[3] For formal proof of this result in case of discrete consumer types, see Cooper (1984) and Acharyya (2005b). A few exceptions to this result are discussed by Kim and Kim (1996) and Srinagesh and Bradburd (1988).

defined in (2) are vertically parallel and the per-unit tariff does not alter the marginal cost of quality, the profit-maximizing qualities offered by the foreign firm to the consumers in the domestic-country market remains the same as q_j^* regardless of the level of the tariff and consequent tariff-inclusive cost-price that the domestic consumers have to pay for the imported varieties.

3. Differential Tariff Regime with Prohibitive Tariff on High-quality Imports:

Keeping with the observation that often imports of different quality are subject to differential tariff rates we assume that for all imports with qualities $q < q_2^*$ a tariif rate of t_1 is applied to whereas the rate t_2 is applied to all imports of quality q_2^* or higher. We will examine how do the variations in the tariff on low-quality imports affect the innovation decision of the local firm for any given tariff on high-quality imports. To begin with, we assume that t_2 is set at the prohibitive level in the sense that the tariff-inclusive import price equals the maximum price that the high-type consumers are willing to pay for q_2^*. From the individual rationality constraint of the high type this prohibitive tariff equals $t_{P2} = \alpha_2 q_2^* - \bar{c} q_2^{*2}$. Note that, the high-end of the home market must be protected from competitive import of similar high-quality varieties from abroad to ensure positive rents from innovation for the home firm. This, however, does not necessitate that the high-end of the market should be completely protected through a prohibitive tariff. Later we will relax this assumption to discuss the implications of non-prohibitive tariff on both the high and low quality products.

3.1. Pre-innovation Market Segmentation:

Given such initial tariff regimes, the tariff inclusive domestic price of the imported quality q_1^* equals $P_1^d = \bar{c} q_1^{*2} + t_1$. But the home firm must charge a price $P_1(t_1)$ strictly less than this to induce

the low-type consumers to buy the domestic variety $\tilde{q}_1$. A little manipulation of the self-selection constraint of the α_1-type consumers yields such a price as,

$$P_1(t_1) = \alpha_1\tilde{q}_1 - \alpha_1 q_1^* + \bar{c}q_1^{*2} + t_1 - \varepsilon = (\bar{c}q_1^{*2} + t_1) - \alpha_1(q_1^* - \tilde{q}_1) - \varepsilon \tag{5}$$

But the home firm will operate only if this price covers marginal cost of producing $\tilde{q}_1$. From (5) it follows then that there is a strictly positive tariff $\tilde{t}_1$ that must at least be offered to protect the domestic firm:

$$\tilde{t}_1 = \left[\alpha_1(q_1^* - \tilde{q}_1) - \bar{c}(q_1^{*2} - \tilde{q}_1^2)\right] = \frac{n_2^2(\alpha_2 - \alpha_1)^2}{4n_1^2\bar{c}} \tag{6}$$

Again using (5) and for ε sufficiently close to zero we get the value of the prohibitive tariff on the low-quality product as

$$t_{P1} = \alpha_1 q_1^* - \bar{c}q_1^{*2} = \frac{\alpha_1^2}{4\bar{c}} \tag{7}$$

This prohibitive tariff t_{P1} on the low-quality import q_1^* enables the local firm to charge the monopoly price along the individual rationality constraint of the low-type consumers i.e. $P_1(t_1) = \alpha_1\tilde{q}_1$. Also it is easy to check that the tariff rate $\tilde{t}_1$ is smaller than the prohibitive tariff t_{P1}.

Therefore,

Result 1: *In the pre-innovation stage, with a prohibitive tariff on the high-quality imported varieties, the low-type domestic consumers buy the imported variety* q_1^* $\forall t_1 \in [0, \tilde{t}_1]$ *where* $\tilde{t}_1 < t_{P1}$.

Proof: Follows from (3), (5) and (6). Also $t_{P1} > \tilde{t}_1$ holds given (4).□

Again the producer can charge an even lower price to the α_2-type domestic consumers say $P_2(t_1)$ and encourage them to buy $\tilde{q}_1$ at price $P_2(t_1)$. Thus $P_2(t_1)$ should be such that α_2-type prefers $\tilde{q}_1$ at price $P_2(t_1)$ over q_1^* at price $P_1^d = \bar{c}q_1^{*2} + t_1$. Therefore $P_2(t_1)$ should be set such that

$$\alpha_2 \tilde{q}_1 - P_2(t_1) > \alpha_2 q_1^* - \bar{c} q_1^{*2} - t_1$$

$$P_2(t_1) < \bar{c} q_1^{*2} + t_1 - \alpha_2 (q_1^* - \tilde{q}_1)$$

Needless to say that $P_2(t_1) < P_1(t_1)$ and $P_2(t_1) > \bar{c}\tilde{q}_1^{\,2}$ iff $t_1 > \alpha_2 (q_1^* - \tilde{q}_1) - \bar{c}(q_1^{*2} - \tilde{q}_1^2) = \tilde{\tilde{t}}_1$ let. One can easily verify that $\tilde{\tilde{t}}_1 > \tilde{t}_1$ and therefore the monopolist can offer the domestic low type product to the α_2-type only if the tariff level is even higher. Now the monopolist has two options. Offer $\tilde{q}_1$ at price $P_2(t_1)$ to both α_1 and α_2-type (pooling menu) or offer $\tilde{q}_1$ at price $P_1(t_1)$ to only α_1-type. The pooling profit can be calculated as

$$\pi_{pool}(t_1) = (n_1 + n_2)\left[\bar{c}(q_1^{*2} - \tilde{q}_1^2) - \alpha_2 (q_1^* - \tilde{q}_1) + t_1\right]$$

and the only α_1-type profit can be calculated as

$$\pi_{\alpha_1 only}(t_1) = n_1\left[\bar{c}(q_1^{*2} - \tilde{q}_1^2) - \alpha_1 (q_1^* - \tilde{q}_1) + t_1\right]$$

$\pi_{pool}(t_1) > 0$ iff $t_1 > \tilde{\tilde{t}}_1$ and $\pi_{\alpha_1 only}(t_1) > 0$ iff $t_1 > \tilde{t}_1$.

Therefore $\Pi = 0 \; \forall t_1 \in [0, \tilde{t}_1]$ and $\Pi = \pi_{\alpha_1 only} \forall t_1 \in \left[\tilde{t}_1, \tilde{\tilde{t}}_1\right]$.

Now let us define $\hat{t}_1$ such that the α_2-type is indifferent between purchasing $\tilde{q}_1$ at price $\alpha_1 \tilde{q}_1$ and purchasing $q_1{}^*$ at price $\bar{c} q_1{}^{*2} + \hat{t}_1$ and one can calculate

$$\hat{t}_1 = \alpha_2 (q_1^* - \tilde{q}_1) + \alpha_1 \tilde{q}_1 - \bar{c} q_1{}^{*2}. \tag{8}$$

