Product Quality in Different Markets and Cost Structure

Kiyoshi Matsubara*

June 2010

Abstract

This paper analyzes the behavior of monopoly firm serving its products to two countries. The main focus of this paper is on how the product-quality choice in different markets are related with the cost structure of the firm. First, This paper examines the effects of production and R&D costs on the product quality separately, and then discusses the general case where the both costs exists. This paper shows that if only production costs exist, providing different levels of product quality is optimal and that if only R&D costs exist, providing the same level of quality is optimal. About the general case, this paper shows the conditions with which the same-quality strategy is optimal in terms of utility and other parameters. As an application, this paper discusses the firm's decision on entry in a foreign market either by exports or FDI. The result is consistent with observations in emerging economies.

JEL Classification: F12, F23, O33.
Keywords: Product Quality, Different Markets, Costs of Quality.

*Financial support from College of Commerce, Nihon University is gratefully acknowledged.
College of Commerce, Nihon University. Mailing Address: 5-2-1 Kinuta, Setagaya, Tokyo 157-8570 Japan. Phone and Fax: +81-3-3749-6868. E-mail: matsubara.kiyoshi@nihon-u.ac.jp

1 Introduction

It is often said that many Japanese manufacturing firms are struggling in the markets of emerging economies, despite their high technology and product quality. Some people even argue that Japanese firms provide with unnecessarily high quality and/or many features by their products that are not demanded by the customers in those markets, resulting in their loss of competitiveness against their rivals. On the other hand, it is also asserted that Japanese consumers are so demanding that Japanese firms always brush up the quality of their products and services. These observations arise one question: how firms determine the quality of their products in each of different markets.

IO literature, pioneered by the seminal work by Mussa and Rosen (1978), discusses firm's decision on quality and price. The focus is, however, on how firms determine their price and quality in a market with different types of consumers, say, relatively quality-sensitive consumers and others. In such a market, revelation of consumers' type is important for the setting of quality and price. Another issue is how to formulate costs of product quality. On one hand, maintaining the product quality with more production may increase the costs. One the other hand, as another strand of IO literature suggests, a fixed spending not related with the quantity but quality such as R&D can be important.[1] In some studies of the trade literature, firms' ability other than productivity is introduced to the firm-heterogeneity model a la Melitz (2003).[2] However, their focus is on how to explain the relationship of firm heterogeneity with firms' operation in domestic/foreign markets, which is different from this paper's.

The purpose of this paper is to analyze the behavior of monopoly firm serving its products to two countries. Consumers in country 1 are assumed to be more quality sensitive than those in country 2 due to their higher income and other factors (Imagine a developed and developing countries as countries 1 and 2 respectively). The number of country 2 consumers is assumed to be higher than that in country 1, so the country 2 is also the important market for the monopoly firm, which is located in country 1. The expenditure of the firm consists of production and R&D costs. The main question in this paper is how the cost structure and other factors affect the firm's decision on the level of product quality in the two markets.

The contributions of this work is to relate the quality choice in different markets with the cost structure of the firm. This paper shows that whether supplying low-quality products in country 2 is profitable depends on how the product

[1]See Acharyya (2005) about a formula of production costs including product quality. Symeonidis (2003) analyzes oligopoly markets where firms perform R&D in vestments to improve the quality of their products, but the production costs are independent of quality.

[2]For instance, Hallak and Sivadasan (2009) develop a two-factor heterogeneous-firm model. They introduce a factor, which they call caliber, affecting the fixed costs of the product quality. They derive the cutoff function showing the minimum level of caliber for a given productivity necessary to survive in the market. On the plain of caliber and productivity, the cutoff function is a downward-sloping curve. By introducing fixed cost of exports and iceberg transport cost, they show the cutoff function of exporter. They show that two kinds of exporters, with low-productivity, high-caliber and high-productivity, low-caliber, may exist.

quality affects the profits, as well as utility and population parameters. Therefore, this paper provides some clue to understanding the behavior of developed-country firms operating in both developed and developing countries. For instance, many developed-country firms in IT industry establish R&D centers in emerging economies such as China and India. One reason is to utilize skilled workers in those countries, some argue, but others may be related with the results in this paper.

This paper examines the effects of production and R&D costs on the product quality separately, and then discusses the general case where the both costs exists. This paper shows that if only production costs exist, providing different levels of product quality is optimal and that if only R&D costs exist, providing the same level of quality is optimal. About the general case, this paper shows the conditions with which the same-quality strategy is optimal in terms of utility and other other parameters. As an application, this paper discusses the firm's decision on entry in country 2 market either by exports or FDI. The result is consistent with observations in emerging economies.

