Opening Hours and Quality Choices

Yamada, Mai

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Mai Yamada†
Graduate School of Economics
Osaka University

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Abstract

Using a duopoly model with symmetric retailers, we show that retailer strategies regarding opening hours and quality choices of goods vary depending on the cost structure of the quality investment in goods. In the case of the cost remaining constant regardless of the length of opening hours, a retailer with longer opening hours chooses higher quality and charges higher prices. Conversely, in the case of the cost increasing proportional to opening hours, a retailer with longer opening hours chooses lower quality and charges lower prices. The latter case is consistent with the behavior of retailers in Japan.

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†Address: 1-7, Machikaneyama, Toyonaka, Osaka 560-0043, Japan. Email: maiyamada0820@gmail.com

1 Introduction

The choice of opening hours is an important issue for retailers such as supermarkets, department stores, and convenience stores. This is because opening hours may be effective as an instrument to differentiate a retailer from competitors. In fact, opening hours vary widely among retailers. In Germany, Halk and Träger (1999) demonstrate that some retailers stay open for longer hours and others for shorter hours under conditions of retail competitiveness. In Japan, opening hours vary with retail categories: department stores such as DAIMARU and high-end supermarkets such as SEIJO ISHII and KINOKUNIYA open for shorter hours; general merchandise stores such as AEON, Daiei, and Ito Yokado known as low-end supermarkets open for longer hours. Since the deregulation of opening hours under Japanese law, these low-end supermarkets have tended to expand their opening hours.[1]

In addition to opening hours, retailers determine the quality level of goods: *low* or *high quality*. Retailers may consider that the quality choice of goods, as well as the opening hours, is effective as a means of achieving a differentiation from other retailers. Indeed, in Japan, quality levels vary among retailers. department stores and high-end supermarkets sell high-quality goods, and general merchandise stores sell low-quality goods.

What factors determine the relationship between opening hours and quality choices of goods? Different types of cost structures of quality investments may have different effects on retailers' strategies regarding opening hours and quality choice of goods. Therefore, we investigate the relationship between opening hours and the quality choice of goods, considering different types of cost structures of quality investment.

In this paper, we define two types of cost structures of quality investment: the cost of quality investment remains constant regardless of the length of opening hours; and the cost of quality investment increases proportional to opening hours. For example, the cost of quality investment in processed foods, clothes, stationery, and advertising remains constant regardless of the length of opening hours. Retailers do not need the additional cost of investment per unit of time to retain the quality of their goods because the quality of their goods remains the same regardless of the length of opening hours. By contrast, the cost of quality investment in intangible goods such as concierge and security services, fresh foods such as fish and vegetables, and daily dishes increases proportional to opening hours. This is because that retailers need the additional cost of investment per unit of time to retain the quality of their goods.

We employ a simple model based on that of Inderst and Irmen (2005). We use a framework that endogenizes the choice of goods quality as well as the variable of opening hours.[2] We also consider two dimensions of horizontal product differentiation: the first dimension represents

[1] *Yomiuri Shimbun on March 24, 2004* shows that Japanese low-end supermarkets have expanded their opening hours since the deregulation of opening hours under Japanese law. For instance, a general merchandise store, AEON, has 364 branches, 159 of which are open 24 hours, and about 90 percent of which are open later than 11 p.m. In March 2004, 70 percent of the branches of the four major Japanese supermarkets (AEON, Daiei, Ito Yokado, and Seiyu) were open later than 11 p.m. In December 2004, 70 percent of the branches of Seiyu were open later than 11 p.m (*Nihon Keizai Shimbun*, December 11, 2004).

[2] As explained below, recent previous papers endogenize opening hours only.

space and the second represents time. We assume a Hotelling line as the spatial dimension, and consider two symmetric retailers on the Hotelling line, at both ends of the unit interval. Consumers are distributed uniformly on the line. To represent the time dimension, we assume that some consumers can buy anytime, while other consumers face time constraints and cannot buy beyond closing time. To model the constraints, we assume the length of time line which represents 24 hours. Consumers who face time constraints are uniformly located on the time line. Consumers who can buy anytime are located at an end of the time line. Each consumer can buy one or zero units of the product from a retailer that maximizes his/her utility. Both retailers incur the cost for quality investments. Also, both retailers charge a single price regardless of the opening hours. In these situations, the game runs as follows. In the first stage, retailers decide the opening hours and the quality of goods. In the second stage, retailers compete in prices.