One can easily check that $\hat{t}_1 > \tilde{\tilde{t}}_1$ since $\alpha_1 \tilde{q}_1 > \bar{c}\tilde{q}_1^{\,2}$. For any $t_1 \in (\tilde{\tilde{t}}_1, \hat{t}_1]$ the monopolist has the choice of offering $\tilde{q}_1$ at price $\alpha_1 \tilde{q}_1$ to the α_1-type only or can offer $\tilde{q}_1$ at price $P_2(t_1) = \bar{c} q_1^{*2} + t_1 - \alpha_2 (q_1^* - \tilde{q}_1) - \varepsilon$ to both types (pooling menu). Calculations show that $\pi_{\alpha_1 only} > \pi_{pool} \forall t_1 \in [\tilde{\tilde{t}}_1, \hat{t}_1)$. Again if $t_1 \geq \hat{t}_1$ the high type can be offered $\tilde{q}_1$ at price $\alpha_1 \tilde{q}_1$ and they

will accept. Therefore the monopolist has the option to offer $\tilde{q}_1$ at price $\alpha_1\tilde{q}_1$ to 'both types' or offer $\tilde{q}_1$ at price $P_2(t_1) = \bar{c}q_1^{*2} + t_1 - \alpha_2(q_1^* - \tilde{q}_1)$ to only α_2-type. In the first case the monopolist's profit will be $\pi_{Both}(t_1) = (n_1 + n_2)[\alpha_1\tilde{q}_1 - \bar{c}\tilde{q}_1^2]$ and in the other case the profit will be $\pi_{\alpha_2 only}(t_1) = n_1\left[\bar{c}(q_1^{*2} - \tilde{q}_1^2) - \alpha_1(q_1^* - \tilde{q}_1) + t_1\right]$. Calculations show that $\exists\, t_1'' > \hat{t}_1$ such that $\pi_{Both} > \pi_{\alpha_2 only}\ \forall\, t_1 \in (\hat{t}_1, t_1'']$ where $t_1'' = \hat{t}_1 + \dfrac{n_1}{n_2}\left[\alpha_1\tilde{q}_1 - \bar{c}\tilde{q}_1^{\,2}\right]$. And finally if $t_1 > t_1''$ then its optimum for the domestic monopolist to offer $\tilde{q}_1$ at price $P_2(t_1) = \bar{c}q_1^{*2} + t_1 - \alpha_2(q_1^* - \tilde{q}_1)$ to only α_2-type over $\tilde{q}_1$ at price $\alpha_1\tilde{q}_1$ to both types i.e. $\pi_{\alpha_2 only} > \pi_{Both}$. We can state the following lemma:

Result 2: *In the pre-innovation stage, with a prohibitive tariff on the high-quality imported varieties, the high-type domestic consumers buy the domestic variety,* $\tilde{q}_1\ \forall t_1 > \hat{t}_1$.

Proof: Follows from the above discussion. □

Now we get a complete characterization of the menus offered by the domestic monopolist and the resulting profits from those menus at different tariff levels. These are given below:

$$\Pi = \begin{cases} 0 & \forall t_1 \in [0, \tilde{t}_1] \\ \pi_{\alpha_1 only} = n_1\left[\bar{c}\left(q_1^{*2} - \tilde{q}_1^2\right) - \alpha_1(q_1 * - \tilde{q}_1) + t_1\right] & \forall t_1 \in [\tilde{t}_1, \hat{t}_1] \\ \pi_{Both} = (n_1 + n_2)[\alpha_1\tilde{q}_1 - \bar{c}\tilde{q}_1^2] & \forall t_1 \in [\hat{t}_1, t_1''] \\ \pi_{\alpha_2 only} = n_2\left[\bar{c}\left(q_1^{*2} - \tilde{q}_1^2\right) - \alpha_1(q_1 * - \tilde{q}_1) + t_1\right] & \forall t_1 > t'' \end{cases} \tag{9}$$

Given these pre-innovation profit levels for different tariff levels, let us now turn to quality innovation and gains thereof.

3.2 Quality Innovation:

Suppose the monopolist can go for an instantaneous and certain innovation by investing a fixed sum F which will help it develop all qualities over the range $[\tilde{q}_1, \bar{q}]$. Therefore after the innovation

is undertaken the home firm is no longer technologically constrained to produce qualities within $[0, \tilde{q}_1]$ and therefore can produce the profit maximizing qualities, denoted by q_1^I and q_2^I. But as the imported low-quality variety q_1^* is available at the tariff inclusive price P_1^d, for all non-prohibitive tariffs, $t_1 < t_{P1}$, the local firm must ensure that the low-type consumers and high-type consumers get at least the same *positive* net surplus by purchasing q_1^I and q_2^I respectively as they would have by purchasing the imported variety q_1^*. That is, he must charge prices such that,

$$P_1(t_1) = \alpha_1 q_1^I - (\alpha_1 q_1^* - \bar{c} q_1^{*2}) + t_1 - \varepsilon \tag{10a}$$

$$P_2(t_1) = \alpha_2 (q_2^I - q_1^*) + (\bar{c} q_1^{*2} + t_1) \tag{10b}$$

Given such prices, it is straightforward to check that the home firm's choices of q_j^I that maximize $\pi(t) = n_1[p_1(t_1) - \bar{c} q_1^{I^2}] + n_2[p_2(t_1) - \bar{c} q_2^{I^2}]$ are the same as the imported qualities: $q_1^I = q_1^*$, $q_2^I = \tilde{q}_2 = q_2^*$.

The fact that the local firm offers the imported quality q_1^* to the low-type consumers signifies the pro-competitive effect of a non-prohibitive tariff. For tariffs greater than t_{P1}, on the other hand, the low-type consumers do not buy the imported low-quality good because at $t_1 > t_{P1}$ they would get negative surplus. Also for $t > t_{P1}$ it is not optimum for the domestic monopolist to offer q_1^* anymore. As t_1 increases beyond t_{P1} the domestic monopolist will reduce the low quality offered gradually such that the low-type consumers purchase the reduced low-quality say $\hat{q}_1$ at price $\alpha_1 \hat{q}_1$ and the high-type purchases quality q_2^* at price $P_2(t_1) = \bar{c} q_1^{*2} + t_1 - \alpha_2 (q_2^* - q_1^*)$ according to the incentive compatibility constraint of the high-type. As t_1 increases and reaches $\hat{t}_1$ the optimal low-quality is downgraded to $\tilde{q}_1$ and that will the optimal low quality offered for all $t > \hat{t}_1$. This leaves

the high-type consumers with a strictly positive net surplus because $p_2(\hat{t}_1) < \alpha_2 q_2^*$. The following Lemma makes a more precise statement regarding quality choices by the local firm in the post-innovation stage for non-prohibitive and prohibitive tariff rates:

Result 3: *Post-innovation the local firm offers the separating menu with* $q_2^I = \tilde{q}_2 = q_2^*$ *offered to the high-type consumers and* q_1^I *offered to the low type consumers where,*

$$q_1^I = \begin{cases} q_1^* & \forall\ 0 \le t_1 \le t_{P1} \\ \hat{q}_1 = \dfrac{\alpha_1(2\alpha_2 - \alpha_1) - 4ct_1}{4c(\alpha_2 - \alpha_1)} & \forall\ t_{P1} < t_1 < \hat{t}_1 \\ \tilde{q}_1 & \forall\ t_1 \ge \hat{t}_1 \end{cases} \tag{11}$$

Proof: See the appendix. □

Since q_1^* is the socially optimal low quality, all $t_1 > t_{P1}$ result in downward quality distortion in the lower segment of the domestic market. Therefore we can state the following corollary:

Corollary 1: All tariff rates greater than the prohibitive tariff, $t_1 > t_{P1}$***, are distortionary.***

This result can be explained as follows. For all $t_1 \in [0, t_{P1}]$, the domestic firm acts like a price-taker. Facing competitive imports from abroad, it cannot raise the price of its product more than the tariff-inclusive marginal cost of production for any given quality. Since both the consumer preferences and the tariff-inclusive marginal cost (of production) curves are vertically parallel, such tariff-inclusive higher prices leave the optimal choice of qualities by the domestic firm same as the imported qualities. Consequently, tariff just redistributes total surplus among domestic consumers and the local producer without generating any quality distortion and, therefore, any dead-weight

loss. Thus, the threat of potential entry mitigates quality distortion for non-prohibitive tariff levels. There will, however, be the usual price distortion.

