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Home-Market and Cost Effects of International Product-Quality Allocation

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Home-Market and Cost Effects of International Product-Quality Allocation

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Abstract

This paper analyzes the behavior of firms 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 and market conditions. About the cost structure, costs depending on quantity and quality (“production costs”) and those depending only on quality (“R&D costs”) are discussed. This paper examines the effects of production and R&D costs on the product quality in the monopoly markets separately, and then discusses two general cases: (1) two firms from different developed countries enter the developing-country market and (2) downward-sloping demand curve assuming a distribution of consumers in each country. This paper shows that if the effects of production costs or the home-market dominate, providing different levels of product quality is optimal and that if the effects of R&D costs or the developing-market dominate, providing the common level of quality is optimal.

JEL Classification: F12, F23, O33.

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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. On 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 firm(s) 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 firm(s), which is located in developed countries. The expenditure of the firm consists of costs depending quantity produced and product quality and those depending only on quality (the former is named "production costs" while the latter "R&D costs" in this paper). The main question in this paper is how the cost structure and other factors affect the firms' 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

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

²For 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.

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 cost structure 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 in the monopoly markets separately, and then discusses two general cases: (1) two firms from different developed countries and (2) downward-sloping demand curve assuming a distribution of consumers in each country. This paper shows that if the effects of production costs or the home-market dominate, providing different levels of product quality is optimal and that if the effects of R&D costs or the developing-market dominate, providing the common level of quality is optimal.

This paper is organized as follows. In section two, the basic setup of the model is described. In section three, the firm's decision in two different markets is examined. Three cases of different cost specification are discussed separately. In each case, profits with the common quality level in the two markets and those with different levels are compared. Then, in section four, the duopoly case is analyzed. Section five discusses the case with downward-sloping demand curve by assuming a distribution of consumers in each country. Section six concludes this paper.

2 Model

In this section, the basic setup of the model is described. Markets in which both the quality and price of a good are important for consumers are considered. First, the utility of a representative consumer 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. If the market is monopoly, the monopoly firm charges the price of aq for a given level of 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,

³See Acharyya (2005) for such possibilities.

when discussing 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. 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 cost depending on both quantity and quality, called “production costs” in this paper. 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 machines in a factory, and other forms of more sophisticated technology. The second term is the cost depending only on quality, called “R&D costs” in this paper. Actually, any costs that are needed for the product quality and do not depend on the quantity produced at the same time may be included in the second term: marketing is an example. Therefore, R&D costs as well as production costs is just a expediential name of the costs having the above characteristics.⁴

In this paper, the following three types of cost functions are discussed:

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

c and d are positive constants. The first type is a variant of the cost function specified by Acharyya (2005).⁵ It is quadratic in q , implying the convexity of the cost function in quality. Note that the first type does not have R&D cost term, which have scale effect as shown below. The third type has two quadratic terms of q , implying very strong convexity in quality. The second type is in the middle of the first and the third ones: it is convex in quality by R&D costs, but not by production costs. In the next section, two markets that are different in the number of consumers and also in the preference for the quality are analyzed, for each of the cost types.

⁴Iyer 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 atmosphere, which they call “affect”. Although in this paper the consumers can perceive the true quality of the product, affect may be interpreted as a kind of R&D costs.

⁵Acharyya (2005)’s specification is $C(x, q) = (\frac{1}{2}cq^2 + c_0)x$, where c_0 is a postivive constant. Because whether c_0 exists does not affect the results in this paper, it is omitted.

3 Two Different Markets

Suppose that two markets, country 1 (home) and country 2 (foreign), exist. The difference in the degree of quality evaluation between the consumers of 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. Another difference is population. Assume that

$$n = n_2 \geq n_1 = 1.$$

Therefore, which market is more important for firms depends on the relative magnitude of a and n . In this section, the case when the monopoly firm serves the two markets is analyzed. Duopoly, i.e. two-firm cases, are discussed in the next section.

