Opening Hours, Store Quality, and Social Welfare

Yamada, Mai

Osaka University

18 May 2014

Opening Hours, Store Quality, and Social Welfare*

Mai Yamada†
Graduate School of Economics
Osaka University

January 23, 2018

Abstract

This paper examines retailer's strategies related to opening hours, store quality, and price. We consider a scenario in which the investment in store quality is more costly for longer opening hours. This scenario is suitable for a case where a retailer invests in quality of service such as concierge service and security service in order to increase customers' convenience during business hours. We show that a retailer with shorter opening hours chooses higher service quality and charges lower prices. We also examine the impact of the liberalized and the regulated opening hours on social welfare. We find that the liberalized opening hours is desirable in view of social welfare because service quality and demand in the liberalized opening hours are greater than those in the regulated opening hours.

JEL Classification: D21; L51; R32;

Keywords: Opening hours; Location; Multi-dimensional product differentiation; Duopoly

*All remaining errors are my own. Comments welcome.

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

1 Introduction

This paper examines whether the liberalized opening hours in the retail sector is socially desirable. The degree of liberalization varies to a large extent. In Europe such as France and Germany, there is a tendency to relax the regulation of opening hours in the retail sector in order to gain tourism demand. On the other hand, in Korean, the regulation of opening hours in the retail sector has been strengthened to protect the retail industry since 2012.

In Japan, there is no explicit regulation of opening hours in the retailer sector. Many Japanese retail stores open for longer. They targets workers who cannot buy at day-time. In 2014, 86.2% of Japanese convenience stores are open 24 hours a day. About 50% of Japanese general merchandise store are open during night-time (see Table 1).[1] However, recently, there is an opinion that opening hours should be regulated to protect the retail industry.

Category	# stores	less than 12 hours	12 to 14 hours	14 to 24 hours	24 hours
General merchandise store	1413	339	422	597	55
Grocery store	14768	5994	5086	2373	1315
Convenience store	35096	-	-	4852	30244

Table 1: Liberalized opening hours in Japanese retail sector (in 2014)

Which is better for society, the regulated or the liberalized opening hours? How does it affect retail strategies related to opening hours, store quality, and price? To address these issues, we provide a symmetric duopoly model based on that of Inderst and Irmen (2005).

The basic structure of the model is as follows. There are two dimensions of product differentiation: the first dimension represents location and the second represents time. To represent the first dimension, we assume a Hotelling line, and consider two symmetric retailers at both ends of the unit interval. Consumers are distributed uniformly on the Hotelling line. To represent the second dimension, we assume a time line, and consider that the two retailers choose their closing time on the time line. Consumers with time constraints are uniformly located on the time line, and they cannot buy beyond closing time of the two retailers. On the other hand, consumers without time constraints are located at the initial point of the time line, and they can buy at any time and compare the two retailers. Each consumer can buy one or zero unit of the product from a retailer that maximizes his/her utility. Retailers charge a single price, regardless of their opening hours. The game runs as follows. In the first stage, retailers decide their opening hours and store quality. In the second stage, retailers compete in prices.

We assume that each retailer invests in store quality to improve consumers' gross value for a retailer. We consider two scenarios of the investment in store quality: the investment in quality of product; the investment in quality of service for customers' convenience. Service for customers' convenience is, for instance, concierge service that employees of the retail store answer customers' questions during opening hours, and security service to ensure customer safety during opening hours. The investment in quality of service for customers' convenience is more costly for longer opening hours. Because of the increased of customers due to extended opening hours, retailers must incur the additional investment in order to maintain quality of service for customers' convenience during extended opening hours. On the other hand, the cost of the investment in quality of product is independent of opening hours. Because quality

[1] Table 1 is based on the report released by *Ministry of Economy, Trade, and Industry* on March 9, 2016.

of product does not change over time, retailers not need to incur the additional investment in order to maintain quality of product during extended opening hours.

We find that opening hours are asymmetric in equilibrium: one retailer opens for longer, another retailer does for shorter. This result consistents with Inderst and Irmen (2005). Store quality and price in equilibrium depend on what retailers invest in. If retailers invest in quality of product, a retailer with longer opening hours sets higher quality of product and higher price. This result may be consistent with the behavior of Japanese major convenience stores such as *Seven-Eleven Japan Co., Ltd.* Because they increase the investment in private-label products, quality and prices of private-label products tend to be higher than those of manufacturer products. On the other hand, if retailers invest in quality of service for customers' convenience, a retailer with shorter opening hours sets higher service quality and lower price.