But when $t_1 = t_{P1}$, the tariff-inclusive price of imported low-quality good become so high as to leave low-type domestic consumers with no surplus. For all tariffs higher than this, the low-type domestic consumers are better off by not consuming the imported variety. This creates scope for the domestic firm to offer them a lower quality than the imported variety at their reservation price and to extract more surpluses from the high-type through consequent increased quality differentiation and discrimination. Therefore, all such tariffs put a dead-weight loss and lower total surplus.

Given the post-innovation quality choices and market coverage as defined in Lemma 2 above, it is now straightforward to determine the following post-innovation profit levels, denoted by $\pi(IN)$, for the local firm under different tariff levels:

$$\Pi(IN) = \begin{cases} (n_1 + n_2)t_1 + n_2[\alpha_2(q_2^* - q_1^*) - (\bar{c}q_2^{*2} - \bar{c}q_1^{*2})] & \forall\ 0 < t_1 < t_{P1} \\ n_1(\alpha_1\hat{q}_1 - \bar{c}\hat{q}_1^2) + n_2[\alpha_2(q_2^* - q_1^*) - (\bar{c}q_2^{*2} - \bar{c}q_1^{*2}) + t_1] & \forall\ t_{P1} \le t_1 < \hat{t}_1 \\ n_1(\alpha_1\tilde{q}_1 - \bar{c}\tilde{q}_1^2) + n_2[\alpha_2(q_2^* - \tilde{q}_1) + \alpha_1\tilde{q}_1 - \bar{c}q_2^{*2}] & \forall\ t_1 \ge \hat{t}_1 \end{cases} \tag{13}$$

The (absolute) gain from innovation is simply the gain from quality discrimination. With heterogeneous set of consumers, and for (5a), quality discrimination or a separating menu maximizes the home firm's profit. But without innovation, the local firm can only offer a pooling menu. Innovation allows it to discriminate between the two types and, therefore, to extract greater surplus from the high-type. However, competition from foreign producers under non-prohibitive tariff on low-quality imports restricts the ability of the home firm to discriminate to the extent it

would have done under complete protection as indicated by the menu defined in (5). That is feasible only for very high tariff rates.

The innovation decision of the local firm, however, depends on whether the *relative* (gross) gain from innovation, $RG(IN) \equiv \pi(IN) - \pi$, at least covers the (fixed) cost of innovation. Combining (9) and (13) and using the values for the selected quality levels from (5) and (11), the relative (gross) gain from innovation for the local firm, as detailed out in the appendix, equals,

$$RG(IN) = \begin{cases} (n_1 + n_2)t_1 + n_2\left[\alpha_2(q_2 * - q_1 *) - \left(\bar{c}q_2 *^2 - \bar{c}q_1 *^2\right)\right] \quad \forall\ 0 \le t_1 < \tilde{t}_1 \\ n_2 t_1 + n_2\left[\alpha_2(q_2 * - q_1 *) - \left(\bar{c}q_2 *^2 - \bar{c}q_1 *^2\right)\right] - n_1\left[\bar{c}\left(q_1 *^2 - \tilde{q}_1^{\,2}\right) - \alpha_1(q_1 * - \tilde{q}_1)\right] \ \forall\ \tilde{t}_1 \le t_1 < t_{P1} \\ n_1(\alpha_1\hat{q}_1 - \bar{c}\hat{q}_1^2) + n_2[\alpha_2(q_2^* - q_1^*) - (\bar{c}q_2^{*2} - \bar{c}q_1^{*2}) + t_1] - n_1\left[\bar{c}\left(q_1^{*2} - \tilde{q}_1^2\right) - \alpha_1(q_1 * - \tilde{q}_1) + t_1\right] \\ \quad \forall\ t_{P1} \le t_1 < \hat{t}_1 \\ n_1(\alpha_1\tilde{q}_1 - \bar{c}\tilde{q}_1^2) + n_2[\alpha_2(q_2^* - \tilde{q}_1) + \alpha_1\tilde{q}_1 - \bar{c}q_2^{*2}] - (n_1 + n_2)\left[\alpha_1\tilde{q}_1 - \bar{c}\tilde{q}_1^2\right] \quad \forall\ \hat{t}_1 \le t_1 < t_1'' \\ n_1(\alpha_1\tilde{q}_1 - \bar{c}\tilde{q}_1^2) + n_2[\alpha_2(q_2^* - \tilde{q}_1) + \alpha_1\tilde{q}_1 - \bar{c}q_2^{*2}] - n_2\left[\bar{c}\left(q_1^{*2} - \tilde{q}_1^2\right) - \alpha_1(q_1 * - \tilde{q}_1) + t_1\right] \\ \quad \forall \mathrm{t}_1 \ge t_1'' \end{cases}$$

(14)

Thus, except for tariff rates other than $t_1 \in [\hat{t}_1, t'')$, the relative (gross) gain from innovation varies with the tariff rate. More precisely,

Proposition 1: *Given a prohibitive tariff on the high-quality variety, relative gain from quality innovation increases with increased tariff for all* $t_1 \in [0, t_{P1}]$. If $t_1 \in [t_{P1}, \hat{t}_1]$ the relative gain *from quality innovation increases if* $n_2 > n_1$. *For even higher tariffs such that* $t_1 \in [\hat{t}_1, t'']$ *incentives for quality innovation remain invariant with tariff rate and falls only for very high tariff rates i.e.* $\mathrm{t}_1 > t_1''$.

Proof: Can be easily calculated from (14) □

A higher tariff on low quality imports enables the home firm to increase the price of high-quality product along the incentive compatibility constraint of the high-type consumers. It is because of this scope of extracting a greater surplus from the high-type that a higher tariff on low-quality imports increases the gain from quality innovation and consequently the incentive for quality innovation. This relationship is shown in Figure 1 by the kinked curve (see next page):

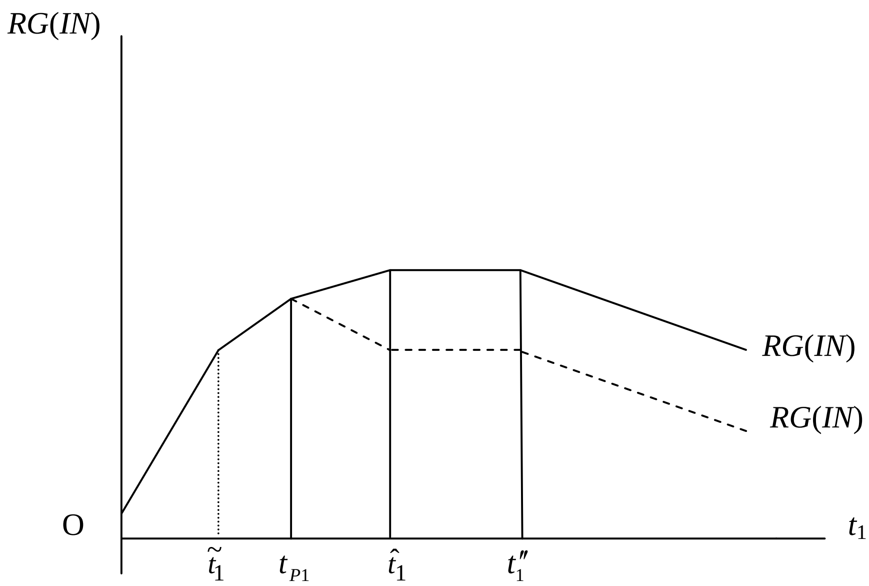

Figure 1: Relative Gain from Quality Innovation

4. Robustness Issues: Non-prohibitive Tariff on High-Quality Imports:

In the earlier section we assumed prohibitive tariff on the high-quality good and examined the innovation incentives with varying low-quality tariff. Now we relax that assumption and generalize our case to non-prohibitive tariff on the high quality product. For such a tariff level, given the tariff-inclusive prices $P_1^d = \bar{c}q_1^{*2} + t_1$ and $P_2^d = \bar{c}q_2^{*2} + t_2$ of the imported qualities q_1^* and q_2^* respectively, the high-type consumers buy q_2^* if ,

$$t_2 - t_1 \le \frac{(\alpha_2 - \alpha_1)^2}{4\bar{c}} \tag{15}$$

Thus, whereas $\forall\ t_2 \le t_1$ this condition is trivially satisfied, $\forall\ t_2 > t_1$ this condition requires that t_2 should not exceed t_1 by more than $\frac{(\alpha_2 - \alpha_1)^2}{4\bar{c}}$. In any case, however, the pre-innovative profit for the local firm remains the same as in case of prohibitively high t_2 discussed above.