This paper is organized as follows. In section two, the basic setup of the model is shown. In section three, the firm's decision with two different markets is examined. Two cases are discussed separately; (1) no R&D costs, and (2) no production costs. In the each case, profits with the same quality level in the two markets and those with different levels are compared. Then, in section four, the general case is analyzed. Section five discusses firm's choice between exports and FDI. Section six concludes this paper.

2 Model

In this section, the basic setup of the model is described. A monopoly market in which both the quality and price of a good are important for consumers is considered. First, the utility of a representative consumer, which is used in the previous literature since Mussa and Rosen (1978), is assumed. Then, how the product quality is related with costs is discussed.

2.1 Consumer's Utility

Suppose that the utility function of a consumer is

$$U = aq - p,$$

where q is the quality of the good, p is the price, and a is a positive constant showing the degree of preference for the quality. The monopoly firm charges the price of aq for a given level of the quality q to take all the surplus from the consumer. If more than one type of consumer in terms of a exist in the market, such all-taking price setting is difficult for the firm. When the firm cannot identify the type of each consumer, some types of consumers are better off by consuming a package of $(a,\ q)$ that the firm does not want them to consume.[3] However, when discussing

[3] See Acharyya (2005) for such possibilities.

two different markets in this paper, these markets are assumed to be segregated in a sense that consumers in country 1 cannot buy products sold in country 2 and vice versa, which allows the firm to subtract all consumer surpluses in the each market. Therefore, any arbitrage activity such as parallel imports is excluded. This assumption makes the analysis tractable and allow the analysis of quality choice under various cost structures.

The next question is how the firm determines the level of the product quality. To answer this question, costs of the quality need to be specified.

2.2 Costs of Product Quality

Consider the following general form of the costs

$$C(x,q) = c(x,q) + F(q),$$

where x is the quantity produced. The first term is the production costs. It is assumed that for a given level of x, c increases as q increases, i.e., producing a higher-quality good costs more. Possible reasons are the necessity of more skilled workers both for production and sales, superior quality machines, and other forms of more sophisticated technology. The second term is the R&D costs, which does not depend on x. actually, any costs that are needed for the product quality and do not depend on the quantity produced may be included in the second term: marketing is an example. Therefore, "R&D costs" is just a expediential name of the costs having the above two characteristics.[4]

In this paper, the following cost function is assumed:

$$C(x,q) = \frac{1}{2}cq^2x + \frac{1}{2}dq^2,$$

where c and d are positive constants, capturing the impact of quality on costs through production and R&D respectively. With this cost function, the profits of the firm are

$$\pi = n\left(aq - \frac{1}{2}cq^2\right) - \frac{1}{2}dq^2, \tag{1}$$

where n is the number of consumers. From equation (1), it seems that production and R&D costs have different effects on the profits. To see that, the following two extreme cases (1) only production costs ($d = 0$) and (2) only R&D costs ($c = 0$) are examined separately.

In case (1), from the first order condition with respect to q, the optimal level of the quality is $\frac{a}{c}$. Similarly in case (2), the optimal level of q is $\frac{na}{d}$. The difference between these two cases is the effect of n, the number of consumers. The production

[4]Iyer and Kuksov (2010) develop a model of vertically differentiated market where consumers cannot observe the true quality of the product and the quality perceived by the consumers depends on both the true quality and other activities such as merchandizing and store atmospherics, which they call affect. Although in this paper the consumers can perceive the true quality of the product, "affect" may be interpreted as a part of factors composing product quality.

costs do not have a market-size effect while the R&D costs do. Even in the one-market case, the difference in the cost structure matters.

In the next section, two markets that are different in the number of consumers and also the preference for the quality are analyzed.

3 Two Different Markets

Suppose that two markets, country 1 (home) and country 2 (foreign), exist. Besides additional costs to sell in market 2 due to trade costs and others, the difference in the degree of quality evaluation between the consumers in the two markets is assumed as follows:

$$a = a_1 \geq a_2 = 1.$$

This assumption implies that the consumers in market 1 is more sensitive to the quality of the good they consume.

