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Abstract

This paper examines whether integration of national markets fosters innovation in the technologically inferior country. In a simple set up where a technologically backward home firm and a technologically advanced foreign firm compete in qualities and prices in an integrated market, we find that the outcome depends on the speed of response of the two firms and their initial technological distance. If the domestic firm is not too far behind the foreign firm to begin with, and if it responds faster, then the technological gap may get reversed. Further, we find that integration may be welfare improving for both the countries. There are, however, distributional implications. While the consumers always gain from such integration, the firms may not.

Key words: Innovation; Technological Gap; Market Integration; Quality Competition.

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1 Introduction

In this paper we examine the effects of integration of national markets on the technological level of countries. We contend that integration creates technological opportunities for both countries, and the outcome depends on which country manages to grab these opportunities. While this idea seems to crop up in the popular debate quite frequently, it has not been been formalized theoretically. In this paper we provide a very simple model that can capture this idea.

In countless debates on costs and benefits of globalization and trade liberalization, one important benefit for the developing countries that has often been perceived is that they provide impetus to the technologically backward producers to innovate and enhance product qualities[1]. That trade protection had made Indian firms inward looking and therefore non-innovative during the 1970s and 1980s has been strongly argued by Desai (1980) and Lall (1989). Porter (1990) and White (1974) also had observed that too much market power for the domestic firms is not conducive for innovation. These arguments share the same Darwinian view that product market competition forces firms to innovate in order to survive. Segerstrom et. al. (1990) have provided theoretical basis of such an argument in a dynamic general equilibrium model of North-South trade: Northern tariffs on Southern exports lower the pace of innovation in the North.

But this is not an unchallenged position or self-enforcing proposition, both theoretically and empirically. This is evident from differences in opinion within the EEC during the mid 1980s regarding appropriate trade policy to induce technologically backward domestic industries to innovate. The German view was that the domestic producers should be exposed to international competition, whereas the French supported the idea of protection till such time the domestic industries close their technology gap [Pearce and Sutton (1986)]. Of late, in a case study of 1246 Turkish manufacturing firms, Pomukcu (2000) does not find any impact of competition in domestic market coming from imports on innovation decisions of firms during 1989-93. On the other hand, contrary to adverse impact of trade protection on innovation decision, Rodrik (1992) has demonstrated that tariff protection fosters innovation and prepones technological catch-up similar in spirit of the Schum-

[1] Quality problems in developing countries are, of course, not just technological. Asymmetric information and associated problems of moral hazard and adverse selection, on the one hand, and reputation problem in contestable nature of markets in the developing countries, on the other hand, are also equally important factors underlying such a problem [Chiang and Masson (1988), Donnenfeld and Mayer (1989), Shapiro (1984), Rashid (1988)].

peterian idea that monopoly power and innovation are positively related. Similar positive effect of tariff on domestic innovation has been observed by Reitzes (1991) in a two-stage Cournot game.

These theoretical arguments have been further supplemented by two results established more recently in the context of an erstwhile protected monopolistic market. First, a reduction of tariff on low-quality imports lowers the incentive for a domestic monopolist to develop the high-quality variety through R&D [Acharyya and Bandyopadhyay (2003)]. Second, lowering of tariff on imported inputs necessary for production of high-quality varieties does not always induce domestic firms to enhance product quality through innovation of complementary inputs [Bandyopadhyay and Acharyya (2004)].

To resolve the debate over the implication of trade liberalization and market integration on the innovation decision of the firms, we take an altogether different approach in this paper. We first endogenize the pre-integration technological limits (and asymmetry) of monopolistic firms in the two countries through their choices of optimal innovation levels in separate national markets[2]. Such innovation levels are determined by the size of the respective national markets and the willingness-to-pay of the *domestic* citizens. Given such endogenously determined technological asymmetry of firms, we then examine their incentives for further innovation under the threat of quality and price competition when the national markets are integrated. Integrating the two national markets creates technological opportunities for both the firms, but which one of the firms manage to take advantage of this opportunity depends on the response speed of the two firms, and their pre-integration quality levels. If the initial quality level of the home-country firm is too low to begin with, then it can never take advantage of these new opportunities. But, if the domestic firm is not too far behind to begin with, then the outcome depends on the relative speed of response[3]. If the foreign firm responds faster (i.e. it is the first mover in the R&D stage), then the technological gap between the two firms widens, and the foreign firm grabs the benefits. If, however, the domestic firm is responds faster (i.e. the first mover in the R&D phase), then the technological gap may get reversed, so that the domestic firm may grab the technological lead.

Further, we find that integration is welfare improving for both the coun-

[2]The analysis that comes closest to ours in this regard is that of Clemenz (1990), who, however, does not consider heterogenous consumer set in the two countries.

[3]There are some comparable results in New Growth Theory at least in respect of initial conditions as the driving force of the pace of innovation. Grossman and Helpman (1991) and Devereux and Lapham (1994), for example, show that if there are only national knowledge spill-overs, innovation fades away in a country which is identical to another country in all respects, but starts off with a smaller number of innovative goods.

tries. There are, however, distributional implications. While the consumers always gain from such integration, the firms may, or may not. Whether a firm gains or not depends on the pre-integration technological distance between the two countries, as well as the response speed of the two firms to the integration. If either the domestic firm is too far back technologically, or is slow to respond, then the foreign firm gains, whereas the domestic firm loses. Otherwise, it is the domestic firm that gains, whereas the foreign firm loses.

