

## INCOME DISTRIBUTION, SPILLOVER EFFECTS AND CHOICE OF PRODUCT QUALITY

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We consider an MNC that is originated from a developed country where income is more or less evenly distributed and serves there a high quality product with the help of sophisticated technology of production. Under liberalized policy this MNC enters into a developing economy where income distribution is highly unequal. Due to prior experience of production it possesses a cost advantage in producing appropriate product quality in the developing country described by the spillover effect. It is shown that this discriminating monopolist serves a lower quality product in the developing country without any cost advantage. This happens due to its uneven income distribution. As spillover effect starts to rise, the product qualities between the countries differentiate more. At the same time profit of MNC rises. This may provide an explanation why MNCs are so eager to enter into a developing country. The developing country also gains in terms of welfare.

*Keywords:* Income Distribution, Product Quality, Trade Liberalization

*JEL classification:* D31, L13, O31

### 1. INTRODUCTION

Under liberalization, entry of a foreign multinational in a developing country has been easy. There is a general expectation that the developing countries will now benefit from the introduction of new and superior quality products by the foreign multinationals. The developing countries are commonly characterized by high income inequality distribution as compared to the developed countries. At the same time the average purchasing power of the general people in a developing (local) country is lower than that of a developed (foreign) country. A question then asked in this context is: Will a foreign multinational supply the same product quality in the developing country as being served in its parent (foreign) country? It is often contended that *the foreign multinationals*

\*The author is extremely grateful to Prof. Tarun Kabiraj, Indian Statistical Institute, Kolkata for helpful discussion. The author is also grateful to the anonymous referees for very helpful comments and suggestions.

*supply a lower quality product in the developing countries* (Das, 1998). Computers sold by IBM, Compaq or cold drinks served by Coca-Cola in USA and in South Asia may exemplify such quality differences.

There is a literature on endogenous product quality choice by a monopolist in a model of vertical product differentiation with heterogeneous preference or taste of the consumers. Mussa and Rosen (1978) show that a monopolist adopts different price-quality combinations for heterogeneous set of consumers who have different tastes and so have different willingness to pay for the product. A consumer with higher willingness to pay for a quality prefers a higher quality product. Kim and Kim (1996) assume that the cost of producing a lower quality is lower due to spill-over effect, that is, the experience gathered by the firm for producing a higher quality good. Tirole (1988), Choi and Shin (1992), Motta (1993), Wauthy (1996) and Acharyya (1998, 2005) also deal with the choice of product quality, given heterogeneity in taste or preference. In these models, consumers are indexed by a taste parameter and it is uniformly distributed within a given range.

Then Gabszewicz and Thisse (1979) have analyzed the effect of income distribution on a vertically differentiated duopoly model. They assume that the marginal willing-to-pay for a higher quality increases with the income level of a consumer. However, these models including Saked and Satton (1982) assume uniform distribution of income.

We extend this literature to find an explanation of the above mentioned fact and to determine the product quality served by a multinational firm in a developing country where uneven pattern of income distribution prevails.

In the present paper I assume that a consumer with a higher income has higher willingness to pay for quality and prefers a high quality product. Then the distribution of the taste or preference of consumers is conditional upon the distribution of income. A multinational firm originated from a developed (foreign) country enters into a developing (local) country and serves a product not produced there. The firm has an experience of producing a high product quality in its own (parent) country where income is more or less evenly distributed. But the income distribution in the local country is highly uneven, namely positively skewed. Since the firm has a prior experience of producing the product with sophisticated technology, it can now reduce the cost of production in the local country due to spillovers of production knowledge. Lemi (2004) discusses that the economists are not unanimous about the spillover effect of foreign direct investment on host country's economy. But in this paper I assume positive spillover because the MNC here is transmitting its own production knowledge from its old plant in own country to a new plant established in local country. It is assumed that the MNC has monopoly in both the foreign country market and the local country market. However it behaves as a multi-product and discriminating monopolist which adopts different price-quality combinations for two different markets. Under this scenario, the basic objective in this paper is to determine the product qualities served by the MNC in two countries. Given the income distribution structures and the cost of production, the

monopolist will determine the equilibrium price-quality combinations for two markets which maximize its total profit. The equilibrium is solved in two stages; in the first stage the firm determines the price-quality combination of the product for the foreign market. Then given the spillover effect, it determines the price and quality of the product for the local market.

The work closely related to mine is the paper by Chatterjee and Raychaudhuri (2004). The focus of their paper is to discuss how a change in income distribution parameter affects the number of product qualities served by the firms in both monopoly and duopoly market structures. They assume that the market is always endogenously covered and show that a monopolist supplies high and low qualities simultaneously if at least a certain degree of inequality exists. Given the income range, as income inequality is reduced below this level the monopolist supplies only the high quality product.

But in the present paper income distributions in two countries remain fixed and market is not endogenously covered. Market sizes in two countries are determined according to profit maximization of the MNC. This paper discusses the effect of income distribution on the quality of good it self, not the number of qualities served by the monopolist. The results derived in this paper are the following:

*(1) The MNC always serves high quality product in the developed country where income is evenly distributed and low quality product in the developing country where income distribution is uneven. Uneven income distribution in the developing country is the motivating factor to serve a lower product quality there.*

*(2) Spillovers of production knowledge only intensifies the degree of difference between the product qualities served to the countries. The higher the spillover effect, the higher will be the product quality and the lower will be the market size in foreign country. In local country the opposite happens. Lower will be the product quality and higher will be the market size. At the same time total profit of the MNC will increase.*

This has a policy implication from the welfare point of view in the developing country. Some people in the local country will now enjoy the product which was not previously produced there. Obviously welfare of the country will increase. Suppose that there are more than one competitive entrant with different spillover effects. Then the question is which MNC or MNCs be preferred from the welfare point of view. Our paper provides a direction to that question. We show that the higher the spillover effect of producing the product in a developing country, the higher will be the welfare of that country. This type of welfare analysis is not considered in any other works.

The intuition of these results may be the following. The cost of producing a quality in a developing country gets reduced due to spillover effect. The strategy of the MNC is to shift some part of the market from the developed country to the developing country. Given the income distribution structures, the MNC may capture a larger market size in the developing country by slight reduction of that in the developed country and in this way it increases total profit. This may be an answer why the MNCs are so eager to enter into the markets of the developing countries. Obviously there is a limit to the increase in profit. The market in the developing country may be extended only up to the full market

coverage. Again there must be some market in the developed country because production of a high quality product creates spillover effect.

Plan of the paper is the following. Section 2 provides the model. In subsection 2.1 we discuss the income distribution structures in each country, the preference function of the consumers and the monopolist's cost function. Subsection 2.2 determines the equilibrium price-quality combinations adopted by the monopolist in two countries. In subsection 2.3 we present the simulation results. In subsection 2.4 an example is considered. An impact of a change in spillover effect on welfare of the local country is analysed in section 3. Finally, section 4 provides some concluding remarks. All mathematical derivations are relegated to the appendix.