The monopoly firm's profits are the following.

$$\pi = n_1\left(aq_1 - \frac{1}{2}cq_1^2\right) - \frac{1}{2}dq_1^2 + n_2\left(q_2 - \frac{1}{2}cq_2^2 - t\right) - \frac{1}{2}dq_2^2, \tag{2}$$

where n_i, q_i, and t are number of consumers in market i, the product quality supplied in market i, and a unit extra cost in market 2 respectively. Besides the sensitiveness of the quality a_i, the two markets can be different in terms of the market size, measured by n_i. It is assumed that the production/sales costs are the same in the two markets, except for the trade costs in market 2, as well as the R&D costs, which makes the model simple.

Our focus is on whether supplying the same quality in the two markets is more profitable and how it is affected by the cost structure. About the R&D costs, it is assumed that if the firm supplies different level of quality in the each market, it must perform R&D separately by its local R&D center. This assumption means that if the firm supplies the same quality in the both markets, then the firm can save the R&D costs. As in the one-market case, first the two extreme cases of $d = 0$ and $c = 0$ are examined. Then the general case where both the production and R&D costs exist is discussed in the next section.

3.1 Case of Only Production Costs

Suppose that the R&D costs do not exist. Then, the firm's profits are as follows.

$$\pi = n_1\left(aq_1 - \frac{1}{2}cq_1^2\right) + n_2\left(q_2 - \frac{1}{2}cq_2^2 - t\right). \tag{3}$$

We compare the following two cases: (1) $q_1 = q_2 = q$ (common level of the product quality), and (2) q_1 may be different from q_2.

3.1.1 Same Quality Level in the Two Markets

The firm's profits are the following.

$$\pi = n_1\left(aq - \frac{1}{2}cq^2\right) + n_2\left(q - \frac{1}{2}cq^2 - t\right). \tag{4}$$

From the first order condition with respect to q, the optimal levels of the product quality and prices are

$$q^* = p_2^* = \frac{an_1 + n_2}{c(n_1 + n_2)}. \quad p_1^* = aq^*. \tag{5}$$

Inserting q^* into the profits (equation 4) yields

$$\pi^*(\text{common } q) = \frac{(an_1 + n_2)^2}{2c(n_1 + n_2)} - n_2 t. \tag{6}$$

3.1.2 Different Quality Levels

From the first order conditions with respect to q_1 and q_2, the optimal levels of the product quality and price in each of the two markets are

$$q_1^* = \frac{a}{c}. \quad p_1^* = aq_1^*. \quad q_2^* = p_2^* = \frac{1}{c}. \tag{7}$$

Note that $q_1^* \geq q^* \geq q_2^*$, implying that compared to the common quality case, consumers in country 1 get higher-quality products while consumers in country 2 get lower-quality ones. Inserting q^* into the profits (equation 4) yields

$$\pi^*(\text{different } q) = \frac{a^2 n_1 + n_2}{2c} - n_2 t. \tag{8}$$

3.1.3 Comparison of Profits of Two Quality Strategies

From equations (6) and (8), it is shown that

$$\pi^*(\text{different } q) - \pi^*(\text{common } q) = \frac{(a-1)^2 n_1 n_2}{n_1 + n_2} \geq 0. \tag{9}$$

Therefore, the profits with different levels of the product quality is higher than those with the common level, unless the consumers of the two markets have the same level of the quality sensitiveness, i.e. $a = 1$. The following proposition summarizes the result.

Proposition 1 *The optimal strategy for the monopoly firm is to assign different levels of product quality to each of the two markets, if only the production costs exist.*

However, this result does not hold in case where only the R&D costs exist, which is discussed in the next subsection. Again, profits in the two cases are compared.

3.2 Case of Only R&D Costs

Suppose that the production costs do not exist. Then, the firm's profits are as follows.

$$\pi = n_1 a q_1 - \frac{1}{2} d q_1^2 + n_2 q_2 - \frac{1}{2} d q_2^2 - n_2 t. \tag{10}$$

We compare the following two cases as in the case where only the production costs exist: (1) $q_1 = q_2 = q$ and (2) q_1 may be different from q_2.