The rest of the paper is organized as follows. In section 2 we set out the assumptions and the basic framework. Choice of initial technology limits in separate national markets is discussed thereafter. Section 3.1 analyzes quality and price competition between technologically asymmetric home and foreign firms in an integrated market. Iincentives for further innovation are examined in section 3.2. Section 4 discusses the gains from market integration in terms of the standard measure of national welfare. Finally, we conclude the paper in section 5.

2 Innovation in Separate Markets

2.1 The Economic Environment

To begin with, consider two separated markets in two countries - home and foreign. Each market is monopolized by a single native firm. A good X with variable and observable quality, indexed by q, is offered by the monopolists in each of these markets.

The decision-making in both the markets follows a two stage process. First, through R&D, the firms develop a range of feasible qualities. This range of feasible qualities developed in the first stage, essentially puts technological limits to the choice of quality in the second stage. Second, both the firms select a quality (from its feasible range) and a corresponding price to maximize its profits in its own market.

We consider a very simple structure of R&D, where innovation is assumed to be certain. Consider some firm with an existing range of feasible quality $[0, q]$ (where q could be 0), and let $[0, \widetilde{q}]$, denote the planned range of feasible quality, where $\widetilde{q} > q$. For increasing the maximal level of feasible quality from q to $\widetilde{q}$, the firm has to incur an R&D cost of $F.(\widetilde{q} - q)$, that is assumed to be the same for both the firms. Moreover, production costs are assumed to be zero.

The number of consumers in the home and the foreign country are n and n^* respectively. The preference structures of the home and the foreign consumers are specified as follows. Each consumer buys, if at all, only one unit of the good. Let $u(\alpha, q)$ denote the utility that a consumer with taste parameter α derives from consuming one unit of a good of quality q. Then

$$u_q(\alpha, q) > 0,\ u_\alpha(\alpha, q) > 0,\ u_{qq}(\alpha, q) < 0, \text{ and } u_{q\alpha}(\alpha, q) > 0,\ \forall q > 0. \quad (1)$$

In case a consumer does not consume anything, her reservation utility is zero.

We assume that foreign consumers have a higher total, as well as marginal willingness-to-pay, for any quality compared to the home consumers. This difference may reflect cross-country income differences, as well as taste diversity. This is formalized by assuming that the taste parameter of the foreign consumers $\alpha^* > \alpha$, the taste parameter of the home consumers. Thus, from (1), these preferences satisfy the following properties:

$$u(\alpha^*, q) > u(\alpha, q) > 0, \text{ and } u_q(\alpha^*, q) > u_q(\alpha, q) > 0,\ \forall q > 0. \quad (2)$$

We shall generally use the superscript $*$ to denote the foreign market.

Note that our specification of the preference structure follows the standard literature on quality choice, e.g. Mussa and Rosen (1978), Gabszewicz and Thisse (1979), and Shaked and Sutton (1982).

We then solve the model through backwards induction.

2.2 Quality Choices in Separated Markets

Let the innovated range of feasible qualities in the home market be $[0, \tilde{q}]$, and that in the foreign market be $[0, \tilde{q}^*]$. Further, let the optimal price-quality menu in the home market be denoted by $(p(\tilde{q}), q(\tilde{q}))$, and that in the foreign market be denoted by $(p^*(\tilde{q}^*), q^*(\tilde{q}^*))$.

We first consider the home market. A representative home consumer accepts any price-quality menu (p, q) that is individually rational, i.e. provided she has at least her reservation level of utility

$$u(\alpha, q) - p \geq 0. \quad (3)$$

The standard tie-breaking rule is adopted here, i.e., in case a consumer is indifferent between buying the good and not buying it, she buys the good.

Next consider the price-quality decision of the monopolist. Optimally, given q, the monopolist will push consumers to their reservation utility by charging $p = u(\alpha, q)$. Hence, given that there are no production costs, the monopolist's profit is given by

$$nu(\alpha, q). \quad (4)$$

Since, $\forall q$, $u_q(\alpha, q) > 0$, it follows that the home firm will offer the technologically feasible topmost quality, i.e. $q(\tilde{q}) = \tilde{q}$ and charge the corresponding price $p(\tilde{q}) = u(\alpha, \tilde{q})$. Of course, selecting the topmost quality follows from the assumption of zero production cost. Thus the consumers' surplus is zero, and the profit, as well as welfare equals $nu(\alpha, \tilde{q})$.

Arguing similarly, the profit-maximizing quality choice in the foreign market is given by $q^*(\tilde{q}^*) = \tilde{q}^*$ and

$$p^*(\tilde{q}^*) = u(\alpha^*, \tilde{q}^*). \tag{5}$$

Thus the consumers' surplus is zero, and the profit, as well as welfare equals $n^* u(\alpha^*, \tilde{q}^*)$.

Figure 1 illustrates the qualities offered to representative home and foreign consumers in the two markets for any $\tilde{q}^* > \tilde{q}$, innovated in the first stage. Note that in the separate national markets, the foreign firm is not bound to choose its menu along the self-selection (or incentive compatible) constraint $s^* s^*$ for the high-type foreign consumers. Post-integration, however, the firms must take into account such a constraint, otherwise the high-type (foreign) consumers will mimic the low-type (home) consumers.