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, i.e. both in countries 1 and 2. This assumption means that if the firm supplies the same quality in the both markets, then the firm can save the R&D costs, i.e. only one R&D center is needed. If the firm supplies the same-quality product to the both markets, such strategy is called “common quality” in this paper. If it supplies products with different levels of quality to the two markets, such strategy is called “different quality” in this paper.

3.1 Type 1: No R&D Costs

Suppose that the monopoly firm has type 1 costs. Then, the firm’s profits are as follows.

$$\pi = \left(aq_1 - \frac{1}{2}cq_1^2 \right) + n \left(q_2 - \frac{1}{2}cq_2^2 \right). \quad (1)$$

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 Common Quality Level in the Two Markets

The firm’s profits are the following.

$$\pi = \left(aq - \frac{1}{2}cq^2 \right) + n \left(q - \frac{1}{2}cq^2 \right). \quad (2)$$

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

$$q^* = p_2^* = \frac{a + n}{c(1 + n)}. \quad p_1^* = aq^*. \quad (3)$$

Inserting q^* into the profits (equation 2) yields

$$\pi^*(\text{common } q) = \frac{(a+n)^2}{2c(1+n)} = \frac{c(1+n)}{2}q^{*2}. \quad (4)$$

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

$$q_1^* = \frac{a}{c}, \quad p_1^* = aq_1^*, \quad q_2^* = p_2^* = \frac{1}{c}. \quad (5)$$

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. Note that this property does not always hold, depending on the type of costs. Inserting q_1^* and q_2^* into the profits (equation 1) yields

$$\pi^*(\text{different } q) = \frac{a^2 + n}{2c}. \quad (6)$$

3.1.3 Comparison of Profits of Two Quality Strategies

From equations (4) and (6), it is shown that

$$\pi^*(\text{different } q) - \pi^*(\text{common } q) = \frac{(a-1)^2n}{2c(1+n)} \geq 0. \quad (7)$$

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 the cost function is type 1 (no R&D costs).*

However, this result does not hold in case with type 2 costs, discussed in the next subsection.

3.2 Type 2 Costs

Suppose that the firm has type 2 costs. Then, the firm's profits are as follows.

$$\pi = \left(a - \frac{1}{2}c\right)q_1 - \frac{1}{2}dq_1^2 + n\left(1 - \frac{1}{2}c\right)q_2 - \frac{1}{2}dq_2^2. \quad (8)$$

We compare the following two cases as the type 1 cost case: (1) $q_1 = q_2 = q$ and (2) q_1 may be different from q_2 .

3.2.1 Common Quality Level in the Two Markets

The firm's profits are the following.

$$\pi = \left(a - \frac{1}{2}c\right)q + n\left(1 - \frac{1}{2}c\right)q - \frac{1}{2}dq^2. \quad (9)$$

Compared to equation (8), in case of the common quality in the two markets, the firm may utilize the scale economy. Note that the coefficient for the quality cost (dq^2) is one half, not one by the assumption about activities related with R&D costs. From the first order condition with respect to q , the optimal levels of the product quality and prices are

$$q^* = p_2^* = \frac{2(a+n) - c(1+n)}{2d}. \quad p_1^* = aq^*. \quad (10)$$

Note that q^* , the optimal level of quality in case of the common quality, is the sum of q_1^* and q_2^* , those in case of the different quality. It is like a excessive high-quality level provided by Japanese firms' in emerging markets, pointed out above. Inserting q^* into the profits (equation 9) yields

$$\pi^*(\text{common } q) = \frac{\{2(a+n) - c(1+n)\}^2}{8d} = \frac{dq^{*2}}{8}. \quad (11)$$

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

$$q_1^* = \frac{2a-c}{2d}. \quad p_1^* = aq_1^*. \quad q_2^* = p_2^* = \frac{n(2-c)}{2d}. \quad (12)$$

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 8) yields

$$\pi^*(\text{different } q) = \frac{(2a-c)^2 + n^2(2-c)^2}{8d} = \frac{d}{2}(q_1^{*2} + q_2^{*2}). \quad (13)$$

3.2.3 Comparison of Profits of Two Quality Strategies

From equations (11) and (13), it is shown that

$$\pi^*(\text{common } q) - \pi^*(\text{different } q) = \frac{(2a-c)(2-c)n}{8d} > 0. \quad (14)$$

Therefore, unlike the case of type 1 costs, i.e. no R&D costs, 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 the cost function is type 2.*

In the next subsection, the case of type 3 costs, where both the production and R&D costs are quadratic in quality, is analyzed.