3.2.1 Same Quality Level in the Two Markets

The firm's profits are the following.

$$\pi = (n_1 a + n_2)\, q - \frac{1}{2} d q^2 - n_2 t. \tag{11}$$

Compared to equation (10), in case of the common quality in the two markets, the firm may utilize the scale economy to save the R&D costs. Note that the coefficient for the quality cost (dq^2) is one half, not one. From the first order condition with respect to q, the optimal levels of the product quality and prices are

$$q^* = p_2^* = \frac{a n_1 + n_2}{d}. \quad p_1^* = a q^*. \tag{12}$$

Inserting q^* into the profits (equation 11) yields

$$\pi^*(\text{common } q) = \frac{(a n_1 + n_2)^2}{2d} - n_2 t. \tag{13}$$

3.2.2 Different Quality Levels

From the first order conditions with respect to q_1 and q_2, the optimal levels of the product quality and price in each of the two markets are

$$q_1^* = \frac{a n_1}{d}. \quad p_1^* = a q_1^*. \quad q_2^* = p_2^* = \frac{n_2}{d}. \tag{14}$$

As the single-market case shows, the optimal levels of quality depends on the market size n_i as well as the utility and cost parameters (a and d respectively). Inserting q^* into the profits (equation 10) yields

$$\pi^*(\text{different } q) = \frac{a^2 n_1^2 + n_2^2}{2d} - n_2 t. \tag{15}$$

3.2.3 Comparison of Profits of Two Quality Strategies

From equations (13) and (15), it is shown that

$$\pi^*(\text{common } q) - \pi^*(\text{different } q) = \frac{a n_1 n_2}{d} > 0. \tag{16}$$

Therefore, unlike the case where only the production costs exist, the profits with the common level of the product quality is higher than those with different level of it in the each market. The following proposition summarizes the result.

Proposition 2 *The optimal strategy for the monopoly firm is to assign the common level of product quality to each of the two markets, if only the R&D costs exist.*

In the next section, the general case where both the production and R&D costs exist is analyzed, based on the results in this section.

4 General Case

As in the last section, we compare the profits with the common level of the product quality with those with different levels.

The profits with the common level of the quality are

$$\pi = n_1\left(aq - \frac{1}{2}cq^2\right) + n_2\left(q - \frac{1}{2}cq^2 - t\right) - \frac{1}{2}dq^2. \tag{17}$$

From the first order condition with respect to q, the optimal levels of the product quality and prices are

$$q^* = p_2^* = \frac{an_1 + n_2}{c(n_1+n_2)+d}. \quad p_1^* = aq^*. \tag{18}$$

Inserting q^* into the profits (equation 17) yields

$$\begin{aligned}\pi^*(\text{common } q) &= \frac{(an_1+n_2)^2}{2\{c(n_1+n_2)+d\}} - n_2 t. \\ &= \frac{1}{2}\left\{\frac{a^2n_1^2}{c(n_1+n_2)+d} + \frac{n_2^2}{c(n_1+n_2)+d} + \frac{2an_1n_2}{c(n_1+n_2)+d}\right\} - n_2 t. \end{aligned}\tag{19}$$

The profits with the different quality levels are as in equation (2). From the first order conditions with respect to q_1 and q_2, the optimal levels of the product quality and prices are

$$q_1^* = \frac{an_1}{cn_1+d}. \quad p_1^* = aq_1^*. \quad q_2^* = p_2^* = \frac{n_2}{cn_2+d}. \tag{20}$$

Inserting q_1^* and q_2^* into the profits (equation 2) yields

$$\pi^*(\text{different } q) = \frac{1}{2}\left(\frac{a^2n_1^2}{cn_1+d} + \frac{n_2^2}{cn_2+d}\right) - n_2 t. \tag{21}$$

From equations (19) and (21), it is shown that

$$\begin{aligned}&\pi^*(\text{common } q) - \pi^*(\text{different } q) \\ &= \frac{n_1n_2}{2\{c(n_1+n_2)+d\}}\left\{2a - \left(\frac{cn_1}{cn_1+d}\cdot a^2 + \frac{cn_2}{cn_2+d}\right)\right\}.\end{aligned}\tag{22}$$

Inside the curly brackets, the first term, denoted by $f(a)$, is linear in a, the parameter of quality sensitiveness in country 1, while the second term, denoted by

$s(a)$, is a quadratic function of a. If $f(a)$ is greater than $s(a)$, then the profits with common quality level are higher than those with different levels, and vice versa.