As a result, we show that the relationship between opening hours and the quality of goods differs depending on the cost structures of quality investment. If the cost of quality investment remains constant regardless of the length of opening hours, a retailer with longer opening hours chooses higher quality. Then, that retailer charges higher prices. By contrast, if the cost of quality investment increases proportional to opening hours, the retailer with longer opening hours chooses lower quality. Then, that retailer charges lower prices. The latter is consistent with behavior of Japanese retailers. Mineo (2005) reveals that consumers recognize that high-end supermarkets such as SEIJO ISHII set shorter opening hours and charge higher prices than do low-end supermarkets such as AEON. In addition, many major convenience stores are open 24 hours in Japan. For example, SEVEN ELEVEN, LAWSON, Family Mart and others never close, which is a major advantage for these types of convenience stores. Previously, major convenience stores in Japan charged high prices instead of remaining open 24 hours because management costs increase with longer opening hours. However, major convenience stores witness price competition. Since 2005, convenience stores have charged lower prices for some goods, and ever since the largest convenience store (SEVEN ELEVEN) cut the prices of soft drinks in that same year, other convenience stores have followed (*Asahi shimbum*, 2005).

Previous literatures highlight the effects of the deregulation of opening hours on retail prices. Clemenz (1990) shows that the deregulation of opening hours may lead to lower prices by using the model of consumer search. This is because longer opening hours ease consumers' search activities. Morrison and Newman (1983) and Tanguay et al. (1995) assume that the access time to small retailers is low, and the access time to large retailers is high. Then, a large retailer needs to set a lower price in order to attract demand. With the deregulation of opening hours, the value of the access time for consumers decreases and the disadvantage of location for large retailers becomes less pronounced. Hence, large retailers attract demand charging higher prices. Small retailers set lower prices.

Unlike these previous studies, recent studies consider opening hours as a strategic variable among retailers. Inderst and Irmen (2005) analyze the effect of the deregulation of opening hours on retail prices in a model that endogenizes the choice of opening hours. As a result, they consider that retailers have incentives to use their opening hours as an instrument to relax price competition by setting asymmetric opening hours among competitors. They show that a retailer

stays open longer than another if the consumers' preference intensity for time is sufficiently high. Similarly, Shy and Stenbacka (2008) analyze how the deregulation of opening hours affects retail prices. They focus on the effect of consumers' shopping-hour flexibility on competition in opening hours and on prices by comparing consumers who can postpone or advance their shopping time with consumers who can either postpone or advance their shopping time but not both. They show that retailers with longer opening hours set higher prices and that asymmetric opening hours among competitors relax price competition.

Other previous literature focused on competition in opening hours by extending the model utilized by Inderst and Irmen (2005) and Shy and Stenbacka (2008). These two studies assumed that consumers are distributed uniformly on the time dimension. By contrast, Shy and Stenbacka (2006) analyze competition in opening hours by considering consumers who are distributed non-uniformly on the time dimension. They show that the voluntary provision of opening hours is inefficiently low from a social point of view.[3] Wenzel (2011) analyzes competition in opening hours in the framework of asymmetric firm types: a retail chain store and an independent retailer. He shows that decisions by retail chain stores regarding opening hours and those of independent stores depend significantly on their differences in efficiency.

Our study differs from the above recent studies in the following two important aspects. First, we consider quality choices of goods as well as opening hours to be strategic variables for retailers. Although some previous studies focused on only the relationship between opening hours and prices, our paper discovers an interesting relationship between opening hours and the quality of goods. Second, we define two types of cost structures of quality investment: the cost of quality investment remains constant regardless of the length of opening hours; and the cost of quality investment increases proportional to opening hours. By defining these, we can show that the relationship between opening hours and the quality of goods among retailers differs depending on the cost structures of quality investment.

In the rest of the paper, Section 2 introduces the model, Section 3 shows the results, Section 4 discusses the paper and finally, section 5 concludes the paper.