2.3 Innovation Levels and Technological Asymmetry

We now solve for the R&D decision of the two firms. We assume that, in the absence of any R&D, the firms produce a quality level of zero. Thus, given the analysis in the preceding sub-section, the home firm's problem in stage 1 simplifies to:

$$\max_{\tilde{q}} \; nu(\alpha, \tilde{q}) - F\tilde{q}, \tag{6}$$

and that of the foreign firm is:

$$\max_{\tilde{q}^*} \; n^* u(\alpha^*, \tilde{q}^*) - F\tilde{q}^*. \tag{7}$$

Thus, the home firm develops a quality range $[0, \overline{q}]$ such that $\overline{q}$ satisfies the following first-order condition (since, $\forall q > 0$, $u_{qq} < 0$, the second order condition is satisfied):

$$u_q(\alpha, \overline{q}) = \frac{F}{n}. \tag{8}$$

From our earlier analysis, the home firm offers the price quality menu $(p(\overline{q}), q(\overline{q}))$, where $p(\overline{q}) = u(\alpha, \overline{q})$ and $q(\overline{q}) = \overline{q}$, and reaps a *net* profit equal to,

$$\pi(\overline{q}) = nu(\alpha, \overline{q}) - F\overline{q}. \tag{9}$$

Note that the choice of the technological range, $\overline{q}$, and hence the price-quality menu depends on, n, F, as well as the taste parameter. The choice of innovation level in the home market is illustrated in Figure 2.

Similarly, the foreign firm develops a quality range $[0, \overline{q}^*]$ such that

$$u_q(\alpha^*, \overline{q}^*) = \frac{F}{n^*}. \tag{10}$$

Hence, from our earlier analysis, the foreign firm offers the price quality menu $(p^*(\overline{q}^*), q^*(\overline{q}^*))$, where $p^*(\overline{q}^*) = u(\alpha^*, \overline{q}^*)$ and $q^*(\overline{q}^*) = \overline{q}^*$, and obtains a net profit equal to

$$\pi^*(\overline{q}^*) = n^* u(\alpha^*, \overline{q}^*) - F\overline{q}^*. \tag{11}$$

The following lemma provides some comparative statics results on the relationship between the innovation level in a market and certain aspects of this market, namely its size and the taste parameter.

Lemma 1. *The innovation level in either market will be larger if the market size increases, or if the consumers' preference for the good increases.*

Proof. Consider the home market. From (1) and (8) it follows that

$$\frac{\partial \overline{q}}{\partial n} = -\frac{F}{n^2 u_{qq}(\alpha, \overline{q})} > 0, \tag{12}$$

$$\text{and,} \quad \frac{\partial \overline{q}}{\partial \alpha} = -\frac{u_{q\alpha}(\alpha, \overline{q})}{u_{qq}(\alpha, \overline{q})} > 0. \tag{13}$$

A similar argument goes through for the foreign market. ■

Proposition 1 below characterizes the equilibrium outcomes in the two markets and also compares the equilibrium quality levels, $\overline{q}$ and $\overline{q}^*$. Comparing the optimal conditions for innovations in the two markets, it is immediate that the technological asymmetry depends on the relative size of the two markets and the differences in the home and foreign consumers' marginal willingness-to-pay for quality. A more precise statement follows.

Proposition 1. *(i) Consider the domestic market. The quality level equals $\overline{q}$, the consumers' surplus is zero, and the profit, as well as welfare equals $nu(\alpha, \overline{q})$.*

(ii) Consider the foreign market. The quality level equals $\overline{q}^*$, the consumers' surplus is zero, and the profit, as well as welfare equals $n^*u(\alpha, \overline{q}^*)$.

(iii) *The home firm develops a lower quality than the foreign firm, i.e.* $\overline{q} < \overline{q}^*$*, if and only if*

$$\frac{n}{n^*} < \frac{u_q(\alpha^*, \overline{q}^*)}{u_q(\alpha, \overline{q}^*)}. \tag{14}$$

Proof. From (8) and (10) it follows that,

$$nu_q(\alpha, \overline{q}(n)) = n^* u_q(\alpha^*, \overline{q}^*).$$

Suppose, for $n = \tilde{n}$, the firms choose the same innovation level, i.e. $\overline{q}(n) = \overline{q}^*$. Then

$$\tilde{n} u_q(\alpha, \overline{q}(\tilde{n})) = n^* u_q(\alpha^*, \overline{q}^*).$$

Clearly, for $n < \tilde{n}$, $\overline{q}(n) < \overline{q}(n) = \overline{q}^*$, whereas for $n > \tilde{n}$, $\overline{q}(n) > \overline{q}(n) = \overline{q}^*$ (follows since $u_{qq} < 0$). Finally, note that $n < \tilde{n}$ if and only if $\frac{n}{n^*} < \frac{u_q(\alpha^*, \overline{q}^*)}{u_q(\alpha, \overline{q}^*)}$. ∎

Note that a sufficient condition for $\frac{n}{n^*} < \frac{u_q(\alpha^*, \overline{q}^*)}{u_q(\alpha, \overline{q}^*)}$ is that $n \leq n^*$.

Proposition 1 implies that a lower quality may be developed in a larger market if the marginal willingness-to-pay there is small compared to that in the smaller market. This is quite consistent with the quality levels observable in developing and developed countries.[4]

In the rest of the paper we shall assume that the home firm is low-quality compared to the foreign firm, i.e. $\overline{q} < \overline{q}^*$ (clearly, this is without loss of generality). By Proposition 1 this is the same as assuming that either the home market is smaller, or that it is not too large in the sense defined in (14).