We also find that, in terms of social welfare, the regulated opening hours is not desirable because of the decreased in store quality and demand. This holds regardless of whether retailers invest in quality of product or in quality of service for customers' convenience in the strore. Although Japanese government considers the regulatory policy on opening hours to protect the retail industry, this paper suggests that the liberalized opening hours is preferable for consumers and retailers.

Several theoretical literatures focus on the effects of the deregulated opening hours on retail prices (Morrison and Newman, 1983; Clemenz, 1990; Tanguay et al., 1995).[2] However, these papers do not consider opening hours as a strategic variable among retail stores. Since 2000, several papers have endogenized opening hours of retailers in oligopoly models (Inderst and Irmen, 2005; Shy and Stenbacka, 2008).[3] Extending the model of Inderst and Irmen (2005), we incorporate the investment in store quality to improve a consumer's gross value for a retailer, which have not been considered in previous related papers.

The remainder of the paper is organized as follows. Section 2 presents the model set-up. Section 3 presents the equilibrium in the liberalization of opening hours and Section 4 does the equilibrium in the regulation of opening hours. Section 5 shows the impact on social welfare. Section 6 discusses, and Section 7 concludes the paper.

2 Model Set-up

The model presented here is based on that of Inderst and Irmen (2005).[4] We consider two dimensions of product differentiation: the first dimension represents location 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 consumer $x \in [0, 1]$ 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 either end of the unit interval. Retailer 1 is located at 0 and retailer 2 is located at 1. A consumer locating at $x \in [0, 1]$

[2] Empirical literatures also examine the effect of deregulated opening hours on retail prices. Kay and Morris (1987) perform simulation by using UK data, and show that retailers charge lower prices under the liberalization of opening hours. On the other hand, Tanguay et al., (1995) show that in Quebec, Canada, the liberalized opening hours lead to higher retail prices in large stores.

[3] The related models are extended by taking into account heterogeneous retailers (Wenzel, 2011) and customer loyalty for retailers (Flores and Wenzel, 2016). Wenzel (2011) shows that the liberalized opening hours can improve social welfare.

[4] We simplify the setting of disutility of consumers in the time dimension, but allow for a continuous choice of opening hours. The main insights in Inderst and Irmen (2005) remain valid in this continuous choice setting.

incurs a transportation cost, $t(x - x_i)^2$, when purchasing products from retailer i, where t is a positive constant.

To represent the second dimension, we assume that there are two types of consumers. Type 1 consumers can buy at any time. In contrast, type 2 consumers face time constraints, and thereby, cannot buy beyond closing time. To model time constraints, we use a linear city that is similar to that in Cancian et al. (1995). 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 is represented by 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.[5] We consider a time line of length 1, and 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. 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 assume that type 2 consumers are uniformly located on the line and that type 1 consumers are located at $y = 0$. Let K be the mass of type 1 consumers and $1 - K$ be that of type 2 consumers. The bold line in Fig.1 shows the mass of type 1 consumers, K (see Fig.1).

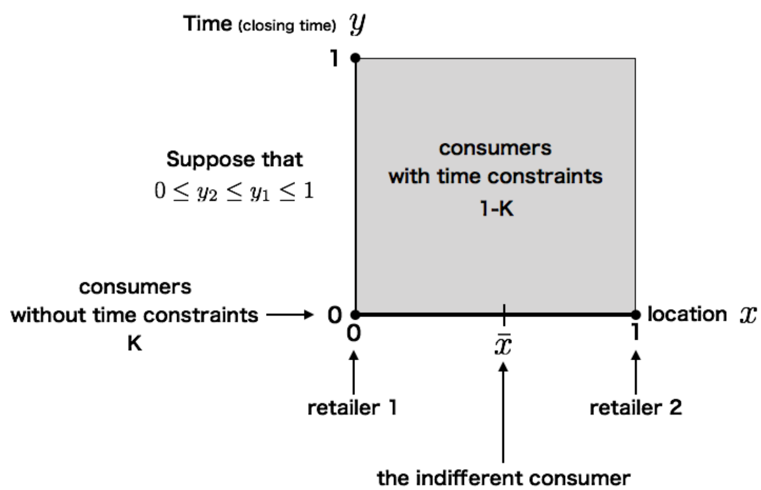

Figure 1: The horizontal axis represents location and the vertical axis represents time.