## 2. MODEL

### 2.1. Description of Income Distribution, Preference and Cost Structure

#### *Income Distribution Structure*

The foreign country consists of population with varying levels of income indexed by  $\hat{\theta} \in \left[ \underline{\theta}, \bar{\theta} \right]$ ,  $\bar{\theta} > \underline{\theta}$ . The population density function defined over this interval is

$$\hat{f}(\hat{\theta}) = \frac{1}{\bar{\theta} - \underline{\theta}} = \frac{1}{k}. \quad (\text{say}) \quad (1)$$

It follows a uniform or even distribution. The potential market size of the country is

$$\hat{S}(\underline{\theta}, \bar{\theta}) = \int_{\underline{\theta}}^{\bar{\theta}} f(\hat{\theta}) d\hat{\theta} = \frac{\hat{\theta}}{k} \Big|_{\underline{\theta}}^{\bar{\theta}} = 1.$$

The local country's population is identified by the income index  $\theta$ , which is distributed over the same interval  $\theta \in \left[ \underline{\theta}, \bar{\theta} \right]$ . The population density function defined over it is  $f(\theta)$  and the simplest characterization of uneven income distribution implies  $f'(\theta) < 0$ . As  $\theta$  increases income per person increases but the number of people eating such income goes down. We further assume

$$f(\theta) = \frac{1}{\theta}, \text{ and } \underline{\theta} > 1. \tag{2}$$

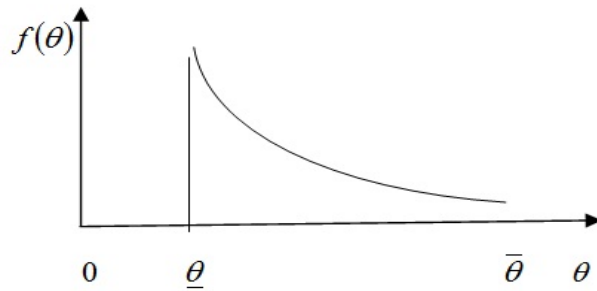
The potential market size in the local country is

$$S(\underline{\theta}, \bar{\theta}) = \int_{\underline{\theta}}^{\bar{\theta}} \frac{1}{\theta} d\theta = \log \theta \Big|_{\underline{\theta}}^{\bar{\theta}} = \log \left( \frac{\bar{\theta}}{\underline{\theta}} \right).$$

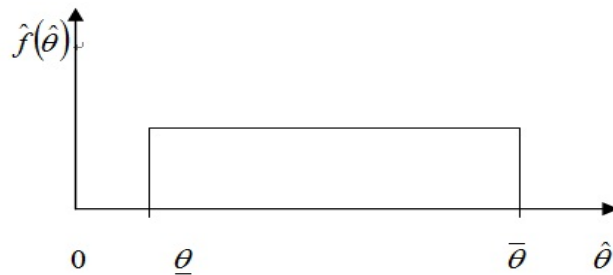
This must satisfy the restriction  $\log \left( \frac{\bar{\theta}}{\underline{\theta}} \right) = 1$ ,

$$\text{i.e., } \frac{\bar{\theta}}{\underline{\theta}} = e^1 = 2.7, \text{ or } \bar{\theta} = 2.7 \underline{\theta}. \tag{3}$$

The income distribution structure in each country is shown in Figure 1.



**Figure 1a.** Income Distribution in Local Country



**Figure 1b.** Income Distribution in Foreign Country

### *Preference Structure*

We assume that preference pattern of the consumers for the product in either country is same and the utility function of a consumer is given by<sup>1</sup>

$$U = \begin{cases} \alpha q - p, & \text{when one unit of the good of quality } q \text{ is} \\ & \text{purchased at price } p \\ = 0 & \text{otherwise} \end{cases}, \quad (4)$$

where each consumer consumes only one unit of a vertically differentiated good. The quality of the good is indexed by  $q \in (0, \bar{q})$  is observable to all. The range of possible qualities is determined by state of existing technology.  $\alpha$  represents the consumer's taste for quality. All consumers prefer high quality for a given price; however a consumer with higher income is more willing to pay to obtain high quality.  $\alpha$  may be thought as the inverse of marginal rate of substitution between income and quality. So a wealthier consumer has a lower marginal utility of money or equivalently, a higher  $\alpha$ . So the taste parameter is assumed to be the function of income of the individual - the higher the income of the consumer, the higher the preference is for high quality, that is,  $\alpha = \alpha(\theta)$ ,  $\alpha'(\theta) > 0$ . However, we simplify the relation and assume

$$\alpha(\theta) = \theta. \quad (5)$$

Therefore, for the marginal income class (say,  $\theta = \theta_0$ ) who is indifferent between buying the product quality  $q$  and retaining income, the following condition holds

$$\alpha(\theta_0) \cdot q = p, \text{ or } \theta_0 q = p. \quad (6)$$

Let the income of a person belonging to the  $\theta$ th class is  $y(\theta)$  and we index it such a way that  $y'(\theta) > 0$ . A consumer with income index  $\theta_j$  can afford to pay

$$\text{if } y_j > p. \quad (7)$$

This is consumer's budget or purchasing power constraint. Maximum quality,  $\bar{q}$  is sufficiently high such that consumer with highest income level is willing to pay his

<sup>1</sup> Tirole (1988) introduces this type of utility function.

<sup>2</sup> There are a large number of functions for which this holds. The examples may be  $y(\theta) = \theta^3$ ,  $y(\theta) = e^\theta$ . However, for  $y(\theta) = \theta^2$ , the simulation results presented in Table 1 will not hold.

entire income to obtain it, i.e.,

$$y(\bar{\theta}) = \bar{\theta} \bar{q}.$$

Hence, the purchasing power constraint is non-binding for a consumer since the reservation price for the top most quality is less than or equal to his income:

$$y_j \geq \theta_j \bar{q}.$$

### *Cost Function*

Let the unit cost of producing a quality,  $\hat{q}$  in the foreign country is  $c(\hat{q})$  which is convex upward. We then assume that if the MNC starts production in local country setting a new plant, it will possess a cost advantage. Valuable knowledge obtained from the production of certain quality of a good can be usefully transplanted into the production of the same good but of different qualities in the form of reduced cost; we call this phenomenon as *spillover effect*.<sup>3</sup> Unit cost of producing a quality,  $q$  in the local country is described by

$$\tilde{c}(q) = c(q) - a(\hat{q} - q), \quad a > 0, \text{ for } q < \hat{q}, \quad (8)$$

where  $a$  is the spillover parameter. This means production of higher quality good in the foreign country creates a positive spillover in the form of reduced cost of a lower quality product in the local country. It will be shown later that  $\hat{q} > q$  for  $a \geq 0$ . Hence the production requires some fixed set up cost. Let us assume that this fixed cost is so small that net profit is always positive. This does not change our results and thus the associated fixed cost is assumed away. Let the cost function of the MNC in foreign country be

$$\hat{C} = \frac{\hat{q}^2}{2} \hat{x}, \quad (9)$$

where  $\hat{x}$  is the output produced in the foreign country. Then the cost function in the local country will be

<sup>3</sup> When a firm has product specific knowledge, it wants to engage in Greenfield DFI (setting a new plant) instead of merger and acquisition to minimize the chance that others to gain access to this knowledge.

$$C = \left[ \frac{q^2}{2} - a(\hat{q} - q) \right] x, \quad a > 0, \text{ and } q \leq \hat{q}, \quad (10)$$

where  $x$  is output produced there.