Example. To illustrate what has been discussed above, consider the following quadratic preference functions:

$$u(\alpha, q) = \alpha q^{\frac{1}{2}}, \text{ and } u(\alpha^*, q) = \alpha^* q^{\frac{1}{2}}. \tag{15}$$

From the first-order conditions (8) and (10), the innovation levels are

$$\overline{q} = \frac{n^2 \alpha^2}{4F^2}, \text{ and } \overline{q}^* = \frac{n^{*2} \alpha^{*2}}{4F^2}. \tag{16}$$

Thus, $\overline{q} < \overline{q}^*$ if

$$\frac{n}{n^*} < \frac{\alpha^*}{\alpha}. \tag{17}$$

[4]Quality asymmetry across the developing and developed countries has been widely observed by many researchers. The above discussion offers a simple explanation in terms of market size and taste diversity (or perhaps income disparity). For a detailed discussion see Acharyya (2005).

Since $\alpha^* > \alpha$, the home firm may have a lower quality even if it has a larger market size.

3 Market Integration

To begin with suppose that the existing quality level of the home firm is $\overline{q}$, and that of the foreign firm is $\overline{q}^*$. We then examine the case where the two markets are integrated through removal of trade barriers.

In the integrated market, the consumers can buy the good from either firm. We assume away any transport cost. Thus post-integration, there is a potentially larger market for both the firms. The question of interest is what effect such integration will have on the level of innovation by the two firms. Will the foreign firm increase its quality advantage even further, or will the domestic firm manage to reduce the difference, perhaps even leap-frog the foreign firm?

For simplicity, we assume that in the post-integration game, in the absence of any technological innovation, the firms choose their existing level of quality. Here the underlying assumption is that, pre-integration, the firms have already chosen their quality levels, $\overline{q}$ and $\overline{q}^*$. Given that there is an existing technology in place, switching to another one, even a lower quality one, is costly, perhaps because it involves changing to different machines, or different work routines.

We examine two alternative 4 stage game form. The first game, G_F, involves the following stages:

Stage 1. The foreign firm decides on its level of R&D.
Stage 2. The home firm decides on its level of R&D.
Stage 3. The firms simultaneously decide on their level of quality.
Stage 4. The firms simultaneously decide on their prices.

This game analyzes the situation where the foreign firm is quicker in responding to the altered situation.

We contrast this case with the game G_D where, in stage 1, it is the home firm that decides on its level of R&D, and, in stage 2, it is the foreign firm that decides on its level of R&D. Stages 3 and 4 are the same for both firms. Note that the quality-price game, i.e. stages 3 and 4, are modelled along the lines of Shaked and Sutton (1982).

Analyzing these two alternative game forms allows us to study the effect that the speed of response has on the final outcomes. We solve for the pure strategy subgame perfect Nash equilibria (SPNE) of the above two games.

Following the standard literature, we assume that each firm offers only one pair of price-quality menu. In addition, we make the following assumption regarding the composition of the integrated market:

$$\frac{n}{n^*} \geq \frac{[u(\alpha^*, q^*) - u(\alpha^*, q)] - [u(\alpha, q^*) - u(\alpha, q)]}{u(\alpha, q^*) - u(\alpha, q)}, \forall q^* > q. \tag{18}$$

The importance of this assumption will be made clear later. At this point it is sufficient to note that this assumption is quite compatible with our earlier assumption in (14). We shall elaborate upon this later, though as will be evident from what follows, the main results remain unchanged even if (18) precludes (14).

Now in the integrated market, the consumption decision and menus selected do not depend solely on the individual rationality constraint. Since consumers now can choose from the home and the foreign varieties, the selected menus must also be incentive compatible. More precisely, the α-type consumers buy q^* at p^* from the foreign firm instead of q at p from the home firm if,

$$u(\alpha, q^*) - p^* \geq u(\alpha, q) - p. \tag{19}$$

Similarly for the α^* type consumers. The tie-breaking rule is that if consumers are indifferent between the two menus, then they select the menu with the higher quality.

3.1 Quality and Price Competition in the Integrated Market

We first solve for the pure strategy SPNE of the stage 3 game. The quality choice in stage 3, (q, q^*), satisfies the technological constraints $q \leq \overline{q}$ and $q^* \leq \overline{q}^*$. Let the price vector in the stage 4 subgame be denoted by $(p(q, q^*), p^*(q, q^*))$.

It is clear that whenever $q = q^*$, the subsequent price game is essentially a standard Bertrand game with homogeneous products and zero marginal costs. Hence $p(q, q) = p^*(q, q) = 0$. Finally let $(\hat{q}, \hat{q}^*, p_1(\hat{q}, \hat{q}^*), p^*(\hat{q}, \hat{q}^*))$ denote a subgame perfect Nash equilibrium of this game.

The following lemma is critical for the argument.

Lemma 2. *Whenever $q < q^*$, $p(q, q^*)$ cannot be strictly positive.*

Proof. Suppose to the contrary that $p(q, q^*) > 0$. To begin with note that consumers of at least one type must be purchasing from the foreign firm. Otherwise it can reduce its price below $u(\alpha, q^*) - u(\alpha, q)$ and attract both types of consumers.