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 denotes a consumer's gross value for retailer i, q_i does the investment level of retailer i. The higher investment level leads to the higher store quality. p_i denotes price charged by retailer i. Each consumer has unit demand, i.e., each consumes one or zero unit of the product. Each consumer buys a product from a retailer that maximizes his/her

[5] Most previous papers assume that consumers are flexible to adjust their shopping time when retail stores are closed at their preferred shopping time (e.g. Shy and Stenbacka (2006, 2008)). In contrast, we assume that they are not flexible. The assumption used in our paper is different from previous papers. We assume the situation where consumers are less motivated to postpone or advance their shopping from prefered shopping time. In other words, we assume the situation where consumers incur high psychological cost to postpone or advance their shopping time.

indirect utility. Each retailer is constrained to charge a single price, regardless of its opening hours.[6]

Each retailer invest $q_i > 0$ in store quality to improve a consumer's gross value for retailer i. We consider scenarios I and II on the investment in store quality. In scenario I, retailers invest $q_i > 0$ in quality of product. The cost of the investment in quality of product is constant regardless of opening hours. This means that retailers not need to incur the additional investment in order to maintain quality of product during extended opening hours because quality of product does not change over time. The cost of the investment in quality of product, which retailer i incurs, is represented by

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

where $r > 0$ represents the parameter of investment cost in store quality.

In scenario II, retailers invest $q_i > 0$ in quality of service for customers' convenience. Service for customers' convenience is, for instance, concierge service which employees of the retail store answer customers' questions during opening hours, and security service to ensure customer safety during opening hours. The cost of the investment in quality of service for customers' convenience is more costly for longer opening hours, unlike scinario I. Because of the increased consumers due to extended opening hours, retailers must incur the additional investment in order to maintain quality of service for customers' convenience during extended opening hours. The cost of the investment in quality of service for customers' convenience, which retailer i incurs, is represented by

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

where K denotes the mass of type 1 consumers without time constraints. $(1-K)y_i$ does the mass of type 2 consumers with time constraints, which increases in opening hours.

The following assumption is imposed on the mass of type 1 consumers, K, the parameter of investment cost in store quality, r, and the consumer's gross value for retailer i, S:

Assumption 1 *$K \in [1/2, 1)$, $r > \frac{1}{6t}$, and $S > 7t$.*

The assumption of $K \in [1/2, 1)$ reflects that the mass of type 1 without time constraints is larger relatively. The assumption on the parameter value r secures the interior-solution of store quality, q_i, and ensures the indifferent consumer locates at $x \in [0, 1]$. The assumption on the gross value S ensures a retailer with longer opening hours does not exclude type 1 consumers by setting a higher price.

The game runs as follows. In the first stage, retailers determine their location in time y_i (closing time) and their store quality, q_i, simultaneously. In the second stage, after observing retailers' location in time and their choices of store quality, retailers compete in price p_i. This game timing reflects the fact that opening hours and store quality are a long-term decision and that prices is a short-term decision in Japanese retail industry.

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

3 Equilibrium in the liberalization of opening hours

To derive equilibrium outcomes in scenarios I and II, without loss of generality, we suppose that opening hours of retailer 1 is larger than or equal to those of retailer 2; that is, $0 \leq y_2 \leq y_1 \leq 1$. Three categories of consumers exist: (i) consumers who are able to buy from retailers 1 and 2 (consumer $y \in [0, y_2]$); (ii) consumers who are able to buy only from retailer 1 (consumer $y \in (y_2, y_1]$); and (iii) consumers who cannot buy any good (consumer $y \in (y_1, 1]$).

The mass of category (i) is $K + (1-K)y_2$, that of category (ii) is $(1-K)(y_1 - y_2)$, and that of category (iii) is $(1-K)(1-y_1)$. The marginal consumer in category 1 (denoted by $\bar{x}$) is determined such that $S + q_1 - p_1 - tx^2 = S + q_2 - p_2 - t(x-1)^2$ is satisfied. Therefore, we obtain

$$\bar{x} = \frac{p_2 - p_1}{2t} + \frac{q_1 - q_2}{2t} + \frac{1}{2}. \tag{3}$$

Demands at retailers 1 and 2 are, respectively,

$$D_1 = (K + (1-K)y_2)\bar{x} + (1-K)(y_1 - y_2), \tag{4}$$

$$D_2 = (K + (1-K)y_2)(1 - \bar{x}). \tag{5}$$

Scenario I: the investment in quality of product

With the cost structure denoted by Eq.(1), profits of retailers 1 and 2 are, respectively,

$$\pi_1 = p_1[(K + (1-K)y_2)\bar{x} + (1-K)(y_1 - y_2)] - r{q_1}^2, \tag{6}$$

$$\pi_2 = p_2[(K + (1-K)y_2)(1 - \bar{x})] - r{q_2}^2. \tag{7}$$

In the second stage, retailers decide prices simultaneously. The first-order conditions with respect to p_i lead to

$$p_1 = \frac{q_1 - q_2}{3} + \frac{t(3K + (1-K)(4y_1 - y_2))}{3(K + (1-K)y_2)}, \tag{8}$$

$$p_2 = \frac{q_2 - q_1}{3} + \frac{t(3K + (1-K)(2y_1 + y_2))}{3(K + (1-K)y_2)}. \tag{9}$$