## 2.2. Choice of Qualities by the MNC

Let us assume that the multinational firm was initially operating only in the developed foreign country. And now it enters the developing country to serve the same product. The market size in the foreign country is given by

$$\hat{S}(\hat{\theta}_0, \bar{\theta}) = \int_{\hat{\theta}_0}^{\bar{\theta}} \frac{1}{k} d\hat{\theta} = \frac{\bar{\theta} - \hat{\theta}_0}{k}. \quad (11)$$

And that in the local country is

$$S(\theta_0, \bar{\theta}) = \int_{\theta_0}^{\bar{\theta}} \frac{1}{\theta} d\theta = \log \frac{\bar{\theta}}{\theta_0}. \quad (12)$$

The corresponding profit expressions in the two markets are

$$\pi_F = [\hat{p} - c(\hat{q})] \hat{S}(\hat{\theta}_0, \bar{\theta}) S,$$

$$\pi_L = [p - \tilde{c}(q)] S(\theta_0, \bar{\theta}),$$

where  $\pi_F$  and  $\pi_L$  are profits from the foreign market and local market. These expressions boil down to, after substitution from (6), (8) and (9)

$$\left. \begin{aligned} \pi_F &= \hat{\theta}_0 \hat{q} \hat{S} - \frac{\hat{q}^2}{2} \hat{S} \\ \pi_L &= \theta_0 q S - \left\{ \frac{q^2}{2} - a(\hat{q} - q) \right\} S \end{aligned} \right\}, \quad (13)$$

The problem of the monopolist is to choose product qualities and the income indices of the marginal income classes in two countries so as to maximize total profit. Then the equilibrium product price and the market size in each country are determined.



### 2.3. Equilibrium Product Quality and Income Index of the Marginal Income Classes in Two Countries

The total profit function of the MNC is given by

$$\pi = \pi_F + \pi_L = \left[ \hat{\theta}_0 \hat{q} \hat{S} - \frac{\hat{q}^2}{2} \hat{S} \right] + \left[ \theta_0 q S - \left\{ \frac{q^2}{2} - a(\hat{q} - q) \right\} S \right]. \quad (14)$$

Hence the two markets are interdependent for  $a > 0$ . For  $a = 0$  markets are separated. Here two stage solution procedure is used. In the first stage we solve equilibrium values of product quality and marginal income class for the foreign country. In the second stage equilibrium for the local country is solved. I consider the second stage problem first and then the first stage problem.

#### *Second Stage*

In this stage equilibrium we determine the optimum product quality and the income index of the marginal income class in the local country given the foreign product quality and spillover parameter. The first order conditions for profit maximization are (see Appendix 1):

$$\left\{ \frac{q^{*2}}{2} - a(\hat{q} - q^*) \right\} \frac{1}{\theta_0^*} = (1 - S^*) q^*, \quad (15)$$

$$\theta_0^* = q^* + a, \quad (16)$$

where  $q^*$  and  $\theta_0^*$  are optimal quality and income index of marginal income class in local country. The second order conditions are satisfied, that is (see Appendix 1),

$$\frac{\partial^2 \pi}{\partial \theta^2} = -\frac{(2-S)q}{\theta} < 0, \text{ and } \frac{\partial^2 \pi}{\partial q^2} = -S < 0. \quad (17)$$

The stability condition is assumed to hold,

$$\Delta = \frac{\partial^2 \pi}{\partial \theta^2} \cdot \frac{\partial^2 \pi}{\partial q^2} - \left( \frac{\partial^2 \pi}{\partial \theta \partial q} \right)^2 = \left( (2-S) \frac{q}{\theta} - S \right) S > 0. \quad (18)$$

Later we show that these are actually satisfied

**Lemma 1:** *The higher the product quality in the foreign country, the lower is the equilibrium product quality in the local country and the larger is the corresponding market size.*

**Proof :** From comparative static exercise (see Appendix 2) we have

$$\frac{\partial q^*}{\partial \hat{q}} = \frac{\partial \theta_0^*}{\partial \hat{q}} = -\frac{aS}{\theta_0^* \Delta} < 0. \quad (19)$$

The economic intuition is the following. Given the spillover parameter, increase in the foreign product quality results in decrease in unit cost of producing the same quality in the local country. So marginal revenue exceeds marginal cost (MR>MC). In order to maximize profit firm will produce more, i.e., the local market size will increase till MR=MC. As a result in equilibrium both  $\theta_0^*$  and  $q^*$  will decrease simultaneously, i.e., the firm will serve lower product quality to larger population coming from lower income group.

**Lemma 2:** *The higher the spillover parameter, the lower will be the equilibrium product quality and the larger will be the market size in local country.*

**Proof:** From the comparative static exercise (see Appendix 2), we obtain

$$\frac{\partial \theta_0^*}{\partial a} = -\frac{[(\hat{q} - q^*) + S^* \theta_0^*] S^*}{\theta_0^* \Delta} < 0, \text{ and } \frac{\partial q^*}{\partial a} = -\frac{[(\hat{q} - q^*) + (2 - S^*) q^*] S^*}{\theta_0^* \Delta} < 0. \quad (20)$$

Given the foreign product quality, as spillover parameter increases, the unit cost of producing the same quality in local country will decrease due to spillover effects. So the firm will produce more till MR=MC. As a result equilibrium product quality and marginal income class will go down.

*First stage*

In this stage given the spillover parameter, the MNC will choose the product quality and the marginal income class for the foreign country so that total profit is maximized subject to the first order conditions given in (15) and (16). The first order conditions for profit maximization are (see Appendix 1):

$$\bar{\theta} - 2\hat{\theta}_0^* + \frac{\hat{q}^*}{2} = 0, \quad (21)$$

$$\left(\hat{\theta}_0^* - \hat{q}^*\right)\hat{S}^* + aS^* = 0, \quad (22)$$

where  $\hat{q}^*$  and  $\hat{\theta}_0^*$  are optimal quality and income index of marginal income class in foreign country. The Second order and stability conditions are assumed to be satisfied, that is (see Appendix 1),

$$\left. \begin{aligned} \frac{\partial^2 \pi}{\partial \hat{\theta}^2} &= -\frac{2\hat{q}^*}{k} < 0, \quad \frac{\partial^2 \pi}{\partial \hat{q}^2} = -\hat{S}^* + \frac{a^2 S^*}{\theta_0^{*2} \Delta} < 0, \\ \text{and } \Omega &= \frac{\partial^2 \pi}{\partial \hat{\theta}^2} \frac{\partial^2 \pi}{\partial \hat{\theta} \partial \hat{q}} - \frac{\partial^2 \pi}{\partial \hat{\theta} \partial \hat{q}} = \left\{ 2 \left( \hat{S}^* - \frac{a^2 S^*}{\theta_0^{*2} \Delta} \right) - \frac{\hat{q}^*}{4k} \right\} \frac{\hat{q}^*}{k} > 0. \end{aligned} \right\} \quad (23)$$

Later we show that these are actually satisfied.