Clearly, $p^*(q, q^*)$ must be either A or B, where

$$A = u(\alpha^*, q^*) - u(\alpha^*, q) + p(q, q^*), \tag{20}$$

$$\text{and, } B = u(\alpha, q^*) - u(\alpha, q) + p(q, q^*) \tag{21}$$

Note that A (respectively B) is such that the type-α^* (respectively type-α) consumers are indifferent between the price quality configuration offered by the home and foreign firms. Given the tie-breaking assumption, if the foreign firm charges any price p, where $A \geq p > B$, then the type-α^* consumers purchase from the foreign firm, while the type-α consumers purchase from the home firm. Whereas if the foreign firm charges any price p where $p \leq B$ then consumers of both the types purchase from it. Clearly, A dominates any other price p' such that $A > p' > B$, while B dominates any other price p'' such that $B > p''$. Thus the foreign firm will either choose A or B. We argue that in either case the home firm can charge a price lower than $p^*(q, q^*)$ and gain.

There are two cases to consider.

Case 1. Suppose that the foreign firm is charging A. If the home firm deviates by charging $p(q, q^*) - \epsilon$, where $\epsilon > 0$, it gains $(p(q, q^*) - \epsilon)n^*$ on the type-α^* consumers, but looses ϵn on the type-α consumers. For ϵ small, the gain outweighs the loss.

Case 2. Suppose that the foreign firm is charging B. Then the home firm has no customers and a profit of zero. By charging any price p' where $0 < p' < p(q, q^*)$ it can obtain both types of customers and a strictly positive profit.

Thus in either case we arrive at a contradiction. Therefore, $p(q, q^*)$ cannot be strictly positive. ■

We are now in a position to write down our next proposition.

Proposition 2. *There is a continuum of subgame perfect Nash equilibria characterized by following strategies:*
Stage 1. $\hat{q}^* = \overline{q}^*$ *and* $\hat{q} \in [0, \overline{q}]$
Stage 2. $p(\widehat{q}, \widehat{q}^*) = 0$ *and* $p^*(\widehat{q}, \widehat{q}^*) = u(\alpha, \widehat{q}^*) - u(\alpha, \widehat{q})$.

Proof. The proof is in several steps.

Step 1. We first argue that whenever $q \leq q^*$, $p(q, q^*) = 0$ and $p^*(q, q^*) = u(\alpha, q^*) - u(\alpha, q)$. Note that from lemma 1 the only possible value for $p(q, q^*)$ is zero. Given this fact the foreign firm should optimally either charge $u(\alpha^*, q^*) - u(\alpha^*, q)$ when it obtains the type-α^* consumers, and has a profit of $n^*[u(\alpha^*, q^*) - u(\alpha^*, q)]$, or charge $u(\alpha, q^*) - u(\alpha, q)$ when it obtains both types of consumers, and has a profit of $(n+n^*)\,[u(\alpha,q^*)-u(\alpha,q)]$. Since by the assumption made in (18), $(n+n^*)\,[u(\alpha,q^*)-u(\alpha,q)] \geq n^*[u(\alpha^*,q^*)-u(\alpha^*,q)]$, it is optimal for the foreign firm to charge $[u(\alpha,q^*)-u(\alpha,q)]$[5]. Finally, given that the foreign firm charges $[u(\alpha,q^*)-u(\alpha,q)]$, the home firm cannot charge a price greater than 0 and gain since it is not going to get any customers.

Step 2. From step 1, the foreign firm's profit is $(n+n^*)\,[u(\alpha,q^*)-u(\alpha,q)]$. Since this is increasing in q^*, the result follows.

Step 3. Finally, note that given $\hat{q}^* = \overline{q}^*$, the home firm is indifferent between all possible quality levels, since its profit level is always zero. ■

Therefore, we have multiple SPNE.[6]

What happens when the distribution pattern does not satisfy (18)? Unfortunately, in this case there is a severe non-existence problem. It is sufficient to argue that there exists (q,q^*) configurations, such that the corresponding price game has no pure strategy Nash equilibrium.

Consider any (q,q^*) such that $q < q^*$. Note that from lemma 1 it follows that $p(q,q^*)$ can only be zero. However, in that case we can mimic the argument in Proposition 1 to claim that the best response of the foreign firm is to charge the price $[u(\alpha^*,q^*)-u(\alpha^*,q)]$. But then the home firm can deviate by charging some price p, where $0 < p < [u(\alpha^*,q^*)-u(\alpha^*,q)] - [u(\alpha,q^*)-u(\alpha,q)]$. In that case the type-$\alpha$ consumers will purchase from the home firm and it will have a strictly positive profit. That is, $p(q,q^*)$ cannot equal zero also. Thus no pure strategy SPNE exists. What happens if we allow for mixed strategies is an open question.

Thus, in an integrated market, the distribution of consumers across different types plays a crucial role. The nature of the SPNE (i.e. the profit levels of the two firms), however, is *independent* of the distribution.

Note that for the quadratic preference functions defined in (15), condition (18) simplifies to:

$$\frac{n}{n^*} > \frac{\alpha^*-\alpha}{\alpha}. \tag{22}$$

Thus in this case both (14) and (18) can hold simultaneously. Figure 3 illustrates this possibility.

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[5]We make the tie-breaking assumption that if a firm is indifferent between two price quality configurations, then it prefers the one that yields a greater number of consumers.