Profits of retailers 1 and 2 amount to

$$\pi_1 = \frac{[K(q_1 - q_2 + 3t) + (1-K)(t(4y_1 - y_2) + y_2(q_1 - q_2))]^2}{18t(K + (1-K)y_2)} - rq_1^2, \tag{10}$$

$$\pi_2 = \frac{[K(q_2 - q_1 + 3t) + (1-K)(t(2y_1 + y_2) + y_2(q_2 - q_1))]^2}{18t(K + (1-K)y_2)} - rq_2^2. \tag{11}$$

In the first stage, retailers decide opening hours and the level of the investment in quality of product simultaneously. As the second derivative with respect to y_i leads to $\frac{\partial^2 \pi_1}{\partial y_1^2} > 0$ and $\frac{\partial^2 \pi_2}{\partial y_2^2} > 0$, we obtain corner solutions. There are three possible corner solutions: $y_1 = 1$ and $y_2 = 0$; $y_1 = 0$ and $y_2 = 0$; $y_1 = 1$ and $y_2 = 1$. We find that only the pair of $y_1 = 1$ and $y_2 = 0$ appears in equilibrium (the proof is presented in the Appendix). This means that a retailer locating at $y = 1$ (retailer 1) targets consumers who face time constraints, and another retailer locating at $y = 0$ (retailer 2) targets consumers who has no-time constraints, and thereby, can buy at any time.

The first-order conditions with respect to q_i are given by

$$\frac{\partial \pi_1}{\partial q_1} = 0 \Leftrightarrow R(q_2) = \frac{-(K + (1-K)y_2)q_2 + 3Kt + (1-K)t(4y_1 - y_2)}{18rt - (K + (1-K)y_2)}, \tag{12}$$

$$\frac{\partial \pi_2}{\partial q_2} = 0 \Leftrightarrow R(q_1) = \frac{-(K + (1-K)y_2)q_1 + 3Kt + (1-K)t(2y_1 + y_2)}{18rt - (K + (1-K)y_2)}. \tag{13}$$

We denote the reaction function by $R(q_j)$. Because $R'(q_j) < 0$, the level of the investment in quality of product are strategic substitutes. If retailer i increases quality of product q_i given q_j, the demand of retailer j decreases.

Substituting $y_1 = 1$ and $y_2 = 0$ into $\partial \pi_i / \partial q_i = 0$, the equilibrium investment level are then:

$$q_1^{l*} = \frac{3rt(4-K) - K}{6r(9rt - K)}, \quad q_2^{l*} = \frac{3rt(2+K) - K}{6r(9rt - K)},$$

where the superscript l denotes the liberalized of opening hours, and the superscript $*$ does the equilibrium value in scenario I. Considering the assumption 1, we find $q_1^{l*} > q_2^{l*}$. The associated price, demand, and profit are

$$p_1^{l*} = \frac{t(3rt(4-K) - K)}{K(9rt - K)}, \quad p_2^{l*} = \frac{t(3rt(2+K) - K)}{K(9rt - K)},$$

$$\bar{x} = \frac{(3rt(5K-2) + K(1-2K))}{2K(9rt - K)}, \quad D_1^{l*} = \frac{3rt(4-K) - K}{2(9rt - K)}, \quad D_2^{l*} = \frac{3rt(2+K) - K}{2(9rt - K)},$$

$$\pi_1^{l*} = \frac{(18rt - K)(3rt(4-K) - K)^2}{36Kr(9rt - K)^2}, \quad \pi_2^{l*} = \frac{(18rt - K)(3rt(2+K) - K)^2}{36Kr(9rt - K)^2}.$$

Considering the assumption 1, we have: $p_1^{l*} > p_2^{l*}$, $D_1^{l*} > D_2^{l*}$, and $\pi_1^{l*} > \pi_2^{l*}$.

Proposition 1 *In the liberalization of opening hours, when retailers invest in quality of product , product quality and price of a retailer with longer opening hours are higher than those of a retailer with shorter opening hours. Demand and profit of a retailer with longer opening hours are also greater than those of a retailer with shorter opening hours.*

The intuition is the following. Retailer 1 with longer opening hours meets the relatively high demand. This promotes the investment in its product, leading to the higher quality of product. Also, it obtains the greater profit although it sets the higher price because it monopolize time-constrained type 2 consumers. On the other hand, retailer 2 with shorter opening hours sets the lower quality of product because it meets the relatively low demand. However, it sets the lower price to attract no time-constrained type 1 consumers who can compare the two retailers.