Figure 1 describes how a and other variables affects the optimal quality strategy.[5] The most important result shown by Figure 1 is that a cutoff point of a exists: if $a < a^*$, $s(a) < f(a)$, and if $a \geq a^*$, $s(a) \geq f(a)$.[6] To understand the effects of various variables, the following comparative statics is helpful.

$$\begin{aligned}
\frac{\partial f(a)}{\partial a} &= 2, \quad \frac{\partial s(a)}{\partial a} = 2a \cdot \frac{cn_1}{cn_1 + d}. \\
\frac{\partial s(a)}{\partial c} &= \frac{a^2 dn_1}{(cn_1+d)^2} + \frac{dn_2}{(cn_2+d)^2}. \\
\frac{\partial s(a)}{\partial n_1} &= \frac{a^2 cd}{(cn_1+d)^2}. \\
\frac{\partial s(a)}{\partial n_2} &= \frac{cd}{(cn_2+d)^2}. \\
\frac{\partial s(a)}{\partial d} &= -\frac{a^2 cn_1}{(cn_1+d)^2} - \frac{cn_2}{(cn_2+d)^2} < 0.
\end{aligned}$$

Figure 1 shows that which quality strategy is better depends on the level of quality sensitiveness in country 1, a. The above comparative statics shows how the line $s(a)$ moves as each of the variables other than a changes. First, an increase in c, production cost parameter, shifts up $s(a)$, which decreases a^*. This production-cost effect gets larger as the R&D cost parameter d increases. Second, an increase in n_1, number of customers in country 1, rotates $s(a)$ counterclockwise and thus decreases a^*. Third, an increase in n_2, number of customers in country 2, shifts up $s(a)$, which decreases a^*. Note that increases in the number of customers in either countries decreases the cutoff value of a, although ways of $s(a)$'s moving are different between n_1 and n_2. Last, an increase in d, R&D cost parameter, rotates $s(a)$ clockwise and simultaneously shits it down, resulting an increase in a^*.

The following proposition summarizes the result.

Proposition 3 *Suppose that both the production and R&D costs exist. Then, a cutoff value of the utility parameter of country 1 consumer exists. If the parameter is lower than that, the optimal strategy is the common level of product quality. If it is higher than the cutoff value, the optimal strategy is the different levels of quality. The production cost parameter has a negative effect on the cutoff value while the R&D cost parameter has a positive one. Market size parameters have negative effects on the cutoff value.*

5 Application: Exports vs. FDI

So far, it is shown that the level of quality sensitiveness in Country 1 is important for the firm to determine its quality strategy. However, in the current setup, the

[5] In Figure 1, $c = 1$ and $d = n_1 = n_2 = 2$.

[6] $a^* = \frac{cn_1+d}{cn_1}\left(1 + \sqrt{\frac{c(n_1+n_2)d+d^2}{c^2 n_1 n_2 + c(n_1+n_2)d + d^2}}\right) > 1$, which is the solution for $f(a) = s(a)$.

unit trade cost t has no effect on the firm's decision, because the trade costs, n_2t, is the same for the both the common- and different-quality level cases. Actually, when the trade cost, including tariff and other trade barriers, is high, FDI may be more attractive than exports for firms entering foreign markets. In this section, the setup is slightly changed to analyze the firm's decision of plant location and quality level.

Suppose that in case of FDI, the firm can save the trade costs. Instead, it is assume that the firm can choose only the different-quality strategy with FDI and that it can choose only the common-quality strategy with exports. With FDI, the firm has R&D centers in both countries to adjust the quality level of its product in the each market, which is a plausible setup. The maximized profits with export, denoted by $\pi^*(\text{Exports})$, are the right hand side of the equation (19). The maximized profits with FDI, denoted by $\pi^*(\text{FDI})$, are the right hand side of the equation (21) plus the trade costs n_2t, because the firm needs not to pay for them. The difference in profits between the two strategies is

$$\pi^*(\text{Exports}) - \pi^*(\text{FDI}) = \frac{n_1 n_2}{2\{c(n_1+n_2)+d\}} \times \left\{2a - \left(\frac{cn_1}{cn_1+d}\cdot a^2 + \frac{cn_2}{cn_2+d}\right) - \frac{2\{c(n_1+n_2)+d\}\cdot t}{n_1}\right\}. \quad (23)$$

From equation (23), the level of unit trade cost equating the profits of the two cases, denoted by t^*, is derived.

$$\begin{aligned} t^* &= \frac{n_1}{2\{c(n_1+n_2)+d\}}\left(-\frac{cn_1}{cn_1+d}\cdot a^2 + 2a - \frac{cn_2}{cn_2+d}\right) \\ &= \frac{-cn_1^2}{2\{c(n_1+n_2)+d\}(cn_1+d)}\left\{a - \left(1+\frac{d}{cn_1}\right)\right\}^2 + \frac{d}{2c(cn_2+d)}. \end{aligned} \quad (24)$$

Figure 2 plots a t^* curve, which is a quadratic function of a, on (a,t) plane. If $a \in [1,\bar{a}]$ and $t < t_{Max} = \frac{d}{2c(cn_2+d)}$, exporting the common-quality product is the optimal strategy.[7] Otherwise, FDI with different-quality product is the best for the firm.