To proceed with the post-innovation stage, the following two lemmas would be helpful:

Result 4: There exists a $t_2^* \in (t_{P1}, t_{P2})$ such that the high-type consumers are indifferent between q_2^* at price $\bar{c}q_2^{*2} + t_2^*$ and q_1^* at price $\alpha_1 q_1^*$.

Proof: From the self-selection constraint of the high-type consumers t_2^* must be such that,

$$\alpha_2 q_1^* - \alpha_1 q_1^* = \alpha_2 q_2^* - \bar{c}q_2^{*2} - t_2^*$$

$$\Rightarrow t_2^* = \alpha_2\left(q_2^* - q_1^*\right) + \alpha_1 q_1^* - \bar{c}q_2^{*2} = \alpha_2 q_2^* - \bar{c}q_2^{*2} - (\alpha_2 - \alpha_1)q_1^* > 0 \tag{16}$$

Now, comparing (21) with (7) it is immediate that $t_2^* > t_{P1}$. On the other hand, since $t_{P2} = \alpha_2 q_2^* - \bar{c}q_2^{*2}$ we get $t_2^* < t_{P2}$. □

Result5: For any $t_2 < t_2^*$, there exists a $t_1' < t_{P1}$ such that the high-type consumers buy locally innovated q_2^* at price $P_2(t_1)$, instead of the imported q_2^* at the tariff inclusive price $P_2^d\ \forall\ t_1 < t_1'$.

Proof: For any $t_1 < t_{P1}$, post-innovation the local firm must offer the menu (P_1^d , q_1^*) to the low-type consumers, and to prohibit the high type consumers to mimic the low-type q_2^* must be offered to them at $P_2(t_1)$ such that,

$$P_2(t_1) = \alpha_2\left(q_2^* - q_1^*\right) + \bar{c}q_1^{*2} + t_1 \tag{17}$$

Let t_1' be such that $P_2(t_1')$ = P_2^d . Then by (22),

$$t_1' = t_2 - \frac{(\alpha_2 - \alpha_1)^2}{4\bar{c}} \tag{18}$$

Thus, $P_2(t_1) < P_2^d \; \forall \; t_1 < t_1'$ leaving the high-type consumers with greater net utility if they buy q_2^* from the local firm than from abroad. What remains to be shown is that $t_1' < t_{P1}$. Substitution of values of t_{P1} and t_2^* from (7) and (16) respectively in (18) yields,

$$t_1' = t_{P1} + (t_2^* - t_2) \tag{18a}$$

Hence the claim. □

Note that $t_1' > 0$ only if,

$$t_2 > \frac{(\alpha_2 - \alpha_1)^2}{4\bar{c}} \equiv \bar{t}_2 = t_2^* - t_{P1} \tag{19}$$

Since we are not considering import subsidy ($t_j < 0$) here, so for all $t_2 < \bar{t}_2$, the above result 5 implies that $P_2(t_1) > P_2^d \; \forall \; t_1 > 0$ so that the local firm must offer q_2^* at the price P_2^d for any import *tariff* on low-quality imports. Given the above two results, consider the following two cases:

Case 1: $0 < t_2 \leq t_2^*$

By (19), there are two relevant sub-cases. First consider any $t_2 = t_2^0$ such that $\bar{t}_2 < t_2^0 < t_2^*$. By result 5, the local firm offers the separating menus (P_1^d, q_1^*) and ($P_2(t_1)$, q_2^*). Thus, given any such non-prohibitive tariff on high-quality imports, the relative gross profit from innovation will be $(n_1 + n_2)t_1 + \frac{n_2(\alpha_2 - \alpha_1)^2}{4\bar{c}}$. But $\forall \; t_1 > t_1'$, since $P_2(t_1) > P_2^d$, the local firm must offer the menu $(P_2^d = \bar{c}q_2^{*2} + t_2^0, q_2^*)$ to the high-type, resulting in a relative gross profit equal to $n_1 t_1 + n_2 t_2^{\,0}$. Note, this would be the gain even for all $t_1 > t_{P1} > t_1'$. For such tariffs though the local firm can extract all surplus from the low-type consumers, the non-prohibitive tariff t_2^0 does not allow it to raise prices

above P_2^d. Thus, there will be no incentive for degrading the low-quality below q_1^* as was the case with prohibitively high t_2 (see result 3). Moreover, there will be no *further* gain for the local firm beyond t_{P1} unlike the prohibitive tariff case discussed in section 3.

Now consider any $t_2 = t_2' < \bar{t}_2$. In this sub-case, $\forall\ t_1 < t_{P1}$, the local firm offers the separating menus (P_1^d, q_1^*) and (P_2^d, q_2^*) resulting in a relative profit equal to $n_1 t_1 + n_2 t_2'$. For $\forall\ t_1 > t_{P1}$, the relative gain remains invariant with respect to t_1 at the maximum level $n_1 t_{P1} + n_2 t_2'$. Thus, in both these sub-cases, there will be no quality distortion.

Case 2: $t_2^* < t_2 < t_{P2}$

From (19) it is immediate that in this case $t_2 > \bar{t}_2$ so that, given (18), $t_1' > t_{P1} > 0$. Hence, by result-5, $\forall\ t_1 < t_{P1}$, the local firm will offer the separating menus (P_1^d, q_1^*) and ($P_2(t_1)$, q_2^*) and the relative gross profit will be $(n_1 + n_2)t_1 + \dfrac{n_2(\alpha_2 - \alpha_1)^2}{4\bar{c}}$. But now $\forall\ t_{P1} < t_1 < t_1'$, it would be feasible and profitable for the local firm to degrade the low quality offered to the low-type consumers below q_1^* and correspondingly raising the price for q_2^* offered to the high-type consumers to extract more surplus from them. The rate of such degradation will be the same as that specified in (11).

The results derived in the above two cases are summarized in the following proposition:

Proposition 2:

(a) ***For all non-prohibitive tariffs on high-quality imports*** $t_2 \in [0, t_2^*]$**,**

- **(i)** ***there will be no quality distortion regardless of the level of*** t_1**.**
- **(ii)** ***the relative gross profit from quality innovation will be increasing in*** $t_1\ \forall\ t_1 > t_{P1}$ ***but will remain invariant thereafter.***

***(iii) the rate of increase in profit with respect to increase in** t_1 **depends on** t_2.*

For $t_2 < \bar{t}_2$ ***, the relative profit increases at the rate*** $n_1 \; \forall \; t_1 < t_{P1}$**. For** $t_2 > \bar{t}_2$ ***, the relative profit increases at the rate*** $(n_1 + n_2) \; \forall \; 0 < t_1 < t_1'$ ***and at the rate*** $n_1 \; \forall \; t_1' < t_1 < t_{P1}$

(b) ***For all non-prohibitive tariffs on high-quality imports such that*** $t_2^* < t_2 < t_{P2}$**, there will be quality distortion at the bottom** $\forall \; t_{P1} < t_1 < t_1'$**.**

Proof: Follows from the above discussion. □

Therefore, non-prohibitive tariff on high-quality imports does not qualitatively change the relationship between tariff on low-quality imports and the innovation incentive. The only significant difference between the prohibitive and non-prohibitive tariff on high-quality imports is that in the latter case for sufficiently small non-prohibitive tariff $t_2 < t_2^*$, there will be no quality distortion regardless of the level of t_1.