Scenario II*:* **the investment in quality of service for customers' convenience**

With the cost structure denoted by Eq.(2), profits of retailers 1 and 2 are, respectively,

$$\pi_1 = p_1[(K + (1-K)y_2)\bar{x} + (1-K)(y_1 - y_2)] - (K + (1-K)y_1)r{q_1}^2, \tag{14}$$

$$\pi_2 = p_2[(K + (1-K)y_2)(1-\bar{x})] - (K + (1-K)y_2)r{q_2}^2. \tag{15}$$

The first-order conditions with respect to p_i lead to Eq.(8) and Eq.(9). Profits of retailers 1 and 2 amount to

$$\pi_1 = \frac{[K(q1 - q2 + 3t) + (1-K)(t(4y_1 - y_2) + y_2(q_1 - q_2))]^2}{18t(K + (1-K)y_2)} - (K + (1-K)y_1)rq_1^2, \tag{16}$$

$$\pi_2 = \frac{[K(q_2 - q_1 + 3t) + (1-K)(t(2y_1 + y_2) + y_2(q_2 - q_1))]^2}{18t(K + (1-K)y_2)} - (K + (1-K)y_2)rq_2^2. \tag{17}$$

As with scenario I, we obtain the corner solution in opening hours and find that only the pair of $y_1 = 1$ and $y_2 = 0$ appears in equilibrium (the proof is presented in the Appendix). Therefore, we have the following lemma.

lemma 1 *In the liberalization of opening hours, one retailer locates at* $y = 1$*, another retailer locates at* $y = 0$*.*

This lemma presents the robustness of Inderst and Irmen (2005).

Solving the profit-maximization problem with respect to q_i, we obtain the reaction functions as follows:

$$\frac{\partial \pi_1}{\partial q_1} = 0 \Leftrightarrow R(q_2) = \frac{-(K + (1-K)y_2)q_2 + 3Kt + (1-K)t(4y_1 - y_2)}{K(18rt - 1) + (1-K)(18rty_1 - y_2)}. \tag{18}$$

$$\frac{\partial \pi_2}{\partial q_2} = 0 \Leftrightarrow R(q_1) = \frac{-(K + (1-K)y_2)q_1 + 3Kt + (1-K)t(2y_1 + y_2)}{K(18rt - 1) + (1-K)(18rty_2 - y_2)}. \tag{19}$$

Because $R'(q_j) < 0$ as with scenario I, the level of the investment in quality of service for customers' convenience are strategic substitutes. If retailer i increases quality of service for that q_i given q_j, the demand of retailer j decreases.

Substituting $y_1 = 1$ and $y_2 = 0$ into $\partial \pi_i / \partial q_i = 0$, the equilibrium investment level are then:

$$q_1^{l**} = \frac{3Krt(4-K) - K}{3Kr(18rt - 1 - K)}, \;\; q_2^{l**} = \frac{3rt(2+K) - K}{3Kr(18rt - 1 - K)},$$

where the superscript $**$ denotes the equilibrium value in scenario II. Considering the assumption 1, we find $q_1^{l**} < q_2^{l**}$. The associated price, demand, and profit are then:

$$p_1^{l**} = \frac{2t(3rt(4-K) - 1)}{K(18rt - 1 - K)}, \;\; p_2^{l**} = \frac{2t(3rt(2+K) - K)}{K(18rt - 1 - K)},$$

$$\bar{x} = \frac{3rt(5K - 2) - K^2}{K(18rt - 1 - K)}, \;\; D_1^{l**} = \frac{3rt(4-K) - 1}{18rt - 1 - K}, \;\; D_2^{l**} = \frac{3rt(2+K) - K}{18rt - 1 - K},$$

$$\pi_1^{l**} = \frac{(18rt - K)(3rt(4-K) - 1)^2}{9Kr(18rt - 1 - K)^2}, \;\; \pi_2^{l**} = \frac{(18rt - 1)(3rt(2+K) - K)^2}{9Kr(18rt - 1 - K)^2}.$$

Considering the assumption, we have: $p_1^{l**} > p_2^{l**}$, $D_1^{l**} > D_2^{l**}$, and $\pi_1^{l**} > \pi_2^{l**}$.