3.3 Type 3 Costs

As in the last subsection, we compare the profits with the common level of the product quality with those with different levels in case of type 3 costs. The profits with the common level of the quality are

$$\pi = \left(aq - \frac{1}{2}cq^2 \right) + n \left(q - \frac{1}{2}cq^2 \right) - \frac{1}{2}dq^2. \quad (15)$$

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

$$q^* = p_2^* = \frac{a+n}{c(1+n)+d}. \quad p_1^* = aq^*. \quad (16)$$

Inserting q^* into the profits (equation 15) yields

$$\pi^*(\text{common } q) = \frac{(a+n)^2}{2\{c(1+n)+d\}}. \quad (17)$$

The profits with the different quality levels are as follows:

$$\pi = \left(aq_1 - \frac{1}{2}cq_1^2 \right) - \frac{1}{2}dq_1^2 + n \left(q_2 - \frac{1}{2}cq_2^2 \right) - \frac{1}{2}dq_2^2. \quad (18)$$

From the first order conditions with respect to q_1 and q_2 , the optimal levels of the product quality and prices are

$$q_1^* = \frac{a}{c+d}. \quad p_1^* = aq_1^*. \quad q_2^* = p_2^* = \frac{n}{cn+d}. \quad (19)$$

Inserting q_1^* and q_2^* into the profits (equation 18) yields

$$\pi^*(\text{different } q) = \frac{1}{2} \left(\frac{a^2}{c+d} + \frac{n^2}{cn+d} \right) = \frac{c+d}{2}q_1^{*2} + \frac{cn+d}{2}q_2^{*2}. \quad (20)$$

From equations (17) and (20), it is shown that

$$\begin{aligned} & \pi^*(\text{different } q) - \pi^*(\text{common } q) \\ &= \frac{n}{2\{c(1+n)+d\}} \left\{ \left(\frac{c}{c+d} \cdot a^2 + \frac{cn}{cn+d} \right) - 2a \right\}. \end{aligned} \quad (21)$$

Inside the large brackets, the first term, denoted by $s(a)$, is a quadratic function of a , the parameter of quality sensitiveness in country 1, while the second term, denoted by $f(a)$, is linear in a . If $s(a)$ is greater than $f(a)$, then the profits with different quality levels are higher than those with common quality level, and vice versa.

Figure 1 describes how a and other variables affects the optimal quality strategy.⁶ The most important result shown by Figure 1 is that a cutoff point of a

⁶Figure 1 describes a different case where $n_1 = n_2 = 2$, than the case analyzed so far, although the results are not changed from the case where $n_1 = 1$. The cost parameters are set as follows: $c = 1$ and $d = 2$.

exists: if $a < a^*$, $s(a) < f(a)$, and if $a \geq a^*$, $s(a) \geq f(a)$.⁷ In the former case, the common quality is optimal, while in the latter case, the different quality is optimal. To understand the effects of various variables, the following comparative statics is helpful.

$$\begin{aligned}\frac{\partial f(a)}{\partial a} &= 2, & \frac{\partial s(a)}{\partial a} &= 2a \cdot \frac{cn}{c+d}. \\ \frac{\partial s(a)}{\partial c} &= \frac{a^2 d}{(c+d)^2} + \frac{dn}{(cn+d)^2}. \\ \frac{\partial s(a)}{\partial n} &= \frac{cd}{(cn+d)^2}. \\ \frac{\partial s(a)}{\partial d} &= -\frac{(a^2+n)c}{(cn+d)^2} < 0.\end{aligned}$$

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 , number of customers in country 2, shifts up $s(a)$, which decreases a^* . Last, an increase in d , R&D cost parameter, rotates $s(a)$ clockwise and simultaneously shifts it down, resulting an increase in a^* .