2 The Model

The model presented here is based on that of Inderst and Irmen (2005).[4] We consider two dimensions of horizontal product differentiation: the first dimension represents space and the second represents time.

To represent the first dimension, we consider a continuum of consumers to be distributed uniformly on a Hotelling line segment $[0, 1]$ with mass 1. The location of an arbitrary consumer indexed by $x \in [0, 1]$ is associated with his/her preferences. There are two symmetric competing retailers in this market. Let x_i $(i \in 1, 2)$ be the location of firm i. The retailers are located at

[3] Clemenz (1994) shows that a monopolist maintains opening hours that are longer than the social optimal level. He also shows that opening hours may not represent the social optimal level under perfect equilibrium.

[4] We simplify the setting concerning disutility of consumers in the time dimension, but allow for a continuous choice of opening hours. We show that their main insights remain valid in this continuous choice setting.

either end of the unit interval. Retailer 1 is located at 0 and retailer 2 is located at 1.

To represent the second dimension, we assume the existence of two types of consumers. Type 1 consumers can buy at any time; that is, they can adjust their shopping hours. By contrast, type 2 consumers face time constraints and cannot buy beyond closing time; that is, they cannot adjust their shopping hours. To model the time constraints, we use a linear city that is similar to that in Cancian et al.(1995)[5], which uses a duopoly setting Hotelling model with a directional constraint.[6] We assume that the length of the time line is 1. We denote by y the point of consumers on the time line located at a distance from 0. Let $y_i (i \in 1, 2)$ be the location of retailer i. Each retailer chooses its opening hour y_i in view of its impact on price competition. In this model, y_i represents the closing time of retailer i. For instance, if all retailers stay open until $y_i = 5/6$, then consumers on the line from 5/6 to 1 cannot buy any goods. We suppose that type 2 consumers are uniformly located on the line and type 1 consumers are located at $y = 0$. Also, let $K \in [1/2, 1)$ be the mass of type 1 consumers and $1 - K$ be that of type 2 consumers.[7]

Consumers have a conditional indirect utility function $V_i(x, y), i = 1, 2$. If a consumer buys from retailer i, his/her utility is equal to

$$V_i(x, y) = \begin{cases} S + q_i - p_i - t(x - x_i)^2 & \text{if } y \leq y_i, \\ 0 & \text{if } y > y_i, \end{cases}$$

where S and q_i denotes the gross surplus all consumers enjoy from a retailer, and q_i is quality and p_i is the price charged by retailer i. A consumer living at $x \in [0, 1]$ incurs a transportation cost of $t(x - x_i)^2$ when the consumer purchases the product from retailer i. The second dimension (time) does not affect the indirect utility but determines whether or not a consumer can buy the product from retailer i. Consumers have unit demands, i.e., each consumes one or zero units of the product. We assume that S is so large that every consumer consumes one unit of the product. Each consumer buys a product from a retailer that maximizes its indirect utility. Each retailer is constrained to charge a single price, regardless of the shopping time.[8]

Each retailer incurs an investment cost for quality. Our paper defines two types of cost structures of quality investment: the cost of quality investment remains constant regardless of the length of opening hours; and the cost of quality investment increases proportional to opening hours. First, the cost structure of quality investment which remains constant regardless of the length of opening hours is

$$I(q_i) = r{q_i}^2 \quad i = 1, 2, \tag{1}$$

[5]To consider a TV schedule problem, they consider a duopoly setting Hotelling model with a directional constraint. In their model, a consumer can move in only one direction on the Hotelling line. The directional constraint represents time. For instance, if a consumer locates at 8 p.m., he/she can watch a TV program after 8 p.m. but cannot watch it before 8 p.m.

[6]Using a Hotelling model, Nilssen (1997) considers an asymmetric directional constraint.

[7]This is because we assume that there are more consumers who can buy at anytime than consumers who face time constraints and cannot adjust their shopping hours. Also, we consider this assumption to meet second order condition, $\frac{\partial^2 \pi_i}{\partial q_i^2} < 0$.