What are the effects of population and cost parameters on the optimal plant location and quality for the firm? First, an increase in n_2, number of consumers in country 2, shifts down the t^* curve, making FDI/different quality more likely. Note that when the t^* curve is shifted down, $\bar{a}$ decreases.

The effect of n_1, number of consumers in country 1, is rather subtle, because it depends on the level of a. The effect is as follows:

$$\frac{\partial t^*}{\partial n_1} = \frac{cn_1\left\{a - \left(1+\frac{d}{cn_1}\right)\right\}}{2\{c(n_1+n_2)+d\}^2(cn_1+d)}\left[(1-a)cn_2 - 2ad - \frac{acdn_2}{cn_1+d}\right] \quad (25)$$

Inside the square brackets, the first term is negative because $a \geq 1$, and thus the sum of the three terms is also negative. In the first fraction, the sign of the

[7] $\underline{a}$ and $\bar{a}$ are the solutions for $-\frac{cn_1}{cn_1+d}\cdot a^2 + 2a - \frac{cn_2}{cn_2+d} = 0$. $\bar{a}$ is equal to a^* in footnote 4. It is shown that $\underline{a} < 1$.

numerator depends on the level of a : it is positive if $a > 1 + \frac{d}{cn_1}$ and is negative otherwise. Therefore the overall effect of n_1 is negative if $a > 1+\frac{d}{cn_1}$ and is positive otherwise.

Figure 3 shows how the optimal strategy changes as n_1 increases. The t^* curve switches from the dotted line t_0^* to the solid line t_1^*. t_{max} is unchanged because it does not depend on n_1. Two special areas should draw an attention. One is the area labeled "Exports→FDI," the area with large a. If (a, t) is in this area, the optimal strategy is switched from exports to FDI by an increase in n_1. A similar result is in Proposition 3 (case when t is not important). However, the other area labeled "FDI→Exports," which has low a and high t, shows a different result. If (a, t) is in this area, the optimal strategy is switched from FDI to exports by an increase in n_1.

The effects of cost parameters may be either positive or negative:

$$\begin{aligned}\frac{\partial t^*}{\partial c} &= \frac{n_1^2\{(cn_1+d)(-cn_1+d)-c^2n_1n_2\}}{2\{c(n_1+n_2)+d\}^2(cn_1+d)^2}\left\{a-\left(1+\frac{d}{cn_1}\right)\right\}^2 \\ &\quad -\frac{d}{\{c(n_1+n_2)+d\}(cn_1+d)}\left\{a-\left(1+\frac{d}{cn_1}\right)\right\}-\frac{2cdn_2+d^2}{2c^2(cn_2+d)^2} \quad (26)\end{aligned}$$

$$\begin{aligned}\frac{\partial t^*}{\partial d} &= \frac{cn_1^2(2cn_1+cn_2+2d)}{2\{c(n_1+n_2)+d\}^2(cn_1+d)^2}\left\{a-\frac{(cn_1+d)^2}{cn_1(2cn_1+cn_2+2d)}\right\}^2 \\ &\quad +\frac{n_1(2c^2n_1n_2-d^2)[\{c^2(n_1+n_2)+2cd\}(n_1+n_2)+d^2]}{2c\{c(n_1+n_2)+d\}^2(2cn_1+cn_2+2d)(cn_2+d)^2} \quad (27)\end{aligned}$$

Production cost parameter, c, has a negative effect if $cn_1 > d$ and $a > 1+\frac{d}{cn_1}$. R&D cost parameter, d, has a negative effect if $2c^2n_1n_2 < d^2$ and $a < \frac{(cn_1+d)^2}{cn_1(2cn_1+cn_2+2d)}$.

The following proposition summarizes the result.

Proposition 4 *Suppose that the firm have two strategies to enter the country 2 market: (1) exports with common product quality and (2) FDI with different product quality. Then, a threshold curve of the unit trade cost exists. If the pair of the utility parameter of country 1 consumer and the unit trade cost is in the area below the threshold curve, then the firm chooses exports/common quality strategy. Otherwise, it chooses FDI/different quality strategy. The effects of cost parameters on the threshold curve depends on the utility parameter and which cost parameters are relatively larger. Depending on the level of utility parameter, market size parameters have opposite effects: the number of consumers in country 1 many have a positive effect while that of country 2 always has a negative one.*

One important difference between Proposition 3 and 4 is the effect of market size parameters. If the unit trade cost does not matter, growth of either markets makes different-quality strategy, i.e. FDI, more likely (Proposition 3). If the unit trade cost matters, on the other hand, the growth of country 1 market makes different-quality strategy more likely only when the difference in quality sensitiveness between the two market is large (Proposition 4). This result of Proposition 4 is consistent with observations in emerging markets. Firms from developed countries are reported not to sell the same products as they sell in their home countries. Rather, many argues that they sell cheaper products with lower quality or smaller volume: typical examples are consumer products such as detergent and bug killer. This is an example of different-quality strategy.