**Proposition 1:** *The higher the spillover parameter,*

(1) *the higher will be the product quality and the lower will be the market size in the foreign country, and*

(2) *the lower will be the product quality and the higher will be the market size in the local country.*

**Proof:** (a) From the comparative static exercise we get (see Appendix 3):

$$\frac{d\hat{q}^*}{da} = \frac{2\hat{q}^* S^*}{k\Omega} > 0, \quad \frac{d\hat{\theta}_0^*}{da} = \frac{\hat{q}^* S^*}{2k\Omega} > 0, \quad \text{and} \quad \frac{d\hat{q}^*}{da} > \frac{d\hat{\theta}_0^*}{da}. \quad (24)$$

Then using (19), (20) and (24) we shall get

$$\left. \begin{aligned} \frac{dq^*}{da} &= \frac{\partial q^*}{\partial a} + \frac{\partial q^*}{\partial \hat{q}^*} \frac{\partial \hat{q}^*}{\partial a} = -\frac{[(\hat{q} - q^*) + (2 - S^*)q^*]S^*}{\theta_0^* \Delta} - \frac{aS^*}{\theta_0^* \Delta} \frac{2\hat{q}^* S^*}{k\Omega} < 0, \\ \frac{d\theta_0^*}{da} &= \frac{\partial \theta_0^*}{\partial a} + \frac{\partial \theta_0^*}{\partial \hat{q}^*} \frac{\partial \hat{q}^*}{\partial a} = -\frac{[(\hat{q} - q^*) + S^* \theta_0^*]S^*}{\theta_0^* \Delta} - \frac{aS^*}{\theta_0^* \Delta} \frac{2\hat{q}^* S^*}{k\Omega} < 0, \end{aligned} \right\} \quad (25)$$

$$\text{and} \quad \left| \frac{dq^*}{da} \right| > \left| \frac{d\theta_0^*}{da} \right|, \quad [\cdot: \Delta > 0]. \quad (26)$$

As spillover parameter increases, monopolist's optimal strategy is to raise the product quality to serve a smaller number of people in the foreign country and to reduce

quality and enhance the market in the local country. Given the characteristics of income distribution structures, the MNC is able to capture a larger market in the local country compared to the reduction of that in the foreign country.

**Proposition 2:** *An increase in spillover effect will increase the total profit of the MNC.*

$$\text{Proof : } \frac{d\pi}{da} = aS^* \frac{2\hat{q}^* S^*}{k\Omega} + (\hat{q} - q)S^* > 0. \text{ (see Appendix 4)} \quad (27)$$

As the spillover parameter takes a larger value, the MNC shifts a part of the market from the foreign country to the local country. As a result profits from the foreign market reduces where as, that from the local market would increase. The latter will outweigh the former and the total profit of the MNC will go up. Of course, profits can not increase further once the full market coverage is reached in the local market.

#### 2.4. Simulation Results

In this section we determine equilibrium values of the variables through simulation for specific values of the spillover parameter (i.e.,  $a$ ).

##### 2.4.1. Equilibrium Product Quality, Market Size and Price for $a = 0$

When there is no spillover effect, i.e.,  $a = 0$ , two markets are completely separated.

##### *Equilibrium in Local Country*

Hence from (15) and (16) we obtain after substitution  $a = 0$ .

$$\frac{q^*}{2} - (1 - S^*)\theta_0^* = 0, \quad S^* \neq 0 \quad (28a)$$

$$\text{and } \theta_0^* = q^*. \quad (28b)$$

Now, let us assume following (3)

$$\theta^* = \lambda \underline{\theta}, \quad 1 < \lambda < 2.7. \quad (29)$$

$S^*$  may be simplified, after substitution from (3) and (29)

$$S^*(\theta^*, \bar{\theta}) = \log \frac{\bar{\theta}}{\theta^*} = \log \frac{2.7\theta}{\lambda\theta} = \log \frac{2.7}{\lambda} = 1 - \log \lambda. \quad (30)$$

Now, substituting (28b) in (28a) we obtain

$$\frac{\theta^*}{2} - (1 - S^*)\theta_0^* = 0, \text{ or, } \frac{1}{2} - (1 - S^*) = 0, \text{ or, } S^* = 0.5,$$

or,  $1 - \log \lambda = 0.5$ , or,  $\lambda = 1.6376$ .

Finally, for the local country<sup>4</sup>

$$S^* = 0.5, \quad \theta^* = q^* = \lambda\theta = 1.6376\theta, \quad \text{and} \quad p^* = \theta^* q^* = 2.68\theta^2. \quad (31)$$

#### *Equilibrium in Foreign Market*

From (21) and (22) we obtain after substitution  $a = 0$ .

$$\bar{\theta} - 2\hat{\theta}_0^* + \frac{\hat{\theta}_0^*}{2} = 0, \quad (32a)$$

$$\text{and } \hat{\theta}_0^* - \hat{q}^* = 0. \quad (32b)$$

Now, substituting (32b) in (32a) we obtain

$$\hat{\theta}^* = \frac{2}{3}\bar{\theta} = \frac{2}{3} \times 2.7\theta = 1.8\theta.$$

Now, following (11),

$$\hat{S}^* = \frac{(2.7 - 1.8)\theta}{(2.7 - 1)\theta} = 0.526.$$

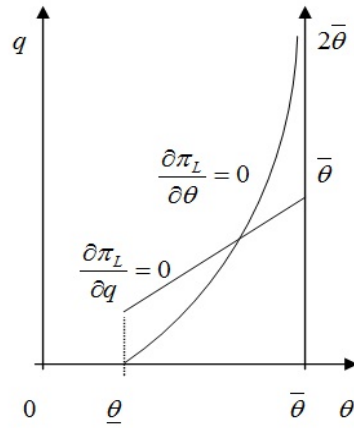
<sup>4</sup> For  $a = 0$  the second order and stability conditions are satisfied, i.e.,  $\frac{\partial^2 \pi}{\partial \theta_0^2} = -\frac{q}{\theta_0} \left( 1 + \frac{q}{2\theta_0} \right) < 0$ ,

$\frac{\partial^2 \pi}{\partial q^2} = -S < 0$  and  $\Delta = 2S(1 - S) > 0$ .