[8]As mentioned in Inderst and Irmen (2005), high menu costs may justify this assumption.

where $r > 0$ represents the parameter of investment costs for quality. This equation (1) represents that the cost of quality investment does not depend on the length of opening hours. We take processed foods, clothes, stationery, and advertising as an example of goods with this cost structure. The quality of their goods remains the same regardless of the length of opening hours. Thus, the cost of quality investment in their goods is fixed regardless of the length of opening hours. Retailers do not need the additional cost of investment per unit of time to retain the quality of their goods even if they expand their opening hours. Second, the cost structure of quality investment increasing proportional to opening hours is

$$I(q_i) = [K + (1 - K)y_i]rq_i{}^2 \quad i = 1, 2. \tag{2}$$

In the equation (2), $K \times rq_i{}^2$ is the fixed costs and $(1 - K)y_i \times rq_i{}^2$ is the additional costs that retailers must pay for maintaining the quality level when opening hours are extended. Also, the equation (2) represents that the cost of quality investment depends on the length of opening hours. For example, the cost of quality investment in intangible goods such as concierge and security services, fresh foods, and daily dishes apply to this cost structure. The quality of their goods do not remain constant all the day. Thus, retailers need the additional cost of investment per unit of time to retain the quality of their goods if they expand their opening hours.

The game runs as follows. In the first stage, retailers simultaneously determine their location in time y_i and choose their quality q_i. In the second stage, after observing all the retailers' locations in time and their choices of quality, each retailer simultaneously determines its price p_i.

3 Equilibrium

To derive the equilibrium outcome in each case of the cost structure of quality investment in goods, we suppose that the opening hour of retailer 1 is larger than or equal to that of retailer 2; that is, $0 \leq y_2 \leq y_1 \leq 1$. In this case, three categories of consumers exist: (i) consumers who are able to buy from retailers 1 and 2 (category 1, $0 \leq y \leq y_2$) ; (ii) consumers who are only able to buy from retailer 1 (category 2, $y_2 < y \leq y_1$); and (iii) consumers who cannot buy a good (category 3, $y_1 < y$).

The mass of category 1 is $K + (1 - K)y_2$, that of category 2 is $(1 - K)(y_1 - y_2)$, and that of category 3 is $(1 - K)(1 - y_1)$. Given quality and prices, the indifferent consumer in category 1 is

$$\bar{x} = \frac{(q_1 - q_2) - (p_1 - p_2) + t}{2t}. \tag{3}$$

In both cases of the cost structure of quality investment in goods, the profit functions of each retailer are

$$\pi_1 = p_1[(1 - K)(y_1 - y_2) + ((1 - K)y_2 + K)\bar{x}] - I(q_1), \tag{4}$$

$$\pi_2 = p_2[((1 - K)y_2 + K)(1 - \bar{x})] - I(q_2). \tag{5}$$

where $\bar{x}$ is given by (3). In both cases of the cost structure of quality investment in goods, the first-order conditions lead to

$$p_1 = \frac{q_1 - q_2}{3} + \frac{t[(4y_1 - y_2)(1-K) + 3K]}{3(1-K)y_2 + K}, \tag{6}$$

$$p_2 = \frac{q_2 - q_1}{3} + \frac{t[(1-K)(2y_1 + y_2) + 3K]}{3(1-K)y_2 + K}. \tag{7}$$

Substituting p_1 and p_2 from (6) and (7) into $\bar{x}$ from (3), we have

$$\bar{x} = \frac{q_1 - q_2}{6t} - \frac{t[(2y_1 - 5y_2)(1-K) - 3K]}{6((1-K)y_2 + K)}. \tag{8}$$

On the basis of these results, we analyze retailers' strategies regarding opening hours and choices of quality in the two cases of the cost of quality investment in goods.