Given the above theory we now explore with the help of some data whether trade liberalization does affect innovative activity (or quality innovation).

5. Data:

We in this section make an attempt to find out whether trade liberalization has some impact on quality innovation or generally on the overall research and development scenario of a country. Getting data on quality innovation is difficult. Therefore as a proxy we took data on national expenditure on research and development in India from 1950- 2010 at 2004-2005 prices. This data was collected from the Department of Science and Technology, Government of India, The Planning Commission and the UNESCO Statistical Yearbook. Since some fraction of research and development in an economy is on quality upgradation we conjecture that expenditure on R&D and expenditure on quality upgradation should logically move in the same direction. Therefore one can

make rational conjectures about the movement of expenditure on quality innovation from total R&D expenditure as well. We also collected data on real GDP at 2004-2005 prices from the Indian Planning Commission website which will act as a possible control for total expenditure on R&D. We would like to examine if there is any significant increase or decrease in R&D expenditure around 1992 which will imply that we do get some evidence about liberalization having some impact on the R&D expenditure (in our case India).

But prior to that since the data that we have is in nature a time series, it is instructive that we check the stationarity of both the R&D and GDP series. So to do that we conduct the Augmented Dickey-Fuller test on both the GDP and R&D series for various lags and we found that the test statistic lies outside the acceptance region of Mackinnon approximate p-value and the 5% critical values and therefore we can reject the null hypothesis that the series has a unit root and therefore both the series are stationary. The results of the Augmented Dickey-Fuller test are given in table-1 (and 1a) for the GDP series and table-2 (and 2a) for the R&D series (See Appendix). Given that both the series are fortunately stationary we can proceed with further analysis. Next we check whether the R&D and the GDP variables are co-integrated, i.e. whether they share a stochastic trend and after conducting the EG-ADF test we find that the both the series are not co-integrated.

5.1 The Dummy Variable approach:

Given above we can proceed with testing for any possible structural break around 1992 and for this we follow the simple dummy variable OLS regression approach to examine whether liberalization had some impact on the overall research and development expenditure in India. For this we construct a liberalization dummy which takes value 1 post 1991 i.e. from 1992 onwards and zero otherwise. We estimate two different regression equations. In one we take the current GDP as the

control variable whereas in the other we take the one period lagged GDP as the control variable. Therefore the first regression model we estimate is

$$R\,\&\,D = \beta_1 + \beta_2 GDP + \beta_3 Dum + u$$

The results are given in table-3. But the estimates of this regression are not reliable since we found that the contemporaneous errors are highly correlated and therefore the regression is plagued by autocorrelation. To correct this we run the Cochrane-Orcutt regression and we get the autocorrelation-corrected estimates given in table 3A. We see that the liberalization dummy is insignificant pointing to the fact that liberalization has hardly any impact on research and development expenditure in India. The current GDP is highly positively significant in explaining the variation in research and development expenditure in India.

There is also a perception that R&D expenditure in this period is more likely to get affected by the GDP in the last period. Therefore as a robustness check we run a second regression where we drop GDP a control variable and take the one period lagged GDP as the control variable. Therefore the second set of regression we estimate is

$$R\,\&\,D = \beta_1 + \beta_2 GDP_{-1} + \beta_3 Dum + u$$

The result of this regression is given in table-4. Again as expected this regression is also affected by autocorrelation and as a remedy we run the Cochrane-Orcutt regression and the results of this regression is given in table 4A. Again the liberalization dummy turns out to be insignificant. The lagged GDP positively affects R&D expenditure of this period and is significant at the 1% level.

Therefore we do not find any evidence of liberalization positively or negatively affecting research and development activity at least in Indian data. This contradicts both the Schumpeterian and Arrowvian conjecture that liberalization negative or positively affects research and development activity in an economy. The level of GDP (current and/or one period lagged) of an economy seems

to positively affect the level of research and development expenditure in an economy. This result is not surprising since there is enough evidence that richer countries spend more on innovations and our result merely reinstates that. Next, as robustness check of the previous finding we also conduct the chow test for known structural break.

5.2 The Chow test:

To check the robustness of the above finding we conduct the chow test to find any possible structural breaks in research and development expenditure in India around 1992. For that we run the following regression with interaction terms of dummy and lagged R&D expenditure and dummy and lagged GDP:

$$R\,\&\,D = \beta_1 + \beta_2 GDP_{-1} + \beta_3 RD_{-1} + \beta_4 Dum * GDP_{-1} + \beta_5 Dum * RD_{-1} + u$$

Then as a final step we conduct an F-test on the coefficients for the interactions and the dummy. Results of the previous regression and the F test are given in table-5. We get the F statistic to be insignificant and therefore we cannot the reject the null hypothesis of no structural breaks. Therefore we again do not get any evidence that liberalization had some influence on research and development expenditure in India.

5.3 Comparing India with other countries:

In this subsection we compare India with some other developed and developing counties in terms of their performance with respect to quality-upgradation or innovation. As a proxy to quality upgradation we use the data on the high technology exports as a percentage of total manufacturing exports (which we conjecture is positively related to quality innovation or upgradation) from the World Development Indicators dataset. We collect data for India, USA, UK, Germany, Japan,

China, Singapore and Brazil. Unfortunately data for most of the countries is provided from 1988 to 2013 and therefore a proper econometric analysis will hardly make any sense. But a comparison is possible and in Figure-1 we do just that. What we see is that India along with Brazil is not doing that well and whereas Singapore’s proportion of high technology exports in total manufacturing exports exceeds almost all countries. The developed counties are performing much better as expected with UK showing sharp decline towards the level of where India is currently. But focusing on India liberalization doesn’t seem to have any significant impact as we do not see any perceptible change around 1992 onwards which supports our fining in the last section. In addition to this, to have a complete picture, we compare the above countries in terms of the level of high-technology exports in US Dollars and that is given in Figure-2. The level of high technology exports for India and Brazil is the least among the selected countries whereas the increase for China is phenomenal. The other developed counties are as expected in between with UK showing a slump in the level of high-technology exports. As usual we do not see much movement in the high technology exports around 1991-92 which is in line with our econometric finding stated earlier.

5.4 Comparing India with Bangladesh:

We in this final section compare India and Bangladesh in terms of their performance with regard to quality upgradation using the same world development indicators data mentioned above. Figure-3 compares the high technology exports as a percentage of total manufacturing exports for both India and Bangladesh. We see that on an average the percentage of high-technology exports has increased for India with some fluctuations but unfortunately has remained stagnant for Bangladesh. We also have data on patent applications by residents from 1960-2013 for India and 1974-2013 for Bangladesh. Figure-4 compares the patent applications by residents for India and Bangladesh. Here

also we get the same trend that whereas the number of patent applications for new innovations has increased in India after 1994 and a sharp rise from 2000-2002 onwards, the number of patent applications from Bangladesh has remained stagnant pointing towards a stagnating innovation environment in that country. Therefore one can conjecture that whereas some innovation has taken place in India with an increasing trend during this period but we do not see much evidence of increased innovative activity for Bangladesh.