[6]The maximum differentiation solution of Shaked-Sutton (1982) where we have $(\widehat{q}=0, \widehat{q}^*=\overline{q}^*)$ is only one of these SPNE. Moreover, the low quality home firm always earns zero profit. Thus in this case quality competition does not relax price competition for the low quality firm.

3.2 Innovation Decision in the Integrated Market

In this sub-section we solve for the SPNE of the whole game.

Let $\Pi(q)$ denote the net profit of the domestic firm if it innovates to a level $q > \overline{q}^*$, given that the foreign firm does not innovate at all. Similarly, the net profit of the foreign firm if it alone innovates to some $q > \overline{q}^*$ is denoted by $\Pi^*(q)$. By Proposition 2, the equilibrium outcome in the price-quality subgame implies that,

$$\begin{aligned} \Pi(q) &= (n+n^*)\,[u(\alpha,q)-u(\alpha,\overline{q}^*)]-F(q-\overline{q}) \qquad (23)\\ \text{and, } \Pi^*(q) &= (n+n^*)\,[u(\alpha,q)-u(\alpha,\overline{q})]-F(q-\overline{q}^*). \qquad (24)\end{aligned}$$

Given (23) and (24), the first order condition for maximizing both $\Pi(q)$ and $\Pi^*(q)$ involve choosing $\overline{\overline{q}}$, where $\overline{\overline{q}}$ satisfies:

$$(n+n^*)u_q(\alpha,\overline{\overline{q}}) = F. \qquad (25)$$

A few comments are warranted at this point. First, if the foreign firm does not innovate at all, then the home firm will develop such a quality level if the net profit $\Pi(\overline{\overline{q}}) \equiv (n+n^*)\,[u(\alpha,\overline{\overline{q}})-u(\alpha,\overline{q}^*)]-F[\overline{\overline{q}}-\overline{q}]$ is non-negative. But it is evident that $\Pi(\overline{\overline{q}})$ varies inversely with $\overline{q}^*$ and positively with $\overline{q}$. Thus, the larger is the initial technological gap $(\overline{q}^*-q)$, greater is the cost and smaller is the benefit from innovation. However, as discussed earlier, since the technology gap determined by the pre-integration R&D efforts itself depends on the relative size of the two markets, so does the innovation decision of the home firm in the integrated market when the foreign firm does not innovate. Further, innovation for the foreign firm is viable whenever $\Pi^*(\overline{\overline{q}}) > 0$. But $\Pi^*(\overline{\overline{q}})$ can be positive even when $\Pi(\overline{\overline{q}}) < 0$. The following lemma makes a more precise statement in this regard:

Lemma 3. $\Pi^*(\overline{\overline{q}}) > \Pi(\overline{\overline{q}})$.

Proof. From (24),

$$\Pi^*(\overline{\overline{q}}) \equiv (n+n^*)\,[u(\alpha,\overline{\overline{q}})-u(\alpha,\overline{q})]-F[\overline{\overline{q}}-\overline{q}^*].$$

A little manipulation yields,

$$\Pi^*(\overline{\overline{q}}) = \Pi(\overline{\overline{q}}) + \pi^*(\overline{q}^*) + F[\overline{q}^*-\overline{q}].$$

Hence the claim. ■

The following proposition now characterizes the SPNE of the whole game.

Proposition 3. (i) *Let* $\Pi(\overline{\overline{q}}) > 0$. *Then, in* G_F, $\hat{q} = \overline{q}$ *and* $\hat{q}^* = \overline{\overline{q}}$. *Whereas in* G_D, $\hat{q} = \overline{\overline{q}}$ *and* $\hat{q}^* = \overline{q}^*$.

(ii) *Let* $\Pi^*(\overline{\overline{q}}) > 0 \geq \Pi(\overline{\overline{q}})$. *Then, in both* G_F *and* G_D, $\hat{q} = \overline{q}$ *and* $\hat{q}^* = \overline{\overline{q}}$.

Proof. Observe that in any SPNE at most one of the firms will invest a positive amount in improving its quality. The other firm will invest nothing. This is because in equilibrium the gross (of investment) profit of at least one of the firms is zero. Thus the net profit of at least one of the firms will be strictly negative in case they both invest in quality improvement.

(i) Given that $\Pi(\overline{\overline{q}}) > 0$, by Lemma 3, $\Pi^*(\overline{\overline{q}}) > \Pi(\overline{\overline{q}}) > 0$. Hence its profitable for both the firms to acquire a quality level of $\overline{\overline{q}}$, assuming that the other firm is not going to invest in R&D.

We first consider the game, G_F, where the foreign firm first decides on its R&D. Clearly, the foreign firm's optimal decision is to either invest till $\overline{\overline{q}}$, or not to invest at all. In case it does not invest at all, the domestic firm will invest till $\overline{\overline{q}}$, and the foreign firm will have a net profit of zero. Whereas if it invests in $\overline{\overline{q}}$, then the domestic firm will not invest at all. Given that the foreign firm invests till $\overline{\overline{q}}$, it follows that the domestic firm's optimal investment, in case it invests at all, is $\overline{\overline{q}}$. However, given that the foreign firm has the same level of quality i.e. $\overline{\overline{q}}$, the net profit of the domestic firm is negative. Hence, at any other positive quality level also the net domestic profit is negative. Given that the domestic firm does not invest at all, the foreign firm will have a net profit of $\Pi^*(\overline{\overline{q}}) > 0$.