6 Conclusions

This paper analyzes the behavior of monopoly firm serving its products to two countries. This paper shows how the product quality choice in different markets are related with the cost structure of the firm. This paper first examines the effects of production and R&D costs on the product quality separately, and then discusses the general case where the both costs exists. This paper shows that if only production costs exist, providing different levels of product quality is optimal and that if only R&D costs exist, providing the same level of quality is optimal. About the general case, this paper shows the conditions with which the same-quality strategy is optimal in terms of utility and other other parameters. The result in the general case is changed when quality-choice problem is jointly discussed with exports-FDI choice.

One limitation of this paper is that welfare analysis is not meaningful. Because of market segregation, the monopoly firm takes all consumer surpluses in the both markets. The second limitation is the form of product differentiation. In this paper, the goods are assumed to be vertically differentiated. Thus horizontally-differentiated products are beyond the analysis of this paper.[8]

The third limitation, related with the first one, is that the two markets are monopolized. Morita and Nguyen (2009) develop a duopoly model where a north firm enters the south market either by exports or FDI and FDI spillovers exist. They assume that in the south market two types of consumers about their quality preferences. They perform comparative statics about a tariff rate, which the north firm must pay in case of exports. They show that a high tariff rate is not necessarily harmful for the southern country. Although their model is complicated due to consideration of consumers' rationality constraints and FDI spillovers, making the country 2 market duopoly but a single type of consumers is a possible future extension.

References

[1] Acharyya, Rajat, "Consumer Targeting under Quality Competition in a Liberalized Vertically Differentiated Market." *Journal of Economic Development* 30(1) (June 2005) 129-150.

[8] A quasi-linear utility function can deal with both vertical and horizontal differentiation (see Symeonidis 2003, for instance). However, with this type of utility, quantity is determined endogenously, which makes the analysis complicated.

[2] Hallak, Juan Carlos and Jagadeesh Sivadasan, "Firms' Exporting Behavior under Quality Constraints." *NBER Working Paper* 14928, April 2009.

[3] Iyer, Ganesh and Dmitri Kuksov, "Consumer Feelings and Equilibrium Product Quality." *Journal of Economics and Management Strategy*, Vol. 19, No. 1 (Spring 2010), 137-168.

[4] Melitz, M., "The impact of trade on intra-industry reallocations and aggregate industry productivity," *Econometrica*, 71(6) (2003), 1695-1725.

[5] Morita, Hodaka, and Xuan T. Nguyen, "FDI, Technology Spillover, and Vertical Product Differentiation," presented in Asia Pacific Trade Seminars (APTS) 2009, available at http://www.econ.hit-u.ac.jp/ trade/apts/.

[6] Mussa, Michael, and Sherwin Rosen, "Monopoly and Product Quality" *Journal of Economic Theory* 18 (1978) 301-317.

[7] Symeonidis, George. "Comparing Cournot and Bertrand equilibria in a differentiated duopoly with product R&D" *International Journal of Industrial Organization* 21 (2003) 39-55.