6. Conclusion and policy prescription:

In this paper we theoretically and empirically examine whether trade liberalization affects overall innovative activity (including quality innovation) in an economy. We start by constructing a theoretical model. In a market for quality differentiated good protected by a differential tariff regime, we show that for lower tariff levels on the low-quality product, increased protection leads to increased quality incentive for quality innovation. But for sufficiently high tariff levels on the low-quality product we find that increased tariff leads to decreased incentive for quality innovation. For lower tariff levels this private gain from quality innovation arises from the scope of quality discrimination among a heterogeneous set of consumers. But with competitive producers abroad, such a scope is limited by the level of tariff protection. Higher is the level of tariff, therefore, the larger is the gain from quality innovation. But for high tariff levels the potential gain from quality discrimination dries off leading to a decreased net gain from quality innovation. This result in essence is robust both for prohibitive and non-prohibitive tariff levels on the high-quality good. But empirically we do not find any evidence of liberalization affecting the overall research and development expenditure in India either positively or negatively. Also from the world development indicators data we compare India with various leading developed and developing countries and find

that the quality innovation scenario in India is far from satisfactory even compared to other major developing economies like China and Brazil. Moreover we do not find any evidence of an increased level of high-technology exports in the post liberalization period. Thus tinkering with economic variables might not have the desired effect that we often expect. Therefore from a policy perspective it might be desirable to provide direct incentives to firms (in terms of tax holidays or otherwise) on investments in R&D and that might have the desired effect in increasing R&D activity in an economy.

From a theoretical perspective we can extend out model to any $k > 2$ types without any qualitative changes in the results derived here. However if we assume continuous distribution, that might alter some of our results. With the possibility of market not being fully covered in such a case, changes in the tariff rates will produce a demand or a market-covering effect. This might alter some of our results and it will be interesting to analyze how the incentive for quality upgradation changes with varying tariff on the low-quality product.

Empirically one can think of taking an industry specific data and examine whether trade liberalization in fact led to quality innovation or not. But for that we need sufficient data both in the pre and post reform period in India which is difficult to get. The CMIE prowess dataset has some R&D data but mostly in the post liberalization period. Therefore meaningful econometric comparison is difficult. This paper deals with the issue at the aggregated level and draws some conclusion out of it. But a more industry specific micro study if possible might throw some light on different variables that affect the relationship between trade liberalization and R&D. These constitute some of our future research agenda.

Appendix:

Proof of Result-3:

For all non-prohibitive tariff rates, given (10a) and (10b) maximization of profit

$$\pi(t) = n_1[p_1(t_1) - \bar{c}{q_1^I}^2] + n_2[p_2(t_1) - \bar{c}{q_2^I}^2] \text{ yields } q_1^I = q_1^*,\ q_2^I = \tilde{q}_2 = q_2^*.$$

The prohibitive and higher tariff rates allow the local firm to offer any menu $(\alpha_1\hat{q}_1, \hat{q}_1)$ along the individual rationality constraint of the low-type and extract the entire surplus. Suppose $\hat{q}_2$ be the quality offered to the high-type consumers for all such tariffs. We show that $\hat{q}_2 = q_2^*$ but $\hat{q}_1 < q_1^*$. But suppose on the contrary that the menu $(\alpha_1 q_1^*, q_1^*)$ is offered to the low-type and let $(P_2(q_1^*), \hat{q}_2)$ be the corresponding incentive-compatible menu for the high-type consumers. Thus,

$$P_2(q_1^*) = \alpha_2(\hat{q}_2 - q_1^*) + \alpha_1 q_1^*$$

On the other hand, the high-type consumers do not buy the imported quality q_1^* if

$$p_2 < P_2(t_1) = \alpha_2\left(\hat{q}_2 - q_1^*\right) + \bar{c}{q_1^*}^2 + t_1.$$

Subtracting $P_2(t_1)$ from both sides yields,

$$P_2(q_1^*) - P_2(t_1) = \alpha_1 q_1^* - \bar{c}q_1^* - t_1$$

Thus, $P_2(q_1^*) < P_2(t_1)\ \forall\ t_1 > t_{P1} = \alpha_1 q_1^* - c{q_1^*}^2$. Since for any given quality q_2, profit is rising in p_2, so the local firm can earn higher profit by charging the price $P_2(t_1)$ instead of $P_2(q_1^*)$. But this is not feasible as long as the menu $(\alpha_1 q_1^*, q_1^*)$ is offered to the low-type, because in such a case for any $p_2 > P_2(q_1^*)$ the high-type would mimic the low-type. Thus, to charge the higher price $P_2(t_1)$, the local firm must offer a menu $(\alpha_1\hat{q}_1, \hat{q}_1)$ that leaves the high-types with the same surplus as the menu $(P_2(t_1), \hat{q}_2)$. Hence,

$$\alpha_2\hat{q}_1 - \alpha_1\hat{q}_1 = \alpha_2\hat{q}_2 - \alpha_2\left(\hat{q}_2 - q_1^*\right) - \bar{c}q_1^{*2} - t_1$$

$$\Rightarrow \hat{q}_1 = q_1^* - \frac{\left(t_1 - t_{P1}\right)}{\left(\alpha_2 - \alpha_1\right)} \tag{12}$$

Thus, for $t_1 = t_{P1}$, $\hat{q}_1 = q_1^*$. For higher tariff rates, substitution of the value of t_{P1} yields,

$$\hat{q}_1 = \frac{\alpha_1(2\alpha_2 - \alpha_1) - 4ct_1}{4c(\alpha_2 - \alpha_1)} \tag{12a}$$

The quality offered to the low-type is degraded more and more as the tariff rate rises above the prohibitive rate. For $t_1 = \hat{t}_1$ as defined in (8), $\hat{q}_1 = \tilde{q}_1$. Given $\hat{q}_1$ as defined in (12a) for any $\hat{q}_2$, the profit of the local firm equals,

$$\pi = n_1\left[\alpha_1\hat{q}_1 - c\hat{q}_1^2\right] + n_2\left[P_2(t_1) - \bar{c}\hat{q}_2^2\right]$$

Substitution of $P_2(t_1) = \alpha_2\left(\hat{q}_2 - q_1^*\right) + \bar{c}q_1^{*2} + t_1$ and maximization of profit *for any given* t_1 yields, $\hat{q}_2 = \frac{\alpha_2}{2\bar{c}} = q_2^*$. Finally, since under a separating menu, the local firm's profit is maximized only for $q_1 = \tilde{q}_1$ and $q_2 = \tilde{q}_2 = q_2^*$, there will be no further downgrading of the low quality for tariff rates higher than $\hat{t}_1$. Hence proved. □