A similar argument shows that, in the game G_D, $\hat{q} = \overline{\overline{q}}$ and $\hat{q}^* = \overline{q}^*$.

(ii) If $\Pi^*(\overline{\overline{q}}) > 0 \geq \Pi(\overline{\overline{q}})$, then the domestic firm never finds it profitable to innovate even if the foreign firm does not innovate. Thus optimally only the foreign firm innovates. ■

Example. In terms of our earlier example, it is easy to verify that for very small initial technology gap, i.e., for $\frac{n}{n^*}$ close to $\frac{\alpha}{\alpha^*}$, developing $\overline{\overline{q}} > \overline{q}^*$ is viable. More precisely, given any n^*, if $n = \frac{\alpha}{\alpha^*}n^* - \epsilon$, then $\Pi(\overline{\overline{q}}) = \frac{n^{*2}\alpha}{F} - \epsilon > 0$.

Proposition 3 above has some very interesting implications. Integrating the world markets creates technological opportunities for both the firms. However, which one of the firms manage to take advantage of this opportunity depends on the response speed of the two firms, and their pre-integration quality levels. If the initial quality level of the domestic firm is too low to begin with, then it can never take advantage of these new opportunities. If, however, the domestic firm is not too far behind to begin with, then the outcome depends on the relative speed of response. If the foreign firm responds faster (i.e. it is the first mover in the R&D stage), then the technological gap between the two firms widen, and the foreign firm grabs the benefits. If, however, the domestic firm is responds faster (i.e. the first mover in the R&D phase), then the technological gap may get reversed, so that the domestic firm may grab the technological lead.

4 Gains from Market Integration

In this section we examine the effects of integration on the welfare level. We consider a pre-integration situation where the R&D costs are sunk, and the technology level of the domestic firm is fixed at $\overline{q}$, and that of the foreign firm is fixed at $\overline{q}^*$.

To begin with, we can use our analysis in the previous section to calculate the post-integration levels of consumers' surplus, profits and welfare in both the markets under the various possible equilibria.

Proposition 4. *(i) Suppose the post-integration equilibrium involves* $\hat{q} = \overline{q}$ *and* $\hat{q}^* = \overline{\overline{q}}$*. Then, in the domestic market, profit is zero and the consumers surplus, as well as welfare equals* $nu(\alpha, \overline{q})$*. In the foreign market, consumers' surplus equals* $n^*[u(\alpha^*, \overline{\overline{q}}) - u(\alpha, \overline{\overline{q}}) + u(\alpha, \overline{q})]$*, profit equals* $\Pi^*(\overline{\overline{q}})$ *and welfare equals* $\Pi^*(\overline{\overline{q}}) + n^*[u(\alpha^*, \overline{\overline{q}}) - u(\alpha, \overline{\overline{q}}) + u(\alpha, \overline{q})]$*.*

(ii) Suppose the post-integration equilibrium involves $\hat{q} = \overline{\overline{q}}$ *and* $\hat{q}^* = \overline{q}^*$*. Then, in the domestic market, consumers' surplus is* $nu(\alpha, \overline{q}^*)$*, profit is* $\Pi(\overline{\overline{q}})$ *and welfare is* $nu(\alpha, \overline{q}^*) + \Pi(\overline{\overline{q}})$*. In the foreign market, profit is zero and consumers' surplus, as well as welfare equals* $n^*[u(\alpha^*, \overline{\overline{q}}) - u(\alpha, \overline{\overline{q}}) + u(\alpha, \overline{q}^*)]$*.*

Interestingly, market integration always benefits the consumers. Integration has two effects on the consumers. First, is the gain through availability of a higher quality. Second, the market price may either increase, or decrease. What our analysis shows, however, is that the first effect always dominates, hence the result.

National welfare, however, depends on how the profit of the two firms change after integration. First consider the case where $\hat{q} = \overline{q}$ and $\hat{q}^* = \overline{\overline{q}}$. From Propositions 1 and 4(i), the home firm undoubtedly loses as it earns zero profit after integration. But, this is exactly compensated by the gain for home (or low-type) consumers. Since home consumers now buy $\overline{\overline{q}}$ at price $u(\alpha, \overline{\overline{q}}) - u(\alpha, \overline{q})$, so home welfare after integration $nu(\alpha, \overline{q})$, exactly equals the pre-integration welfare $nu(\alpha, \overline{q})$.

The foreign firm, on the other hand, may not benefit from integration. The number of home consumers relative to the number of foreign consumers is once again important. The foreign firm gains if and only if

$$\{(n + n^*)\,[u(\alpha, \overline{\overline{q}}) - u(\alpha, \overline{q})] - F[\overline{\overline{q}} - \overline{q}^*]\} - n^* u(\alpha, \overline{q}^*) > 0. \tag{26}$$

Next, from Propositions 1 and 4(ii), national welfare of the foreign country increases if and only if

$$\Pi^*(\overline{\overline{q}}) + n^*[u(\alpha^*, \overline{\overline{q}}) - u(\alpha, \overline{\overline{q}})] > 0. \tag{27}$$

Given that $\Pi^*(\overline{\overline{q}}) \geq 0$, this is satisfied.