The following proposition summarizes the result.

Proposition 3 *Suppose that the cost function is type 3. 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, c , has a negative effect on the cutoff value while the R&D-cost parameter, d , has a positive one. Market size n has a negative effect on the cutoff value.*

4 Two Developed-Country Firms

So far, it is shown that the level of quality sensitiveness in country 1, as well as the population in country 2, is important for the firm to determine its quality strategy. Also, it is shown that the cost structure of the firm matters as well. In this section, the case when two developed-country firms operate in the developing country as well as its own countries is examined. How the difference in the degree of quality valuation between the two developed countries affects each firm's strategy is the main focus in this session. Because it is assumed that the two firms have the same cost structure, a case when the two firms face the same "a" is not very interesting and thus not discussed.

⁷ $a^* = \frac{cn+d}{cn} \left(1 + \sqrt{\frac{2cdn+d^2}{cn+d}}\right) > 1$, which is the solution for $f(a) = s(a)$.

Suppose that there are two developed countries, 1 and 2, and one developing country, 3. One firm exists in countries 1 and 2 respectively. Developed-country firms, firms 1 and 2, operate in its own country and country 3, which has no domestic firm. In this setting, the two firms enjoy their monopoly in their own countries while the country 3 market is duopoly. With monopoly in two markets, setting its price equal to consumer's quality valuation makes the analysis very simple. However, with duopoly, such simplification does not work: country 3 consumers choose a product giving higher utility to them. Therefore, we restrict our analysis to the symmetric case in country 3, i.e. both firms supply the same product in terms of both quality and price. This implies that the country 3 market is equally divided by firms 1 and 2. Even with this restriction, some interesting results are shown below. We examine the behavior of the two firms with each of two different cost specifications: type 1 (convexity of q in production costs and no R&D costs) and type 2 (convexity of q in R&D costs). Without loss of generality, $a_1 > a_2$ is assumed hereafter.

4.1 Type 1 Costs: No R&D Costs

Suppose that a firm's cost function is $C(x, q) = \frac{cq^2x}{2}$ where x is quantity produced and q is the level of product quality. Then firm i ($i = 1, 2$)'s profits are as follows (subscripts indicate firms while superscripts indicate markets):

$$\pi_i = \left\{ a_i q_i^i - \frac{c}{2} (q_i^i)^2 \right\} + n_i \left\{ q_i^3 - \frac{c}{2} (q_i^3)^2 \right\}. \quad (22)$$

From the analysis of the monopoly case, different quality strategy gives higher profits to the both firms. The each firm supplies a product of quality $q_i^i = \frac{a_i}{c}$ in its own country, and does a product of the same quality $q^3 = \frac{1}{c}$ in country 3. Therefore, introducing duopoly in country 3 does not change the results with type 1 costs.

4.2 Type 2 Costs

Suppose that a firm's cost function is $C(x, q) = cqx + \frac{d}{2}q^2$. In the monopoly case, the common quality strategy is the optimal. This is true for firm 2, which faces lower quality valuation in its home country than firm 1. However, it is not always the case for firm 1. First, firm 1 must supply a product of quality $q^{3*} = \frac{2(a_2 - c) + n(1 - c)}{2d}$, which maximizes firm 2's profits with the common quality in markets 2 and 3. Therefore, firm 1's choice is not simply between the common and different quality. Rather, it is between (1) common quality of q^{3*} in markets 1 and 3, and (2) different quality levels. In choice 2, q_1 is chosen to maximize $(a_1 - c)q_1 - \frac{d}{2}(q_1)^2$. The optimal q_1 is $q_1^* = \frac{a_1 - c}{d}$. Because of the same quality constraint, $q_1^3 = q^{3*}$.⁸

In the duopoly case, firm 1's optimal strategy is not always the common quality. If the following inequality holds, it is the different quality:

$$L = \{2(a_2 - c) + n(1 - c)\} + c < a_1 = R(a_1). \quad (23)$$

⁸With choice 2, firm 1's R&D costs are $\frac{d}{2}\{(q_1^*)^2 + (q^{3*})^2\}$.