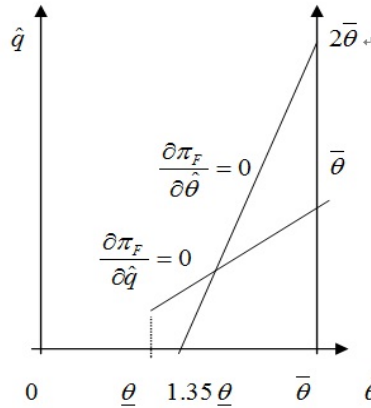
Finally, for the foreign country<sup>5</sup>

$$\hat{S}^* = 0.526, \quad \theta^* = q^* = 1.8\theta, \quad \text{and} \quad \hat{p}^* = \hat{\theta}^* \hat{q}^* = 3.24\theta^2. \quad (33)$$

Diagrammatic representation, of the equilibriums are shown in Figure 2.



**Figure 2a.** Equilibrium in Local Country with No Spillovers



**Figure 2b.** Equilibrium in Foreign Country with No Spillovers

<sup>5</sup> For  $a=0$  the second order and stability conditions are satisfied, i.e.,  $\frac{\partial^2 \pi}{\partial \hat{\theta}_0^2} = -\frac{2\hat{q}^*}{k} < 0$ ,  
 $\frac{\partial^2 \pi}{\partial \hat{q}^2} = -\hat{S} < 0$  and  $\Omega = (3\hat{\theta} - \bar{\theta}) \frac{\hat{S}}{k} > 0$ .

**Observation 1:** *It is the uneven income distribution structure in the local country which motivates the MNC to serve there a lower product, not the cost advantage it possesses.*

(31) and (33) show the effect of income distribution on the product quality served to a countries by the MNC. For the same marginal income class in both countries, the monopolist covers a larger market (market size is measured from the upper end of the income class) in the foreign country than that in the local country due to the difference in income distribution structures. Hence in order to maximize total profit, the discriminating monopolist serves a higher product quality to the higher income group in the foreign country compared to that in the local country. Thus the higher the income inequality in a country, the lower will be the product quality served by the MNC.

#### 2.4.2. Equilibrium Product Quality, Market Size and Price for $a > 0$

For positive spillovers, i.e.,  $a > 0$ , two markets are completely interdependent. The first order condition (15) may be written as:

$$\left( \frac{q^{*2}}{2} + aq^* \right) \frac{1}{\theta_0^*} - (1 - S^*)q^* = \frac{a\hat{q}^*}{\theta_0^*}, \text{ or, } [q^* + 2a - 2(1 - S^*)\theta_0^*]q^* = 2a\hat{q}^*.$$

This boils down to, after substituting from (16) and (21)

$$[\theta_0^{*2} + a - 2(1 - S^*)\theta_0^*](\theta_0^* - a) = 4a(2\hat{\theta}_0^* - \bar{\theta}),$$

$$\text{or, } \theta_0^{*2} - 2\theta_0^*(\theta_0^* - a)(1 - S^*) = 4a(2\hat{\theta}_0^* - \bar{\theta}) + a^2. \quad (34)$$

The first order condition (22) may be written as

$$aS^* = (\hat{q}^* - \hat{\theta}_0^*)\hat{S}^*.$$

This boils down to after substitution from (21)

$$aS^* = (3\hat{\theta}_0^* - 2\bar{\theta})\hat{S}^*. \quad (35)$$

For a given value of  $a$ , we may determine two unknowns  $\hat{\theta}^*$  and  $\theta^*$  from (34) and (35).

To simplify, let us consider all the variables in terms of  $\underline{\theta}$ . Following Proposition 1 we assume the income index of marginal income class in the local country is lower and

that for the foreign country is higher under positive spillover than the corresponding values with zero spillover parameter. Now we may write following (31) and (33)

$$\theta^* = \lambda \underline{\theta}, \quad 1 < \lambda \leq 1.6376 \quad (36 \text{ i})$$

$$\hat{\theta}^* = \delta \underline{\theta}, \quad 1.8 \leq \delta < 2.7, \quad (36 \text{ ii})$$

$$a = \varepsilon \underline{\theta}, \quad \varepsilon > 0. \quad (36 \text{ iii})$$

Condition (34) boils down to, after substitution from (3), (30), (36 i-iii)

$$\lambda^2 - 2\lambda(\lambda - \varepsilon)\log \lambda = 4\varepsilon(2\delta - 2.7) + \varepsilon^2. \quad (37)$$

Condition (35) boils down to, after substitution from (36)

$$\varepsilon S^* = (3\delta - 5.4) \cdot \frac{2.7 - \delta}{1.7}. \quad (38)$$

Now we use (37) and (38) for simulation process to determine  $\theta_0^*$  and  $\hat{\theta}_0^*$  for specific values of  $a$ . Simulation results for different values of  $a$  are given in Table 1. It can be easily checked that the second order and stability conditions are satisfied for these values of the variables given  $a$ . It may be noted that  $a = .2\underline{\theta}$  corresponds to the full market coverage in the local country. Clearly simulation results confirm Proposition 1 and 2.

**Table 1.**

$a$	0	$0.059 \underline{\theta}$	$0.108 \underline{\theta}$	$0.164 \underline{\theta}$	$0.2 \underline{\theta}$
$\hat{\theta}^*$	$1.8 \underline{\theta}$	$1.82 \underline{\theta}$	$1.84 \underline{\theta}$	$1.87 \underline{\theta}$	$1.95 \underline{\theta}$
$\hat{q}^*$	$1.8 \underline{\theta}$	$1.88 \underline{\theta}$	$1.96 \underline{\theta}$	$2.08 \underline{\theta}$	$2.4 \underline{\theta}$
$\hat{p}^*$	$3.24 \underline{\theta}^2$	$3.42 \underline{\theta}^2$	$3.61 \underline{\theta}^2$	$3.89 \underline{\theta}^2$	$4.68 \underline{\theta}^2$
$\hat{S}^*$	0.529	0.5176	0.5059	0.4882	0.4417
$\theta^*$	$1.6376 \underline{\theta}$	$1.6057 \underline{\theta}$	$1.5495 \underline{\theta}$	$1.4548 \underline{\theta}$	$1.0073 \underline{\theta}$
$q^*$	$1.6376 \underline{\theta}$	$1.5467 \underline{\theta}$	$1.4414 \underline{\theta}$	$1.2908 \underline{\theta}$	$0.8073 \underline{\theta}$
$p^*$	$2.68 \underline{\theta}^2$	$2.48 \underline{\theta}^2$	$2.23 \underline{\theta}^2$	$1.88 \underline{\theta}^2$	$0.81 \underline{\theta}^2$
$S^*$	0.5	0.5264	0.5621	0.6251	$0.9926 \cong 1$
$\pi$	$1.5256 \underline{\theta}^2$	$1.5444 \underline{\theta}^2$	$1.5552 \underline{\theta}^2$	$1.5769 \underline{\theta}^2$	$1.5941 \underline{\theta}^2$