Next consider the case where $\hat{q} = \overline{\overline{q}}$ and $\hat{q}^* = \overline{q}^*$. From Propositions 1 and 4(ii), the foreign firm loses after market integration. The welfare of the foreign country, however, increases provided

$$u(\alpha^*, \overline{\overline{q}}) - u(\alpha^*, \overline{q}^*) - u(\alpha, \overline{\overline{q}}) + u(\alpha, \overline{q})] > 0. \tag{28}$$

This can be re-written as

$$\int_{\overline{q}^*}^{\overline{\overline{q}}} [u_q(\alpha^*, q) - u_q(\alpha, q)]dq > 0. \tag{29}$$

Given that $u_{q\alpha} > 0$, the above always holds.

Finally, it is easy to show that the national welfare of the home country unambiguously increases. From Propositions 1 and 4(ii), this holds provided

$$\Pi(\overline{\overline{q}}) + n[u(\alpha, \overline{q}^*) - u(\alpha, \overline{q})] > 0, \tag{30}$$

which is clearly satisfied.

Summarizing the preceding discussion we have our final result.

Proposition 5. *(i) Suppose* $\Pi^*(\overline{\overline{q}}) > 0 > \Pi(\overline{\overline{q}})$. *The post-integration outcome involves the foreign firm alone innovating. In this case the domestic welfare is unaffected, while foreign welfare increases.*

(ii) Suppose $\Pi^*(\overline{\overline{q}}) > \Pi(\overline{\overline{q}}) > 0$. *In* G_F, *the post-integration outcome involves the foreign firm alone innovating. In this case the domestic welfare is unaffected, while foreign welfare increases. Whereas in* G_D, *the post-integration outcome involves the domestic firm alone innovating. In this case welfare increases in both the countries.* ■

Thus we find that integration is welfare improving for both the countries. There are, however, distributional implications. While the consumers always gain from such integration, the firms may, or may not. Whether a firm gains or not depends on the pre-integration technological distance between the two countries, as well as the response speed of the two firms to the integration.

5 Conclusion

One of the central message of this paper is that integration creates technological opportunities for both countries, and the outcome depends on which country manages to grab these opportunities.We show that, post-integration, quality and price competition between the firms creates a winner-takes-all situation, with technological opportunities for both the firms. However, which one of the firms manage to take advantage of this opportunity depends on the response speed of the two firms, and their pre-integration quality levels. If the domestic firm is not too far behind the foreign firm to begin with, and if it responds faster, then the technological gap may get reversed, with the domestic firm grabbing the technological lead. Otherwise, however, the foreign firm innovates, with a further widening of the technological gap between the two firms.

Further, we find that integration may be welfare improving for both the countries. At least it does not lower welfare of the countries. There are, however, distributional implications. While the consumers always gain from such integration, the firms may, or may not.

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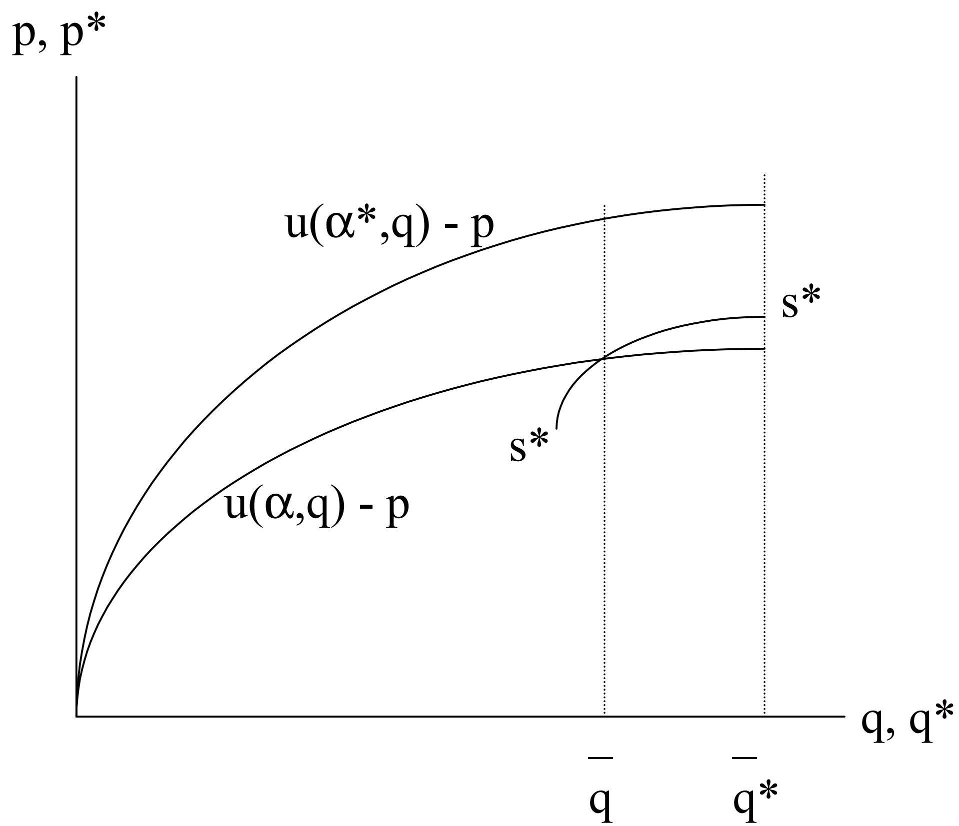

Figure 1: Quality Choices in Separated Markets