3.1 The cost structure of quality investment remaining constant regardless of the length of opening hours

In this section, we analyze the case where the cost of quality investment remains constant regardless of the length of opening hours. Substituting p_1 and p_2 from (6) and (7) and $\bar{x}$ from (8) into (4) and (5), we have

$$\pi_1 = \frac{[K((q_1 - q_2) + 3t) + (1-K)(t(4y_1 - y_2) + y_2(q_1 - q_2))]^2}{18t(K + (1-K)y_2)} - rq_1^2, \tag{9}$$

$$\pi_2 = \frac{[K((q_2 - q_1) + 3t) + (1-K)(t(2y_1 + y_2) + y_2(q_2 - q_1))]^2}{18t(K + (1-K)y_2)} - rq_2^2. \tag{10}$$

Differentiating π_i $(i = 1, 2)$ with respect to y_i, we have the following three patterns of corner solution: (1) retailer 1 opens for longer hours and retailer 2 opens for shorter hours, $y_1 = 1$, $y_2 = 0$; (2) both retailers open for shorter hours, $y_1 = 0$, $y_2 = 0$; (3) both retailers open for longer hours, $y_1 = 1$, $y_2 = 1$.

By examining whether each retailer has the incentive to deviate from opening hours in each pattern, we can lead to the following lemma (the proof is presented in the Appendix):

lemma 1

If the cost of quality investment in goods remains constant regardless of the length of opening hours, one retailer locates at $y = 1$ and the other retailer locates at $y = 0$ in equilibrium.

A retailer who could earn more profit by deviating would want to change the length of the opening hours. In the all patterns, we have $\frac{\partial \pi_1^*}{\partial y_1} > 0$, $\frac{\partial \pi_2^*}{\partial y_2} < 0$. In pattern (1), both retailers have no incentive to deviate from locating at $y_1 = 1$, $y_2 = 0$. In pattern (2), retailer 1 has an incentive to deviate from locating at $y = 0$. In pattern (3), retailer 2 has an incentive to deviate from locating at $y = 1$. Thus, the only equilibrium is pattern (1): retailer 1 opens for longer hours and retailer 2 opens for shorter hours. This lemma presents the robustness of Inderst and Irmen (2005). One retailer locating at $y = 1$ (retailer 1) targets consumers who face time

constraints and the other retailer locating at $y = 0$ (retailer 2) targets consumers who can buy at anytime.

We now discuss how this location strategies affect quality. We derive quality of each retailer under the equilibrium as[9]

$$q_1^* = \frac{K - 3rt(4 - K)}{6r(K - 9rt)}, \tag{11}$$

$$q_2^* = \frac{3rt(2 + K) - K}{6r(9rt - K)}. \tag{12}$$

From the second-order conditions, $rt > \frac{K}{9}$, we can get the relationship of quality: $q_1^* > q_2^*$. Considering this relationship in (6) and (7), the relationship of prices is $p_1^* > p_2^*$. Also, the profits of retailer 1 are larger than those of retailer 2. Then, we have the following proposition.

Proposition 1

The quality level of a retailer who locates at $y = 1$ is higher than that of a retailer who locates at $y = 0$. Then, the price of a retailer who locates at $y = 1$ is higher than that of a retailer who locates at $y = 0$. The profits of a retailer who locates at $y = 1$ are larger than those of a retailer who locates at $y = 0$.

A retailer with longer opening hours (retailer 1) chooses higher quality levels and charges higher prices. The relationship between opening hours and prices is equivalent to Inderst and Irmen (2005) and Shy and Stenbacka (2008). The intuition of lemma 1 and proposition 1 is the following. Retailer 1, who commits to opening for longer hours, has a better chance to earn more profits. Because the cost of quality investment remains constant regardless of the length of opening hours, investing in quality of goods does not represent a cost pressure for retailer 1, even with extended opening hours. Thus, retailer 1 promotes investments in quality of goods to obtain demand. Besides, retailer 1, targeting consumers who face time constraints, can receive monopoly rents and set higher prices. Conversely, retailer 2, who commits to opening for shorter hours, has less chance to earn profits. Promoting investments in quality is a cost pressure for retailer 2. Therefore, retailer 2 does not increase quality investments. Instead, retailer 2 can meet the high level of demand of the non-constrained consumers by charging lower prices. This is because the consumers who can buy at any time compare the two retailers. The heterogeneity of opening hours acquires the function of market segmentation.