**Observation 2:** *Increase in spillover of knowledge (to produce a lower product quality) only magnifies the degree of quality differential served to the countries.*

Table 1 shows the effect of increase in spillover parameter on equilibrium product qualities and the prices, marginal income classes and market sizes in two countries and lastly on total profit of MNC. As spillover of knowledge (in terms of cost reduction for producing a lower product quality) increases, MNC raises foreign product quality by raising its price and serves much lower product quality at lower price in the local country. Hence the difference between the qualities intensifies. As a result market size in foreign country shrinks and that in the local country spreads. Since income distribution in local country is uneven, reduction of market size is over compensated by its enlargement in the local country

### 2.5. Example

In this subsection I construct a simple example where it can be readily verified that the simulation results satisfy a consumer's budget or purchasing power (PP) constraint. Let

$$y(\theta) = \theta^3, \quad y'(\theta) > 0.$$

The PP constraint is satisfied for the consumer with income index  $\theta$ , ( $\theta > \theta^*$ ) when

$$y(\theta) \geq p^*. \quad (39)$$

This is for the consumers in local country. For a foreign consumer with income index  $\hat{\theta}$ , ( $\hat{\theta} > \hat{\theta}^*$ ) it becomes

$$y(\hat{\theta}) \geq \hat{p}^*. \quad (40)$$

It can be checked from Table 1 that for every considered value of spillover parameter,  $a$

$$\hat{\theta}^{*3} > \hat{p}^*, \text{ and } \theta^{*3} > p^*.$$

Thus the PP constraint is satisfied for marginal income class in both countries. Obviously for higher income classes it must satisfy.

### 3. WELFARE ANALYSIS

In this section we analyse the effect of change in spillovers on the welfare of the local country. We assume that the MNC takes out the whole profit from the local country. Hence the aggregate social welfare in the local country from this product is the consumer surplus only.

#### *Consumer Surplus*

The total CS from the product is then given by:

$$CS = \int_{\theta_0^*}^{\bar{\theta}} \theta q^* f(\theta) d\theta - \theta_0^* q^* \int_{\theta_0^*}^{\bar{\theta}} f(\theta) d\theta = q^* \left[ \int_{\theta_0^*}^{\bar{\theta}} \theta f(\theta) d\theta - \theta_0^* S(\theta_0^*, \bar{\theta}) \right], \quad (41)$$

where  $\theta_0^* q^*$  is the price of the product and a consumer with income index  $\theta$  is willing to pay the amount  $\theta q^*$ .

Therefore the change in CS due to increase in spillover parameter is given by

$$\frac{dCS}{da} = \frac{\partial CS}{\partial a} + \frac{\partial CS}{\partial q^*} \cdot \frac{\partial q^*}{\partial a}. \quad (42)$$

The first term in the R.H.S. of the above expression is the direct effect of an increase in  $a$  and the second term is the indirect effect.

#### *Direct Effect*

$$\frac{\partial CS}{\partial a} = \frac{\partial CS}{\partial q^*} \frac{\partial q^*}{\partial a} + \frac{\partial CS}{\partial \theta_0^*} \frac{\partial \theta_0^*}{\partial a}.$$

The first term in the R.H.S. of the above expression accounts for the loss in CS of the consumers who previously were buying the higher quality product and the second term accounts for the gain in CS due to price reduction as more people from lower income class are buying the product now. Consumer surplus of new consumers is positive. We finally get (see Appendix 5)

$$\frac{\partial CS}{\partial a} = -\frac{S}{\theta_0^* \Delta} \left[ \left\{ \bar{\theta} + aS^* - (1 + 2S^*)\theta_0^* \right\} (q^* - q^*) + \left\{ 2\bar{\theta} - 2\theta_0^* - (\bar{\theta} + \theta_0^*)S^* \right\} q^* \right].$$

From the simulation results given in section 2.4, we can easily check that both first term and second term in the bracket is negative whatever be the value of  $a$ . Thus the direct effect of an increase in spillover parameter is positive. An increase in spillover effect results in a reduction in cost of producing the quality in the local country. Hence, the firm will produce more of the good to serve the population coming from the lower end of the income class, but of lower quality.

*Indirect Effect*

$$\frac{\partial CS}{\partial \hat{q}^*} = \frac{\partial CS}{\partial q^*} \frac{\partial q^*}{\partial \hat{q}^*} + \frac{\partial CS}{\partial \theta_0^*} \frac{\partial \theta_0^*}{\partial \hat{q}^*}.$$

The first term in the R.H.S. in the above expression accounts for the loss of CS of the consumers due to a lower quality and the second term accounts for the gain in CS due to an increase in market size.

$$\begin{aligned} \text{Now, } \frac{\partial CS}{\partial \hat{q}^*} &= \left( \frac{\partial CS}{\partial q^*} + \frac{\partial CS}{\partial \theta_0^*} \right) \frac{\partial \theta_0^*}{\partial \hat{q}^*} \left[ \frac{\partial \theta_0^*}{\partial \hat{q}^*} = \frac{\partial q^*}{\partial \hat{q}^*} \text{ from (19)} \right] \\ &= \left[ \bar{\theta} + aS^* - (1 + 2S^*)\theta_0^* \right] \frac{\partial \theta_0^*}{\partial \hat{q}^*}. \text{ (see Appendix 5)} \end{aligned}$$

Therefore,

$$\frac{\partial CS}{\partial \hat{q}^*} \frac{\partial \hat{q}^*}{\partial a} = \left[ \bar{\theta} + aS^* - (1 + 2S^*)\theta_0^* \right] \frac{\partial \theta_0^*}{\partial \hat{q}^*} \frac{\partial \hat{q}^*}{\partial a}.$$

From the simulation results given in section 2.4, again we can check that the first term in the multiplication is negative. The second term is negative (see (19)) but the third term is positive (see (24)). The net indirect effect of an increase in spillover parameter is also positive. As spillover parameter increases, the monopolist's strategy is to uplift foreign product quality because increase in quality difference reduces the cost of producing a given quality in the local country. Thus as spillover effect increases, indirect effect adds weight to direct effect in making positive impact on consumer surplus.

**Proposition 3:** *The higher the spillover effect on producing the local product quality, the higher will be the welfare in the local country.*

**Proof:** From the above analysis we obtain  $\frac{dCS}{da} > 0$ .

The economic intuition of the result is the following. As spillovers go up, the monopolist serves more and more people coming from the lower income group in local country. We know that for the local country the lower the income index, the higher will be the population density. So growth rate of increase in market size is positive. CS is positive for the new consumers. At the same time the old consumers will buy lower product quality at lower price. For them CS may be negative. The ultimate effect of increase in spillover parameter on welfare of the local country is positive. Gain in CS of new consumers outweigh the loss of CS of old consumers.