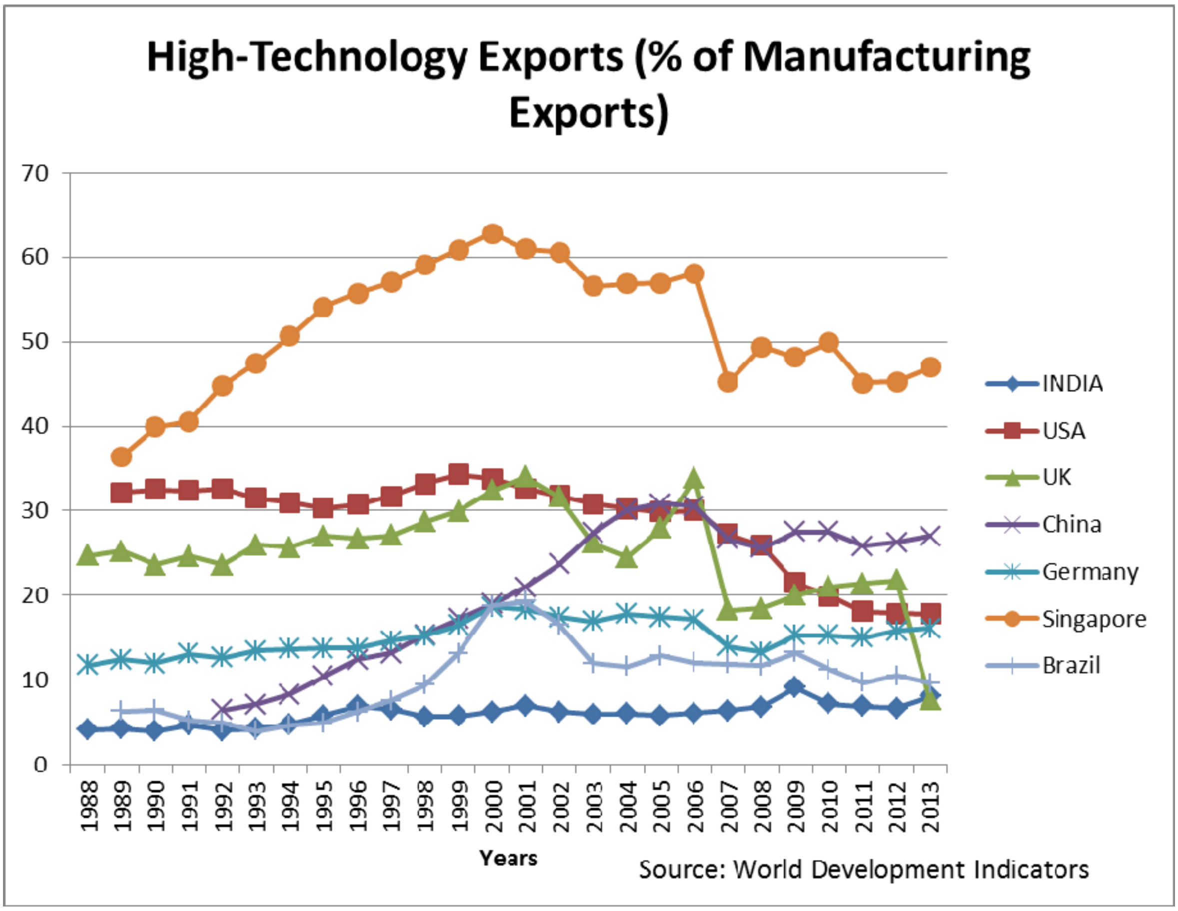
High-Technology Exports (% of Manufacturing Exports)
70
60
50
40
30
20
10
0
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Years
INDIA
USA
UK
China
Germany
Singapore
Brazil
Source: World Development Indicators

Figure-1

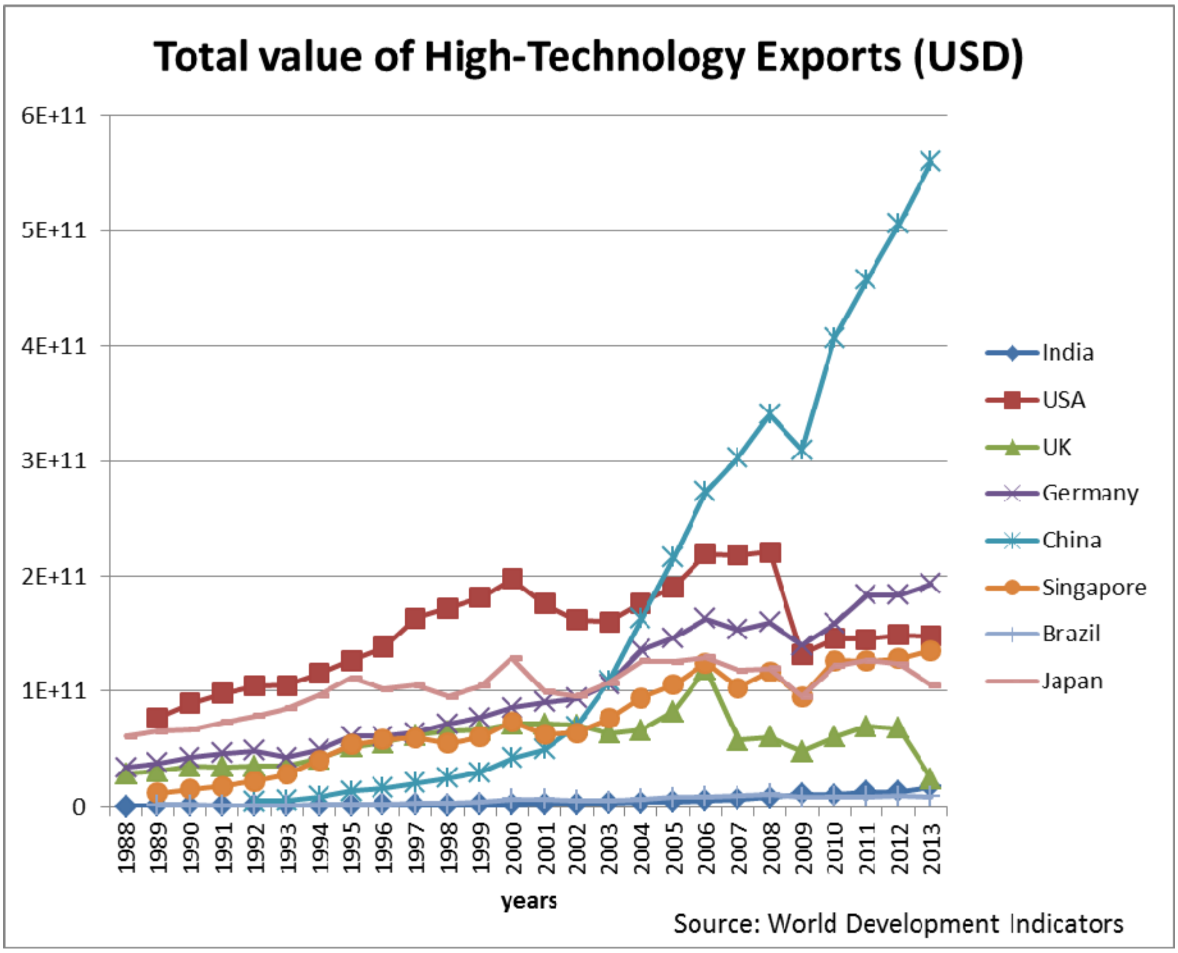
Total value of High-Technology Exports (USD)
6E+11
5E+11
4E+11
3E+11
2E+11
1E+11
0
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
years
India
USA
UK
Germany
China
Singapore
Brazil
Japan
Source: World Development Indicators