3.2 The cost structure of quality investment increasing proportional to opening hours

In this section, we analyze the case where the cost of quality investment in goods increases proportional to opening hours. Substituting p_1 and p_2 from (6) and (7) and $\bar{x}$ from (8) into (4) and (5), the profit function of each retailer is given by

$$\pi_1 = \frac{[K((q1 - q2) + 3t) + (1 - K)(t(4y_1 - y_2) + y_2(q_1 - q_2))]^2}{18t(K + (1 - K)y_2)} - [K + (1 - K)y_1]rq_1^2 \tag{13}$$

[9]From the first-order conditions and reaction functions, a retailer's quality is a strategic substitute.

$$\pi_2 = \frac{[K((q_2 - q_1) + 3t) + (1 - K)(t(2y_1 + y_2) + y_2(q_2 - q_1))]^2}{18t(K + (1 - K)y_2)} - [K + (1 - K)y_2]rq_2^2 \quad (14)$$

Differentiating π_i $(i = 1, 2)$ with respect to y_i, we have the following three patterns of a corner solution as the previous subsection: (1) retailer 1 opens for longer hours and retailer 2 opens for shorter hours, $y_1 = 1$, $y_2 = 0$; (2) both retailers open for shorter hours, $y_1 = 0$, $y_2 = 0$; (3) both retailers open for longer hours, $y_1 = 1$, $y_2 = 1$.

By examining whether each retailer has the incentive to deviate from opening hours in each pattern, we can lead to the following lemma (the proof is presented in the Appendix):

lemma 2

Even in cases where the cost of quality investment in goods increases proportional to opening hours, one retailer locates at $y = 1$, and the other retailer locates at $y = 0$ in equilibrium.

In the all patterns, we have $\frac{\partial \pi_1^*}{\partial y_1} > 0$, $\frac{\partial \pi_2^*}{\partial y_2} < 0$. As in the case where the cost of quality investment in goods remains constant regardless of the length of opening hours, only pattern (1) is equilibrium. In patterns (2) and (3), one of the two retailers has an incentive to deviate from locating at $y = 1$ $(y = 0)$ because the retailer can earn more profit by deviating. Lemma 2 also shows the robustness of Inderst and Irmen (2005).

We now discuss how this location strategy affects quality choices among retailers. We derive quality in the equilibrium as[10]

$$q_1^* = \frac{3rt(4 - K) - 1}{3r(18rt - 1 - K)} \quad (15)$$

$$q_2^* = \frac{3rt(2 + K) - K}{3rK(18rt - 1 - K)} \quad (16)$$

From the second-order conditions, $rt > \frac{1}{9}$, we can get the relationship $q_1^* < q_2^*$. Considering this relationship in (6) and (7), the relationship of prices is $p_1^* < p_2^*$. The profits of retailer 1 are larger than those of retailer 2 as seen in previous subsection. Then, we have the following proposition.

Proposition 2

The quality level of a retailer who locates at $y = 1$ is lower than that of a retailer who locates at $y = 0$. The price of a retailer who locates at $y = 1$ is lower than that of a retailer who locates at $y = 0$. The profits of a retailer who locates at $y = 1$ are larger than those of a retailer who locates at $y = 0$.

Unlike the previous case, a retailer with longer opening hours (retailer 1) will lower the quality level and charge lower prices. The intuition of lemma 2 and proposition 2 is the following. In the previous case that the cost of quality investment in goods remains constant regardless of the length of opening hours, retailer 1 who commits to open for longer promotes investments in quality of goods to increase demand. However, in the case where the cost of quality investment

[10]From the first-order conditions and reaction functions, a retailer's quality level is a strategic substitute.

in goods increases in proportion to the length opening hours, retailer 1 who open for longer hours feels a cost pressure if investments in quality are promoted. Thus, retailer 1 lower quality levels of goods. Instead, retailer 1 obtains demand by setting lower prices. However, retailer 1 has a better chance to earn profits than retailer 2 because retailer 1 has committed longer opening hours. As a result, the profits of retailer 1 are greater than those of retailer 2. Conversely, retailer 2, with shorter opening hours, has a reduced chance to earn profits. However, the promotion of investments in quality is not a cost pressure for retailer 2. Thus, retailer 2, who commits to shorter opening hours, has an incentive to increase quality levels of goods, leading to charging higher prices. As in the previous case, the heterogeneity of opening hours acquires the function of market segmentation.