In Figure 2, L is a horizontal line while $R(a_1)$ is a 45 degree line.⁹ The two lines cross each other at $a_1^* = 2(a_2 - c) + n(1 - c)$. As inequality (23) shows, if $a_1 > a_1^*$, the different quality is optimal for firm 1. Otherwise, the common quality is optimal.

Therefore, in the duopoly case with type 2 costs, the optimal strategy for firm 1 is not always the common quality, although it is for firm 2, having less quality-sensitive consumers in its own country. Several points should be noted. First, in this case, firm 2 is a quality leader in a sense that it can choose the optimal common-quality level without concerning firm 1's behavior. This is possible because firm 2 is less restricted by its home-market consumers than firm 1, and also because it can utilize the scale economy of R&D costs. Second, for firm 1, two forces affect its choice on quality: home-market effect and scale effect of R&D costs. If the former dominates the latter, i.e. $a_1 > a_1^*$ in Figure 2, its optimal choice is the different quality. Otherwise, the common quality is optimal, although firm 1 is a quality follower in this case.

5 Demand Curve and Price-Quality Decision

So far, Mussa-Rosen type utility is used to describe consumers' preference for product quality. However, as the last section of duopoly analysis shows, this setup restricts the analysis substantially. Because consumers choose only one product giving highest utility to them, only the symmetric equilibrium, i.e. same price and quality is analyzed for country 3. To solve this problem, another variable capturing consumer's distribution about quality valuation is introduced. With this variable, θ , a consumer's utility in country j ($j = 1, 2$) is specified as follows:

$$u_j = a_j \theta q - p_j, \quad \theta \in [0, 1].$$

θ is assumed to distribute uniformly. A consumer with a higher θ values the quality more for a given price.¹⁰ A consumer with nonzero utility buys the product, which determines a cutoff value of θ :

$$u_j \geq 0 \Leftrightarrow \theta \geq \frac{p_j}{a_j q} \equiv \hat{\theta}_j.$$

Therefore, demand for the product in country j is:

$$x_j = n_j(1 - \hat{\theta}_j) - n_j \left(1 - \frac{p_j}{a_j q}\right)$$

With this demand curve, nontrivial price-quality setting may be analyzed. Again, a monopoly firm supplying its product to countries 1 and 2 is considered. Only

⁹In Figure 2, horizontal axis is a_1 and the vertical axis is the values of L and R . Because $a_1 > a_2$, the horizontal axis starts at a_2 , not zero.

¹⁰ θ may be interpreted to capture an income distribution of a country, because a higher θ is generally associated with a higher income. See Fajgelbaum et. al (2010) for further discussion.

the type 2 cost case is examined.¹¹ The monopoly firm's decision is two stages. In stage one, the firm determines its product quality strategy and the level(s) of quality. In stage two, it decides the prices. The model is solved by backward induction. When the firm chooses the different quality, its profits are as follows.

$$\pi_{d.q.} = (p_1 - cq_1) \left(1 - \frac{p_1}{aq_1}\right) - \frac{d}{2}q_1^2 + n(p_2 - cq_2) \left(1 - \frac{p_2}{q_2}\right) - \frac{d}{2}q_2^2. \quad (24)$$

First, from the first order conditions with respect to prices p_1 and p_2 , the optimal prices for given levels of quality is following.

$$p_1^* = \frac{(a+c)q_1}{2}. \quad p_2^* = \frac{(1+c)q_2}{2}. \quad (25)$$

Inserting p_1^* and p_2^* into profits (equation 24) yields the firm's objective function in stage 1:

$$\pi_{d.q.}^{stage1} = \frac{(a-c)^2q_1}{4a} - \frac{d}{2}q_1^2 + \frac{n(1-c)^2q_2}{4} - \frac{d}{2}q_2^2. \quad (26)$$

From the first order conditions with respect to levels of product quantity q_1 and q_2 , the optimal levels of quantity are as follows.