Figure-2

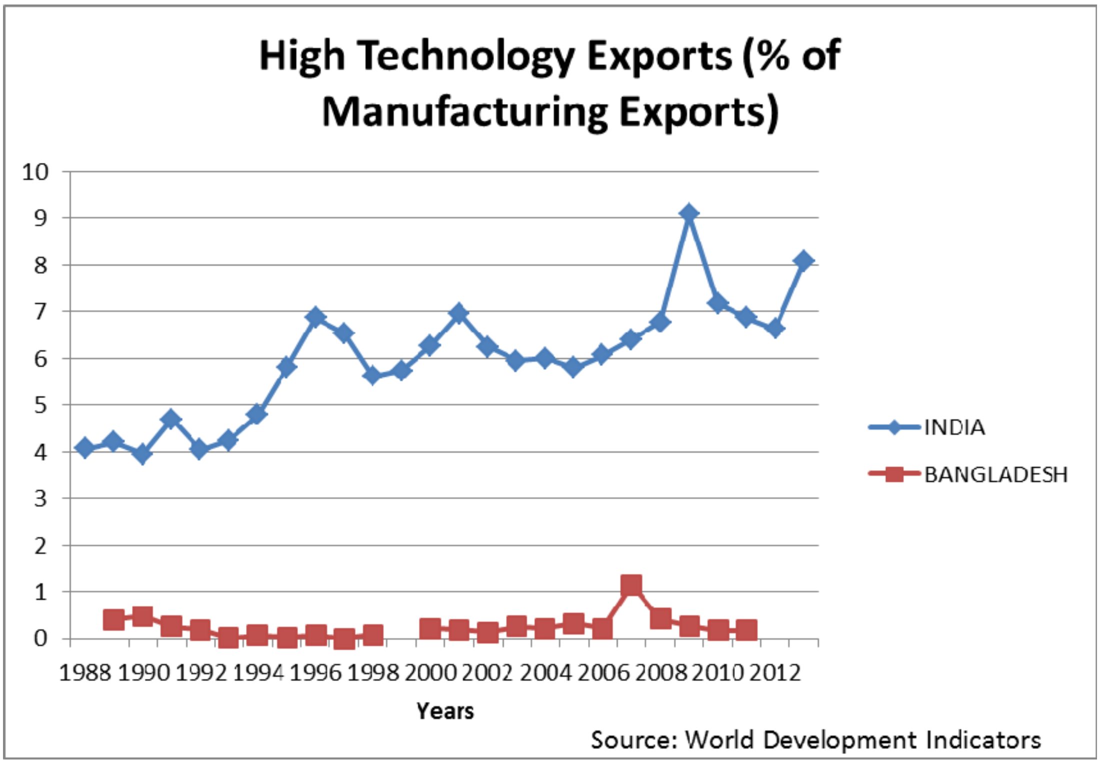

Figure-3

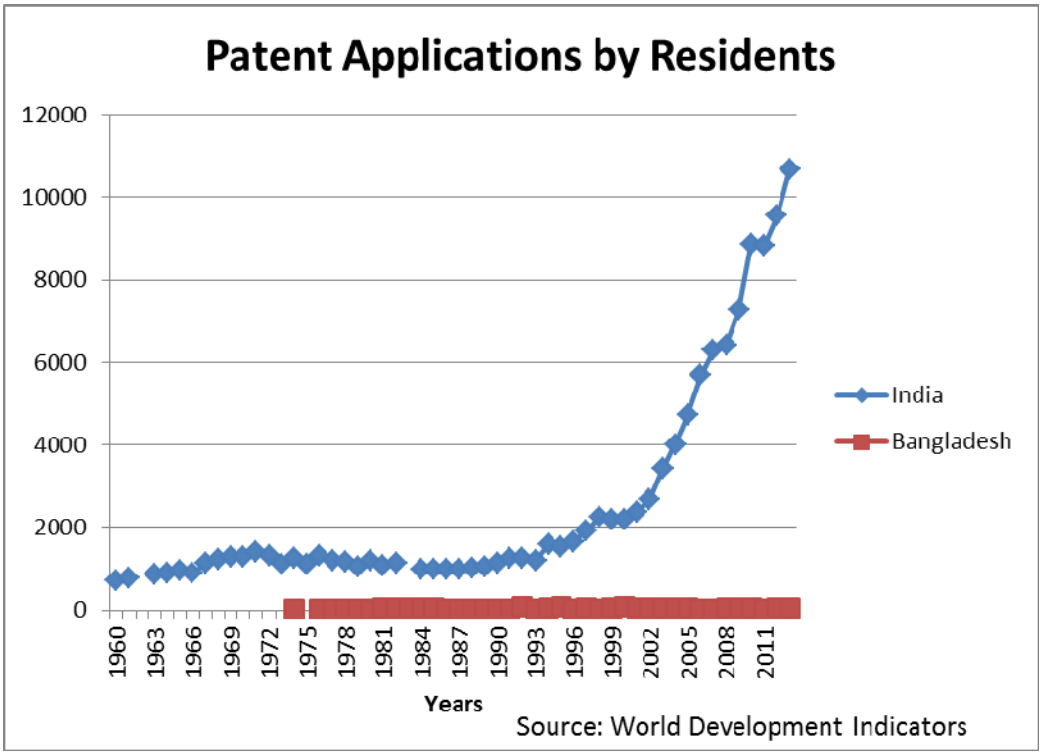

Figure-4

Augmented Dickey-Fuller results for GDP

Augmented Dickey-Fuller test for unit root GDP with Lag 0

Number of observations = 60

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	14.915	-4.128	-3.490	-3.174

MacKinnon approximate p-value for Z(t) = 1.0000

Table-1

Augmented Dickey-Fuller test for unit root GDP with Lag 5

Number of observations = 60

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	4.305	-4.139	-3.495	-3.177

MacKinnon approximate p-value for Z(t) = 1.0000

Table 1a

Augmented Dickey-Fuller results for R&D

Augmented Dickey-Fuller test for unit root GDP with Lag 0

Number of observations = 60

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	4.666	-4.128	-3.490	-3.174

MacKinnon approximate p-value for Z(t) = 1.0000

Table-2

Augmented Dickey-Fuller test for unit root GDP with Lag 5

Number of observations = 60

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	2.475	-4.139	-3.495	-3.177

MacKinnon approximate p-value for Z(t) = 1.0000

Table 2a

Table-3

Dependent Variable: R&D

Independent Variables	Coefficient	Std. Error	t-statistic	p-Value
GDP	0091454	.0001714	53.34	0.000***
Lib Dummy	-778.2467	425.0136	-1.83	0.072*
Constant	2706.804	171.2216	-15.81	0.000***

No. of observations: 61
F (2, 58) = 4522.98
Prob.> F = 0.0000
R^2 = 0.9936
Adjusted R^2 = 0.9934
Durbin-Watson statistic 0.353386

Table-3A

Cochrane-Orcutt Regression (Autocorrelation corrected)

Dependent Variable: R&D

Independent Variables	Coefficient	Std. Error	t-statistic	p-Value
GDP	.0080524	.0003998	20.14	0.000***
Lib Dummy	-323.5268	472.9116	-0.68	0.497
Constant	-906.551	1537.716	-0.59	0.558

No. of observations: 60
F (2, 58) = 206.13
Prob.> F = 0.0000
R^2 = 0.8785
Adjusted R^2 = 0.8743
Durbin-Watson statistic (original) 0.353386
Durbin-Watson statistic (transformed) 1.387978

Table-4

Dependent Variable: R&D

Independent Variables	Coefficient	Std. Error	t-statistic	p-Value
Lagged GDP	.0100183	.0001919	52.21	0.000***
Lib Dummy	-971.208	436.2135	-2.23	0.030**
Constant	-3027.737	180.9255	-16.73	0.000***

No. of observations: 60
F (2, 58) = 4302.25
Prob. > F = 0.0000
R^2 = 0.9934
Adjusted R^2 = 0.9932
Durbin-Watson statistic 0.390554

Table-4A

Cochrane-Orcutt Regression (Autocorrelation corrected)

Dependent Variable: R&D

Independent Variables	Coefficient	Std. Error	t-statistic	p-Value
Lagged GDP	.009033	.0003563	25.36	0.000***
Lib Dummy	130.0685	488.0574	0.27	0.791
Constant	-2097.79	907.9921	-2.31	0.025**

No. of observations: 59
F (2, 58) = 346.99
Prob. > F = 0.0000
R^2 = 0.9253
Adjusted R^2 = 0.9227
Durbin-Watson statistic (original) 0.390554
Durbin-Watson statistic (transformed) 1.160799

Chow-test Results:

Table-5

Dependent Variable: R&D

Independent Variables	Coefficient	Std. Error	t-statistic	p-Value
Lagged R&D	1.006614	.1232439	8.17	0.000
Lagged GDP	.0003828	.0013583	0.28	0.779
Lib Dummy	-760.6939	795.6446	-0.96	0.343
Dummy*Lagged R&D	-.1929113	.2066979	-0.93	0.355
Dummy*Lagged GDP	.0019827	.0020333	0.98	0.334
Constant	-21.91903	501.2112	-0.04	0.965

No. of observations: 60
F (2, 58) = 5178.02
Prob. > F = 0.0000
R^2 = 0.9979
Adjusted R^2 = 0.9977

F test on Dummy and the Interaction terms:

Result of the F-test:

(1) Dum = 0
(2) Dum_GDPL1 = 0
(3) Dum_RDL1 = 0

F (3, 54) = 0.33
Prob > F = 0.8050

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