4 Discussion

On the basis of our results, we demonstrate the implications for management under the deregulation of opening hours. We assume that there are two symmetric retailers in a market. If a retailer commits first to opening for longer hours, that retailer can earn more profits regardless of the differences in the cost structures of quality investment. In the case that quality investment costs increases proportional to opening hours, by intuition, all retailers may have an incentive to open for shorter hours, but we show that a retailer with longer opening hours can earn more profits. However, in this case, a retailer with longer opening hours must choose lower quality in order to obtain more profits. This means that the retailer can benefit even without efforts to increase quality investment. On the other hand, in the case where the quality investment cost remains constant regardless of opening hours, a retailer with longer opening hours must choose higher quality. This means that the retailer needs to make an effort to increase quality investment to obtain more profits.

Our paper assumes that the cost of quality investment in intangible goods such as concierge, security, and cleaning service, fresh foods, and daily dishes increases proportional to opening hours. In this case, we show that a retailer with longer opening hours chooses lower quality and charges lower prices. In Japan, there is a difference in the quality levels of their goods between stores with shorter opening hours and supermarkets with longer opening hours. For example, the quality levels of security and cleaning service at department stores such as DAIMARU and high-end stores such as SEIJO ISHII with shorter opening hours are considerably higher, so they charge higher prices. By contrast, general merchandise stores such as AEON, Daiei, and Ito Yokado with longer opening hours lower the quality levels of security and cleaning service, so they can set lower prices. Thus, proposition 2 is consistent with all Japanese retailers.

We assume that each retailer is constrained to charge a single price regardless of the opening hours. However, some retailers implement "time services", in which some goods of a supermarket become cheaper during certain hours. In other words, some retailers actually change the prices of fresh foods and daily dishes according to the time of day. In this paper, we assume that menu costs are high for retailers. However, with the advent of computerized management of price labels, retailers can change their prices of goods easily and cost effectively. In a future study,

considering the system of time services, we will reexamine retailers' strategies regarding opening hours and quality choices of goods.

5 Conclusion

This paper examines competition among retailers with respect to the choices of opening hours and quality. We employ a duopoly model with symmetric firms. The basic setting is based on that in Inderst and Irmen (2005). We focus on the relationship of opening hours and choices of quality between two retailers under the deregulation of opening hours. Our results depend on the cost structure of quality investment in goods. If retailers invest in goods with the cost structure of quality investment remaining constant irrespective of the length of opening hours, a retailer with longer opening hours chooses higher quality goods and then he/she charges higher prices. On the other hand, if retailers invest in goods with the cost of quality investment increasing proportional to opening hours, a retailer with longer opening hours chooses lower quality goods and then he/she charges lower prices. Also, the profit of a retailer with longer opening hours is larger than that of a retailer with shorter opening hours, regardless of the differences in the cost structures of quality investment.

Appendix

Proof of Lemma 1

We examine whether retailers have incentive to deviate in each pattern. In the pattern (1), we have:

$$q_1^* = \frac{K - 3rt(4-K)}{6r(K-9rt)} \tag{17}$$

$$q_2^* = \frac{3rt(2+K) - K}{6r(9rt-K)} \tag{18}$$

Substituting q_1^* and q_2^* in (17) and (18) into the first-order condition with respect to y_i and considering the second-order condition with respect to q_i, $rt > \frac{K}{9}$, we have:

$$\frac{\partial \pi_1^*}{\partial y_1} = \frac{4(1-K)t(K-3rt(4-K))}{3K(K-9rt)} > 0 \tag{19}$$

$$\frac{\partial \pi_2^*}{\partial y_2} = \frac{(1-K)t(27(K-2)(K+2)(rt)^2 - 6K(K-4)rt - K^2)}{6K^2(K-9rt)^2} < 0 \tag{20}$$