$$q_1^* = \frac{(a-c)^2}{4ad}. \quad q_2^* = \frac{n(1-c)^2}{4d}. \quad (27)$$

Inserting q_1^* and q_2^* into profits (equation 26) yields the firm's profits with different quality:

$$\pi_{d.q.}^* = \frac{(a-c)^4 - a^2n^2(1-c)^4}{32a^2d}. \quad (28)$$

When the firm chooses the common quality, its profits are as follows

$$\pi_{c.q.} = (p_1 - cq) \left(1 - \frac{p_1}{aq}\right) + n(p_2 - cq) \left(1 - \frac{p_2}{q}\right) - \frac{d}{2}q^2. \quad (29)$$

First, from the first order conditions with respect to prices p_1 and p_2 , the optimal prices for given levels of quality is following.

$$p_1^* = \frac{(a+c)q}{2}. \quad p_2^* = \frac{(1+c)q}{2}. \quad (30)$$

Inserting p_1^* and p_2^* into profits (equation 29) yields the firm's objective function in stage 1:

$$\pi_{c.q.}^{stage1} = \frac{(a-c)^2q}{4a} + \frac{n(1-c)^2q}{4} - \frac{d}{2}q^2. \quad (31)$$

From the first order conditions with respect to levels of product quantity q , the optimal levels of quantity are as follows.

$$q^* = \frac{(a-c)^2 + an(1-c)^2}{4ad}. \quad (32)$$

¹¹For the type 1 cost case, the profits with optimal prices are a fifth-order polynomial of q , which is difficult to solve analytically.

Note that q^* , the optimal level of quality in case of the common quality, is the sum of q_1^* and q_2^* , those in case of the different quality. This property is the same as in the case without θ . Inserting q_* into profits (equation 31) yields the firm's profits with the common quality:

$$\pi_{c.q.}^* = \frac{\{(a-c)^2 + an(1-c)^2\}^2}{32a^2d}. \quad (33)$$

It is shown that $\pi_{c.q.}^* > \pi_{d.q.}^*$. Therefore, the common quality gives higher profits to the monopoly firm, like the case without θ .

Another advantage of introducing θ is that the welfare analysis in an ordinal sense is possible: a consumer surplus in either country is not zero. Consumer surplus in country j ($j = 1, 2$) is defined as $CS_j \equiv \int_{\hat{\theta}_j}^1 (a_j\theta q - p_j)d\theta$.

The consumer surpluses of countries 1 and 2 are the following.

$$\begin{aligned} CS_1 &= \frac{q(a-c)^2}{8a}, \\ CS_2 &= \frac{q(1-c)^2}{8}. \end{aligned} \quad (34)$$

For both countries, the level of quality with the common quality is higher than that with the different quality. Therefore, in the monopoly case with type 2 costs, the common quality gives higher consumer surpluses to both home and foreign countries (countries 1 and 2 respectively). Because the common quality gives higher profits to the monopoly firm, it is the welfare maximizing quality allocation.

The following proposition summarizes the result.

Proposition 4 *Suppose that the consumers in countries 1 and 2 are distributed uniformly in each country and that the monopoly firm has type 2 costs. Then, the profit-maximizing and welfare maximizing strategy is the common quality, with higher level of quality than those of the different quality strategy.*

6 Conclusions

This paper analyzes the behavior of firms 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 and market conditions. About the cost structure, costs depending on quantity and quality (“production costs”) and those depending only on quality (“R&D costs”) are discussed. This paper examines the effects of production and R&D costs on the product quality in the monopoly markets separately, and then discusses two general cases: (1) two firms from different developed countries enter the developing-country market and (2) downward-sloping demand curve assuming a distribution of consumers in each country. This paper shows that if the effects of production costs or the home-market dominate, providing different levels of product quality is optimal and that if the effects of R&D costs or the developing-market dominate, providing the common level of quality is optimal.

At this point, this paper has not made success in relating the results with real-world examples, which is an important future work. Also, the duopoly in developing country with downward sloping curved is not examined yet, another possible direction for future research.