Proposition 2 *In the liberalization of opening hours, when retailers invest in quality of service for customers' convenience, service quality of a retailer with shorter opening hours are higher than that of a retailer with longer opening hours. Price, demand, and profit of a retailer with longer opening hours are higher than those of a retailer with shorter opening hours.*

The intuition is as follows. Although retailer 1 with longer opening hours may have an incentive to promote the investment in quality of service for customers' convenience because it meets the relatively high demand. However, because the investment in quality of service for that is more costly for longer opening hours, it sets the lower quality of service for that. Nevertheless, it can obtain its greater profit by setting the higher price because it monopolize time-constrained type 2 consumers. On the other hand, retailer 2 with shorter opening hours promotes the investment in quality of service for that, and thereby, it sets the higher quality of service for that even though it meets the relatively low demand. This is because its shorter opening hours yield the lower cost of the investment in quality of service for that. Also, it sets lower prices to attract no time-constrained type 1 consumers who can compare the two retailers.

4 Equilibrium in the regulation of opening hours

In the regulation of opening hours, no retailers can extend opening hours to target time-constrained type 2 consumers, who locate uniformly on the time line. All retailers locate at $y_i = 0$ on the time line, and target no time-constrained type 1 consumers who locate $y_i = 0$ on the time line. Demands at retailers 1 and 2 are, respectively, $D_1 = K\bar{x}$ and $D_2 = K(1-\bar{x})$.

Scenario I: **the investment in quality of product**

Profits of retailers 1 and 2 are, respectively,

$$\pi_1 = p_1(K\bar{x}) - r{q_1}^2, \tag{20}$$

$$\pi_2 = p_2(K(1-\bar{x})) - r{q_2}^2. \tag{21}$$

The first-order conditions with respect to p_i lead to

$$p_1 = \frac{q_1 - q_2}{3} + t, \tag{22}$$

$$p_2 = \frac{q_2 - q_1}{3} + t. \tag{23}$$

Therefore, profits of retailers 1 and 2 are given by

$$\pi_1 = \frac{K(q_1 - q_2 + 3t)^2}{18t} - rq_1^2, \tag{24}$$

$$\pi_2 = \frac{K(q_2 - q_1 + 3t)^2}{18t} - rq_2^2. \tag{25}$$

Solving the profit maximization with respect to q_i, we obtain the reaction functions as follows:

$$\frac{\partial \pi_1}{\partial q_1} = 0 \Leftrightarrow R(q_2) = \frac{K}{18rt - K}(3t - q_2), \tag{26}$$

$$\frac{\partial \pi_2}{\partial q_2} = 0 \Leftrightarrow R(q_1) = \frac{K}{18rt - K}(3t - q_1). \tag{27}$$

Because $R'(q_j) < 0$, the level of the investment in quality of product are strategic substitutes as with the liberalized opening hours.

Solving Eq.(26) and Eq.(27), the equilibrium investment level are then:

$$q_1^{re*} = q_2^{re*} = \frac{K}{6r},$$

where the superscript re denotes the regulated opening hours. The associated price, demand, and profit are

$$p_1^{re*} = p_2^{re*} = t,$$

$$\bar{x} = \frac{1}{2}, \;\; D_1^{re*} = D_2^{re*} = \frac{K}{2},$$

$$\pi_1^{re*} = \pi_2^{re*} = \frac{K(18rt - K)}{36r}.$$

Proposition 3 *In the regulation of opening hours, when retailers invest in quality of product , product quality, price, demand, and profit are equal among retailers.*

Scenario II: the investment in quality of service for customers' convenience

Profits of retailers 1 and 2 are, respectively,

$$\pi_1 = p_1(K\bar{x}) - Krq_1{}^2, \tag{28}$$

$$\pi_2 = p_2(K(1 - \bar{x})) - Krq_2{}^2. \tag{29}$$

The first-order conditions with respect to p_i lead to Eq.(22) and Eq.(23). Therefore, profits of retailers 1 and 2 are given by

$$\pi_1 = \frac{K(q_1 - q_2 + 3t)^2}{18t} - Krq_1^2, \tag{30}$$

$$\pi_2 = \frac{K(q_2 - q_1 + 3t)^2}{18t} - Krq_2^2. \tag{31}$$

Solving the profit-maximization problem with respect to q_i, we obtain the reaction functions as follows:

$$\frac{\partial \pi_1}{\partial q_1} = 0 \Leftrightarrow R(q_2) = \frac{1}{18rt - 1}(3t - q_2), \tag{32}$$

$$\frac{\partial \pi_2}{\partial q_2} = 0 \Leftrightarrow R(q_1) = \frac{1}{18rt - 1}(3t - q_1). \tag{33}$$

Because $R'(q_j) < 0$, the level of the investment in quality of service for customers' convenience are strategic substitutes as with the liberalized opening hours.