#### 4. CONCLUSION

In this paper we have discussed the scenario where an MNC serving a good quality product in its own (developed) country enters into the market of a developing country to serve the same product not produced there before. The developing country is characterized by uneven income distribution where as the income distribution in developed country is even. This difference in income distribution leads the MNC to choose a lower product quality for the developing country. However the MNC possesses a cost advantage for producing a lower product quality for the developed country as it can transfer the previous knowledge of producing a higher quality called spillover effect. The quality difference between the countries rises as spill over effect goes up. At the same time the market in the developed country shrinks and that in the developing country expands and the total profit of the MNC goes up. This explains why the MNCs are so eager to enter into the developing economies. On the other hand, the higher the spillover effect of an MNC, the higher the welfare of the local country is. This has one implication to the choice of entry of firms in a developing country. In case of perfect information, the local government should allow entry of those firms which have larger spillover effects, if local welfare is the immediate concern. However this analysis may be extended where the MNC faces a competition from a local firm in the developing country. Obviously in equilibrium two firms choose two different qualities with more market coverage. The quality differential would depend on the specification of cost function of the firms. The local firm may be less efficient in developing a new product quality appropriate under the new situation. Obviously in the absence of government intervention welfare of the developing country will be the sum of consumer surplus and net loss or gain in local firm's profit as MNC snatches a part of its market after entry. So welfare effect would be different from analysis in this paper.

## APPENDIX

**1. Equilibrium in Local and Foreign Country Market**

Total profit function of MNC as given in (14)

$$\pi = \left[ \hat{\theta}_0 \hat{q} \hat{S} - \frac{\hat{q}^2}{2} \hat{S} \right] + \left[ \theta_0 q S - \left\{ \frac{q^2}{2} - a(\hat{q} - q) \right\} S \right]. \quad (1a)$$

*Second stage*

The first order conditions of profit maximization as obtained from (1a) derivatives are:

$$\frac{\partial \pi}{\partial \theta_0} = -(1-S)q + \left\{ \frac{q^2}{2} - a(\hat{q} - q) \right\} \frac{1}{\theta_0} = 0, \text{ and } \frac{\partial \pi}{\partial q} = (\theta_0 - q - a)S = 0.$$

Simplification of these two conditions yields

$$\left\{ \frac{q^{*2}}{2} - a(\hat{q} - q^*) \right\} \frac{1}{\theta_0^*} = (1-S^*)q^*, \quad \text{and } \theta_0^* = q^* + a. \quad (1b)$$

The second order conditions are:

$$\frac{\partial^2 \pi}{\partial q^2} = -S < 0, \text{ and } \frac{\partial^2 \pi}{\partial \theta_0^2} = -q \frac{1}{\theta_0} - \left[ \left\{ \frac{q^2}{2} - a(\hat{q} - q) \right\} \frac{1}{\theta_0^2} \right].$$

This boils down to, after substitution from 1<sup>st</sup> order condition of (1b)

$$\frac{\partial^2 \pi}{\partial \theta^2} = -(2-S) \frac{q}{\theta_0} < 0.$$

The stability condition is assumed to hold

$$\Delta = \frac{\partial^2 \pi}{\partial q^2} \frac{\partial^2 \pi}{\partial \theta_0^2} - \frac{\partial^2 \pi}{\partial q \partial \theta_0} = \left( (2-S) \frac{q}{\theta_0} - S \right) S > 0.$$

*First Stage*

First order derivatives obtained from (1a) are :

$$\frac{\partial \pi}{\partial \hat{\theta}_0} = \hat{q}\hat{S} - \hat{\theta}_0 \hat{q}\hat{f} + \frac{\hat{q}^2}{2} \hat{f} = \left( \bar{\theta} - \hat{\theta}_0 - \hat{\theta}_0 + \frac{\hat{q}}{2} \right) \frac{\hat{q}}{k}, \quad [\because \hat{f} = \frac{1}{k} \text{ and } \hat{S} = \frac{\bar{\theta} - \hat{\theta}}{k}]$$

$$\frac{\partial \pi}{\partial \hat{q}} = \hat{\theta}_0 \hat{S} - \hat{q}\hat{S} + \frac{\partial z}{\partial \hat{q}},$$

where  $z = \theta_0 q S - \left[ \frac{q^2}{2} - a(\hat{q} - q) \right] S$ , and  $\frac{\partial z}{\partial \hat{q}} = \frac{\partial z}{\partial q} \frac{\partial q}{\partial \hat{q}} + \frac{\partial z}{\partial \theta_0} \frac{\partial \theta_0}{\partial \hat{q}} + \frac{\partial z}{\partial \hat{q}}$ .

After substitution of 1<sup>st</sup> order condition of second stage we obtain

$$\frac{\partial \pi}{\partial \hat{q}} = (\hat{\theta}_0 - \hat{q})\hat{S} + aS.$$

The first order conditions of profit maximization are

$$\bar{\theta} - 2\hat{\theta}_0^* + \frac{\hat{q}^*}{2} = 0, \quad \text{and} \quad (\hat{\theta}_0^* - \hat{q}^*)\hat{S}^* + aS^* = 0. \quad (1c)$$

Second order derivatives are:

$$\frac{\partial^2 \pi}{\partial \hat{\theta}_0^2} = -\frac{2\hat{q}^*}{k}, \quad \text{and} \quad \frac{\partial^2 \pi}{\partial \hat{q}^2} = -\hat{S}^* + \frac{\partial aS}{\partial \theta_0} \frac{\partial \theta_0}{\partial \hat{q}}.$$

This boils down to, after substitution from (2a)

$$\frac{\partial^2 \pi}{\partial \hat{q}^2} = -\hat{S}^* + \frac{a^2 S^*}{\theta_0^{*2} \Delta}.$$

Hence the stability condition is assumed to hold, i.e.,

$$\Omega = \frac{\partial^2 \pi}{\partial \hat{\theta}_0^2} \frac{\partial^2 \pi}{\partial \hat{q}^2} - \frac{\partial^2 \pi}{\partial \hat{\theta}_0 \partial \hat{q}} = \left\{ 2 \left( \hat{S}^* - \frac{a^2 S^*}{\theta_0^{*2} \Delta} \right) \frac{\hat{q}^*}{k} - \frac{\hat{q}^{*2}}{4k^2} \right\}$$

$$= \left\{ 2 \left( \hat{S}^* - \frac{a^2 S^*}{\theta_0^{*2} \Delta} \right) - \frac{\hat{q}^*}{4k} \right\} \frac{\hat{q}^*}{k} > 0$$

## 2. Comparative Static Effect of Increase in $\hat{q}$ on $\theta_0^*$ and $q^*$

Assuming  $a$  constant and differentiating totally each Equation of (1b) we obtain

$$\begin{aligned} -(2-S)q d\theta + [(q+a) - (1-S)\theta] dq &= a d\hat{q}, \\ d\theta - & \quad \quad \quad dq = 0. \end{aligned}$$