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

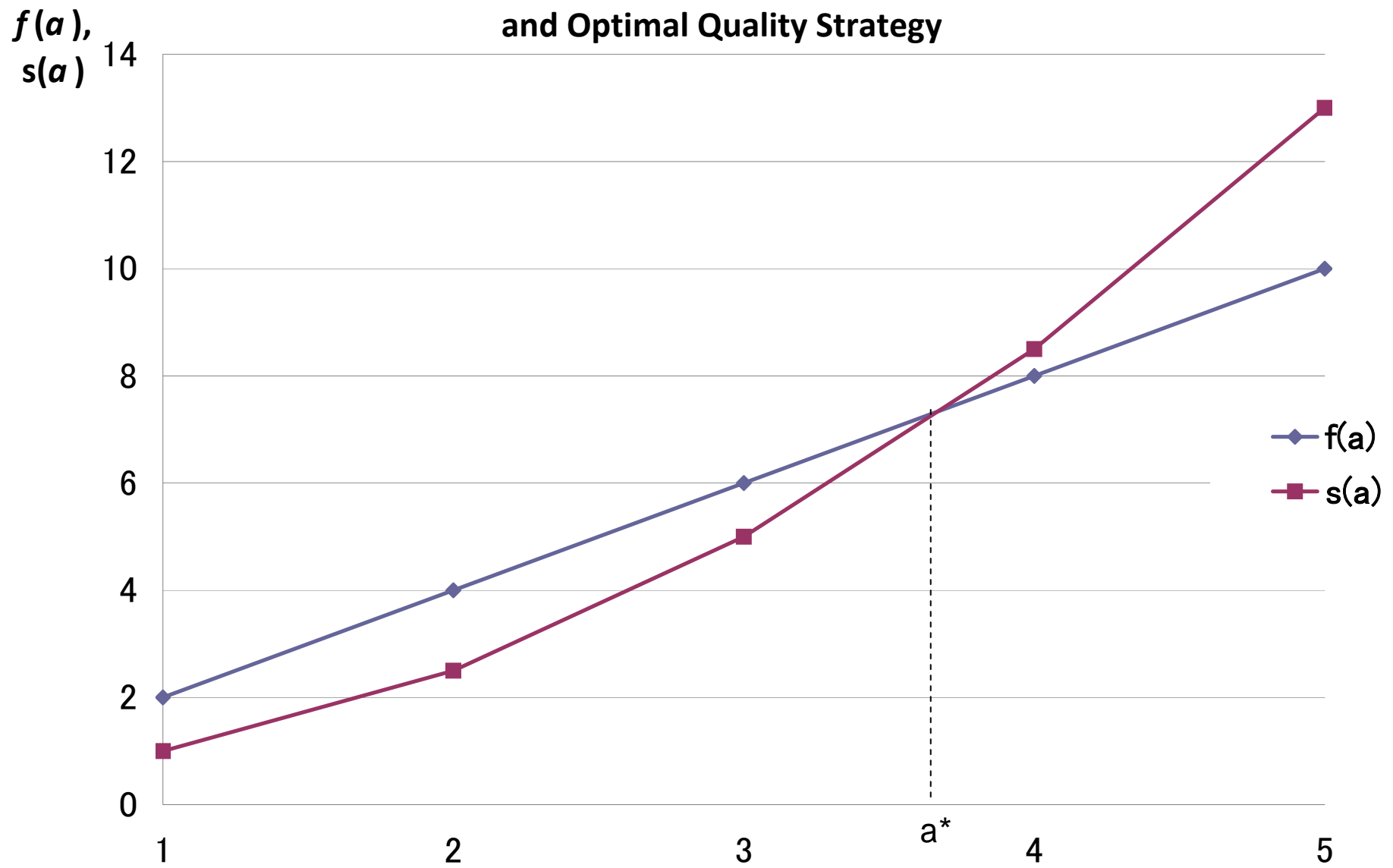


Figure 2: Firm 1's Optimal Strategy with Type 2 Costs and Duopoly in Country 3