Solving Eq.(32) and Eq.(33), the equilibrium investment level are then:

$$q_1^{re**} = q_2^{re**} = \frac{1}{6r}.$$

The associated price, demand, and profit are given by

$$p_1^{re**} = p_2^{re**} = t,$$

$$\bar{x} = \frac{1}{2}, \ \ D_1^{re**} = D_2^{re**} = \frac{K}{2},$$

$$\pi_1^{re**} = \pi_2^{re**} = \frac{K(18rt - 1)}{36r}.$$

Proposition 4 *In the regulation of opening hours, when retailers invest in quality of service for customers' convenience, service quality, price, demand, and profit are equal among retailers.*

Comparison the liberalized opening hours with the regulated opening hours:

We compare retail strategies related to store quality, price, demand, and profit in the liberalization of opening hours with those in the regulation of opening hours. Considering the assumption 1, we find that store quality, price, demand, and profit in the liberalization of opening hours are greater than those in the regulation of opening hours. This outcome is important for policymaker who debates on the regulated opening hours. Table 2 summarizes comparison the liberalized of opening hours with the regulated of opening hours.

	store quality	price	demand	profit
Liberalization	higher	higher	higher	higher
Restriction	lower	lower	lower	lower

Table 2: Comparison the liberalized opening hours with the regulated opening hours

5 Impact on social welfare

This section examines whether the liberalized or the regulated opening hours yields greater social welfare. Social welfare consists of the following three factors: the level of the investment in store qualily, transportation costs of consumers, and the cost of the investment in store quality.

In scenario I, social welfare in the liberalized opening hours is given by

$$W_I^l = \int_0^{\bar{x}} (S + q_1 - tm^2)dm + K \int_{\bar{x}}^1 (S + q_2 - t(1-m)^2)dm - rq_1^2 - rq_2^2, \tag{34}$$

and that in the regulated opening hours is given by

$$W_I^{re} = K \int_0^{\bar{x}} (S + q_1 - tm^2)dm + K \int_{\bar{x}}^1 (S + q_2 - t(1-m)^2)dm - rq_1^2 - rq_2^2, \tag{35}$$

where the subscript I denotes scenario I. In scenario II, social welfare in the liberalized opening hours is given by

$$W_{II}^l = \int_0^{\bar{x}} (S+q_1-tm^2)dm+K \int_{\bar{x}}^1 (S+q_2-t(1-m)^2)dm-(K+(1-K)y_1)rq_1^2-(K+(1-K)y_2)rq_2^2, \tag{36}$$

and that in the regulated opening hours is given by

$$W_{II}^{re} = K \int_0^{\bar{x}} (S + q_1 - tm^2)dm + K \int_{\bar{x}}^1 (S + q_2 - t(1-m)^2)dm - Krq_1^2 - Krq_2^2, \tag{37}$$

where the subscript II denotes scenario II. Considering the assumption 1, we find that $W_I^{re*} < W_I^{l*}$ and $W_{II}^{re**} < W_{II}^{l**}$ (see the Appendix). That is, social welfare in the liberalizaton of opening hours is greater than that in the regulation of opening hours regardless of whether retailers invest in quality of product or in quality of service for customers' convenience in the strore.

What factors contribute to the werlfare gain in the liberalized opening hours? To clarify this matter, we examine the effect of the liberalized opening hours on consumers (two different types of consumers) and retailers.

The impact on two different types of consumers: no time-constrained type 1 consumers benefit from the increased store quality compared to the regulated opening hours. Time-constrained type 2 consumers also benefit because a retailer opens for longer. Furthermore, in scenario I, type 2 consumers benefit because product quality of a retailer with longer opening hours is greater than that of a retailer with shorter opening hours. In scenario II, although service quality of a retailer with longer opening hours is lower than that of a retailer with shorter opening hours, type 2 consumers benefit from the increased service quality compared to the regulated opening hours.

The impact on retailers: although retailers incur the higher cost of investment in store quality compared to the regulated opening hours, the increased store quality yields the greater profit because retailers meet the increased demand compared to the regulated opening hours.

From the above, the increased store quality and demand compared to the regulated opening hours are factors of the welfare gain in the liberalization of opening hours. In Japan, the government tries to regulate opening hours to protect the retail industry. However, we find that the regulated opening hours yields lower store quality such as product and service for customers' convenience, and lower demand, resulting in the welfare loss. Therefore, we have the following proposition.