After substitution of equilibrium condition  $\theta_0 = q + a$  we may write

$$\begin{bmatrix} -(2-S)q & S\theta \\ 1 & -1 \end{bmatrix} \begin{bmatrix} \frac{\partial \theta}{\partial \hat{q}} \\ \frac{\partial q}{\partial \hat{q}} \end{bmatrix} = \begin{bmatrix} a \\ 0 \end{bmatrix}, \quad \therefore \frac{\partial \theta_0^*}{\partial \hat{q}} = -\frac{aS}{\theta_0 \Delta} < 0 \text{ and } \frac{\partial q}{\partial \hat{q}} = -\frac{aS}{\theta_0 \Delta} < 0. \quad (2a)$$

*Effect of Increase in  $a$  on  $\theta_0^*$  and  $q^*$*

Assuming  $\hat{q}$  is constant and differentiating (1b) we obtain

$$\begin{bmatrix} -(2-S)\frac{q}{\theta} & S \\ S & -S \end{bmatrix} \begin{bmatrix} \frac{\partial \theta_0^*}{\partial a} \\ \frac{\partial q^*}{\partial a} \end{bmatrix} = \begin{bmatrix} \frac{\hat{q}-q}{\theta} \\ S \end{bmatrix},$$

$$\therefore \frac{\partial \theta_0^*}{\partial a} = -\frac{[(\hat{q}-q) + \theta_0^* S] S}{\theta_0^* \Delta} > 0, \text{ and } \frac{\partial q^*}{\partial a} = -\frac{[(\hat{q}-q) + (2-S)q^*] S}{\theta_0^* \Delta} > 0. \quad (2b)$$

## 3. Comparative Static-Effect of Increase in $a$ on $\hat{q}^*$ and $\hat{\theta}_0^*$

Following the analysis of Appendix 2, from (1c) we may write

$$\begin{bmatrix} -\frac{2\hat{q}}{k} & \frac{\hat{q}}{2k} \\ \frac{\hat{q}}{2k} & -\left(\hat{S} - \frac{a^2 S}{\theta^2 \Delta}\right) \end{bmatrix} \begin{bmatrix} \frac{\partial \hat{\theta}_0^*}{\partial a} \\ \frac{\partial \hat{q}^*}{\partial a} \end{bmatrix} = \begin{bmatrix} 0 \\ -S \end{bmatrix},$$

$$\therefore \frac{\partial \hat{\theta}_0^*}{\partial a} = \frac{\hat{q}S}{2k\Omega}, \text{ and } \frac{\partial \hat{q}^*}{\partial a} = \frac{2\hat{q}S}{k\Omega}. \quad (3a)$$

#### 4. Effect of Increase in $a$ on the Total Profit

The first order derivative of total profit function (1a) w. r. t  $a$  is given by:

$$\begin{aligned} \frac{d\pi}{da} &= \frac{\partial \pi_F}{\partial \hat{\theta}_0} \frac{\partial \hat{\theta}_0}{\partial a} + \frac{\partial \pi_F}{\partial \hat{q}} \frac{\partial \hat{q}}{\partial a} + \frac{\partial \pi_L}{\partial \theta_0^*} \frac{\partial \theta_0^*}{\partial a} + \frac{\partial \pi_L}{\partial q} \frac{\partial q}{\partial a} + \left( \frac{\partial \pi_L}{\partial \theta_0^*} \frac{\partial \theta_0^*}{\partial \hat{q}} + \frac{\partial \pi_L}{\partial q} \frac{\partial q}{\partial \hat{q}} \right) \frac{\partial \hat{q}}{\partial a} \\ &+ \frac{\partial \pi_L}{\partial \hat{q}} \frac{\partial \hat{q}}{\partial a} + \frac{\partial \pi_L}{\partial a} = 0 + 0 + 0 + 0 + 0 + aS \frac{2\hat{q}S}{k\Omega} + (\hat{q} - q)S = aS \frac{2\hat{q}S}{k\Omega} + (\hat{q} - q)S > 0. \end{aligned}$$

#### 5. Effect of Increase in $a$ on the Consumer Surplus of Local Country

$$\frac{\partial CS}{\partial q^*} = \int_{\theta_0^*}^{\bar{\theta}} f(\theta) \theta d\theta - \theta_0^* S^* = \theta \Big|_{\theta_0^*}^{\bar{\theta}} - \theta_0^* S^* = \bar{\theta} - \theta_0^* - \theta_0^* S^*,$$

$$\text{and } \frac{\partial CS}{\partial \theta_0^*} = q^* \left[ -\theta^* f(\theta^*) - S^* + \theta^* f(\theta^*) \right] = -q^* S^*.$$

$$\therefore \left[ \frac{\bar{\theta} \int \alpha(\theta) f(\theta) d\theta}{d\theta^*} = -\alpha(\theta^*) f(\theta^*) \right].$$

*Direct Effect*



$$\frac{\partial CS}{\partial a} = \frac{\partial CS}{\partial q_0^*} \frac{\partial q^*}{\partial a} + \frac{\partial CS}{\partial \theta_0^*} \frac{\partial \theta^*}{\partial a} = \left[ (\bar{\theta} - \theta^* - \theta_0^* s^*) - \frac{\{(2 - s^*)q^* + (\hat{q}^* - q^*)\} s^*}{\theta_0^* \Delta} \right] \\ + \left[ (-q^* s^*) - \frac{\{(\hat{q}^* - q^*) + \theta_0^* s^*\} s^*}{\theta_0^* \Delta} \right].$$

(after substitution from (2a))

Ultimately we obtain after substitution from (2b)

$$\frac{\partial CS}{\partial a} = -\frac{S}{\theta_0^* \Delta} \left[ \left\{ \bar{\theta} + a s^* - (1 + 2s^*) \theta_0^* \right\} (\hat{q}^* - q^*) + \left\{ 2\bar{\theta} - 2\theta_0^* - (\bar{\theta} + \theta_0^*) s^* \right\} q^* \right].$$

*Indirect Effect*

$$\frac{\partial CS}{\partial \hat{q}^*} \frac{\partial \hat{q}^*}{\partial a} = \left( \frac{\partial CS}{\partial q^*} + \frac{\partial CS}{\partial \theta_0^*} \right) \frac{\partial \theta_0^*}{\partial \hat{q}^*} \frac{\partial \hat{q}^*}{\partial a} = (\bar{\theta} - \theta_0^* - (2\theta_0^* - a) s^*) \frac{\partial \theta^*}{\partial \hat{q}^*} \frac{\partial \hat{q}^*}{\partial a}.$$

$$[\because \theta^* = q^* + a \text{ from (1a)}]$$

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*Received July 16, 2010, Revised November 2, 2010, Accepted April 29, 2011.*