Thus, both retailers have no incentive to deviate because retailer 1 wants to open for longer and retailer 2 wants to open for shorter. That is, $y_1 = 1$ and $y_2 = 0$ are the equilibrium. Also, in the pattern (2), we have:

$$q_1^* = \frac{K}{6r} \tag{21}$$

$$q_2^* = \frac{K}{6r} \tag{22}$$

Substituting q_1^* and q_2^* in (21) and (22) into the first-order condition with respect to y_i, we have:

$$\frac{\partial \pi_1^*}{\partial y_1} = \frac{4}{3}(1-K)t \ > 0 \tag{23}$$

$$\frac{\partial \pi_2^*}{\partial y_2} = -\frac{1}{6}(1-K)t \ < 0 \tag{24}$$

Thus, retailers 2 have no incentive to deviate because he/she wants to open for shorter. However, retailer 1 has incentive to do because he/she wants to open for longer. That is, $y_1 = 0$ and $y_2 = 0$ are not the equilibrium. Finally, in the pattern (3), we have:

$$q_1^* = \frac{1}{6r} \tag{25}$$

$$q_2^* = \frac{1}{6r} \tag{26}$$

Substituting q_1^* and q_2^* in (25) and (26) into the first-order condition with respect to y_i, we have the same result as (23) and (24). Thus, retailers 1 has no incentive to deviate because he/she wants to opens for longer. However, retailer 2 has incentive to do and he/she wants to open for shorter. That is, $y_1 = 1$ and $y_2 = 1$ are not the equilibrium. Thus, the only equilibrium is that retailer 1 locates at $y_1 = 1$ and retailer 2 locates at $y_2 = 0$, and then the quality in equilibrium are (17) and (18). Also, the quality in equilibrium are greater retailer 1 than retailer 2, $q_1^* > q_2^*$.

Proof of Lemma 2

We examine whether retailers have incentive to deviate in each pattern. In the pattern (1), we have:

$$q_1^* = \frac{3rt(4-K)-1}{3r(18rt-1-K)} \tag{27}$$

$$q_2^* = \frac{3rt(2+K)-K}{3r(18rt-1-K)} \tag{28}$$

Substituting q_1^* and q_2^* in (27) and (28) into the first-order condition with respect to y_i, we have:

$$\frac{\partial \pi_1^*}{\partial y_1} = \frac{(-1+K)(K+6(K^2-8K-4)rt+9(K^3-16K^2+40K+80)rt^2+1296(K-4)rt^3)}{9Kr(1+K-18rt)^2} \tag{29}$$

$$\frac{\partial \pi_2^*}{\partial y_2} = \frac{(1-K)(-K^2+12K^2rt+9(-9K^2+8K+4)rt^2+(162K^2-648)rt^3)}{9K^2r(1+K-18rt)^2} \tag{30}$$

Considering the second-order condition with respect to q_i, $rt > \frac{1}{9}$, we have:

$$\frac{\partial \pi_1^*}{\partial y_1} > 0 \tag{31}$$

$$\frac{\partial \pi_2^*}{\partial y_2} < 0 \tag{32}$$

Thus, both retailers have no incentive to deviate because retailer 1 wants to open for longer and retailer 2 wants to open for shorter. That is, $y_1 = 1$ and $y_2 = 0$ are the equilibrium. Also, in the pattern (2) and (3), we have:

$$q_1^* = \frac{1}{6r} \tag{33}$$

$$q_2^* = \frac{1}{6r} \tag{34}$$

Substituting q_1^* and q_2^* in (33) and (34) into the first-order condition with respect to y_i and considering the second-order condition, $rt > \frac{1}{9}$, we have:

$$\frac{\partial \pi_1^*}{\partial y_1} = \frac{1}{36}(-1+K)(\frac{1-48rt}{r}) \ > 0 \tag{35}$$

$$\frac{\partial \pi_2^*}{\partial y_2} = \frac{(-1+K)(1+6rt)}{36r} \ < 0 \tag{36}$$

Thus, in the pattern (2), retailers 2 have no incentive to deviate because he/she wants to open for shorter. However, retailer 1 has incentive to do because he/she wants to open for longer. That is, $y_1 = 0$ and $y_2 = 0$ are not the equilibrium. Finally, in the pattern (3), retailer 1 has no incentive to do because he/she wants to open for longer. On the other hand, retailer 2 has incentive to do because he/she wants to open for shorter. That is, $y_1 = 1$ and $y_2 = 1$ are not the equilibrium. The only equilibrium is that retailer 1 locates at $y_1 = 1$ and retailer 2 locates at $y_2 = 0$ even in the case where the investment cost for quality increases proportional to the length of opening hours.

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