Figure 1: Quality Sensitiveness in Country 1 and Optimal Quality Strategy

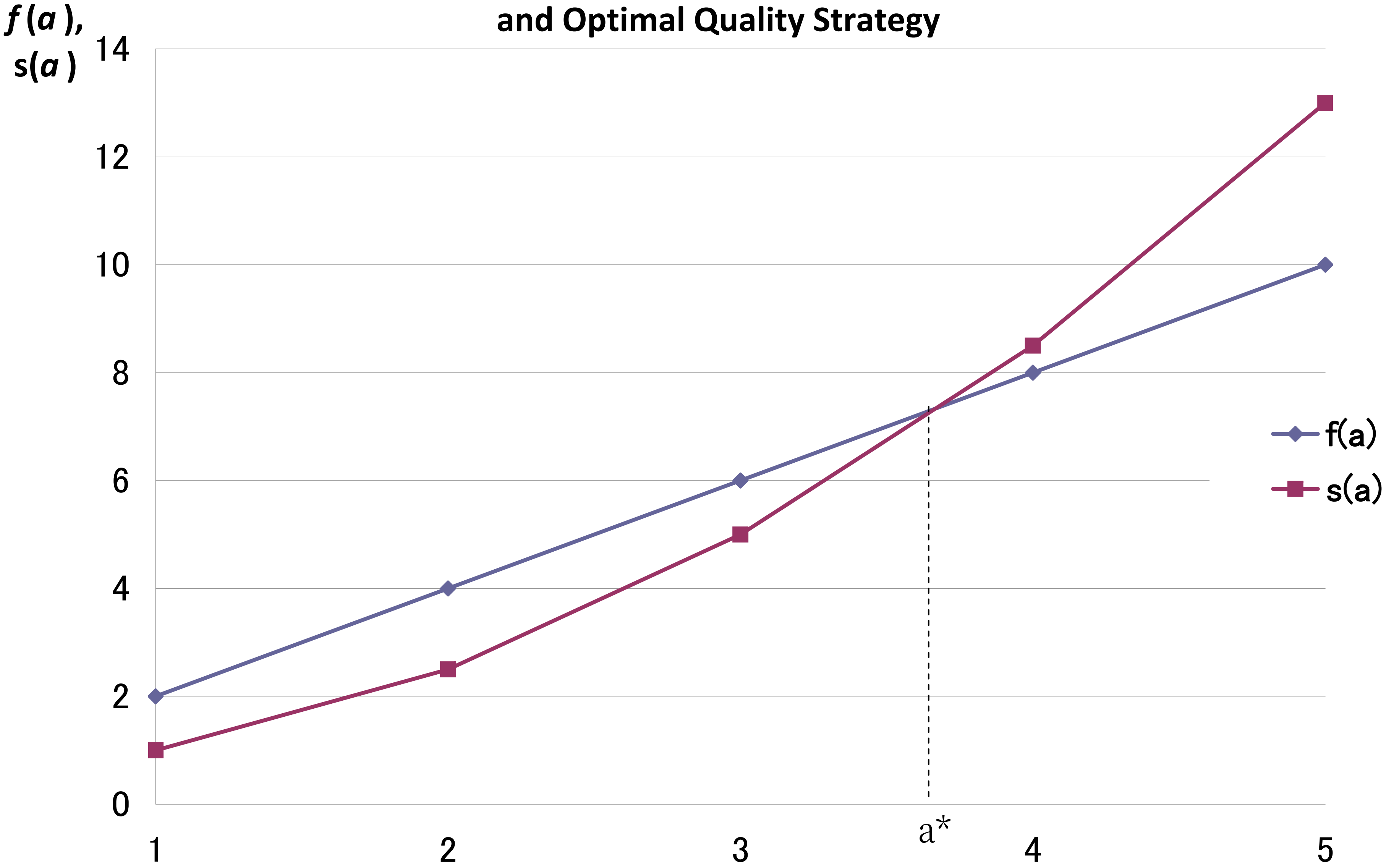

Figure 2: Quality Sensitivity in Country 1, Unit Trade Cost, and Optimal Plant Location/Quality

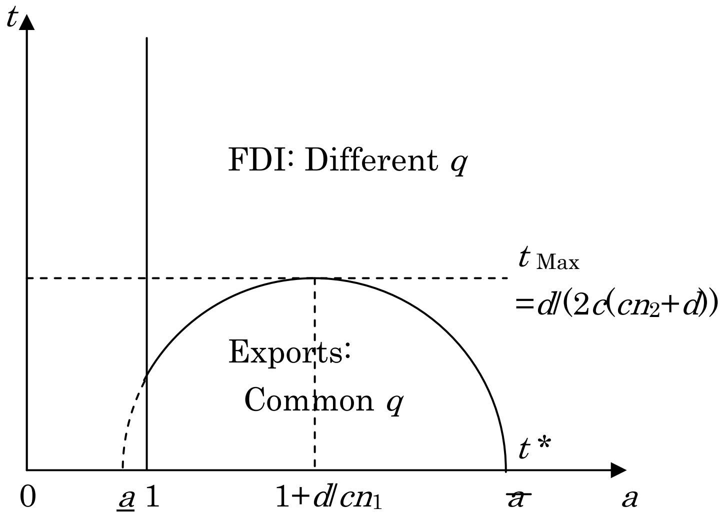

Figure 3: Effect of larger n_1