Proposition 5 *Social welfare in the liberalizaton of opening hours is greater than that in the regulation of opening* *hours. This occurs due to the increased store quality and demand compared to the regulated opening hours.*

6 Discussion

In this section, we consider a scenario where retailers invest in both quality of product and quality of service for customers' convenience. They incur not only the investment cost given by Eq.(1), but also that given by Eq.(2). In the first stage, retailers simultaneously determine their closing time and their store quality (quality of product, and quality of service for customers' convenience). In the second stage, retailers compete in price. As the mathematical procedures is the same as previous sections, we only show results. However, the conditional indirect utility function, and the cost of the investment in store quality are replaced by

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

$$I(q_{iA}, q_{iB}, y_i) = rq_{iA}^2 + (K + (1 - K)y_i)rq_{iB}^2 \quad i = 1, 2, i \neq j,$$

where q_{iA} denotes the level of the investment in quality of product by retailer i, and q_{iB} denotes the level of the investment in quality of service for customers' convenience by retailer i. We find that store quality of retailer i, q_{iA} and q_{iB}, are strategic complements. The increased quality of product (quality of service for customers' convenience) of retailer i leads to the increased demand, and thereby, the increased quality of service for customers' convenience (quality of product) of retailer i leads to higher consumers' marginal indirect utility.

In the liberalization of opening hours, only the pair of $y_1 = 1$ and $y_2 = 0$ appears in equilibrium, as with the previous section. We now define store quality of each retailer as follows: $Q_1^l \equiv q_{1A} + q_{1B}$ and $Q_2^l \equiv q_{2A} + q_{2B}$, where the superscript l denotes the liberalized opening hours. Unlike the previous section, store quality in equilibrium depends on K which denotes the mass of no time-constrained type 1 consumers. If $\frac{1}{2} \leq K < \frac{2}{3}$, we find that the equilibrium value of Q_1^l is smaller than that of Q_2^l. This means that retailer 1 with longer opening hours chooses the lower store quality when there are fewer consumers who can compare the two retailers (type 1 consumers). If $\frac{2}{3} < K < 1$, we find that the equilibrium value of Q_1^l is larger than that of Q_2^l. This means that retailer 1 with longer opening hours chooses the higher store quality when there are many consumers who can compare the two retailers (type 1 consumers). We also find that price, demand, and profit of retailer 1 with longer opening hours are higher than those of retailer 2 with shorter opening hours. This holds regardless of the mass of K.

In the regulation of opening hours, we define store quality of each retailer as follows: $Q_1^{re} \equiv q_{1A} + q_{1B}$ and $Q_2^{re} \equiv q_{2A} + q_{2B}$, where the superscript re denotes the restricted opening hours. Then, we find that Q_1^{re} is equal to Q_2^{re}. That is, store quality is equal among retailers. Price, demand, and profit are also equal among retailers.

Comparing the liberalized and the regulated opening hours, we find that store quality, price, demand, and profit in the liberalization of opening hours are greater than those in the regulation of opening hours by considering the assumption 1. This is the same result as the previous section.

We examine the impact of the liberalized and the regulated opening hours on social welfare. Social welfare in the liberalized opening hours is given by

$$W^l = \int_0^{\bar{x}} (S + Q_1 - tm^2 dm) + K \int_{\bar{x}}^1 (S + Q_2 - t(1-m)^2 dm) - rq_{1A}^2 - (K + (1-K)y_1) rq_{1B}^2 - rq_{2A}^2 - (K + (1-K)y_2) rq_{2B}^2.$$

Social welfare in the regulated opening hours is given by

$$W^{re} = K \int_0^{\bar{x}} (S + Q_1 - tm^2 dm) + K \int_{\bar{x}}^1 (S + Q_2 - t(1-m)^2 dm) - rq_{1A}^2 - Krq_{1B}^2 - rq_{2A}^2 - Krq_{2B}^2.$$

Substituting the equilibrium values into the above equations, we find that the equilibrium value of W^{re} is smaller than the equilibrium value of W^l by considering the assumption 1. That is, if retailers invest in both quality of product and quality of sevice for customers' convenience, social welfare in the liberalization of opening hours is greater than that in the regulation of opening hours as with the previous section. This occurs due to the increased store quality and demand compared to the regulated opening hours. Although retailers incur the higher cost of investment in store quality compared to the regulated opening hours, the increased store quality yields the greater profit because retailers meet the higher demand due to extended opening hours. Thus, retailers benefit from the liberalized opening hours. Consumers also benefit from the liberalized opening hours. No time-constrained type 1 consumers benefit from the increased store quality compared to the regulated opening hours. Time-constrained type 2 consumers benefit from extended opening hours and the increased store quality compared to the regulated opening hours. When there are many consumers who can compare the two retailers (type 1 consumers), time-constrained type 2 consumers benefit because store quality of a retailer with longer opening hours is higher than that of a retailer with shorter opening hours. When there are fewer consumers who can compare the two retailers (type 1 consumers), although store quality of a retailer with longer opening hours is lower than that of a retailer with shorter opening hours, time-constrained type 2 consumers benefit from the increased store quality compared to the regulated opening hours.

7 Conclusion

Using a duopoly model with symmetric retailers, this paper examines the retail strategies related to opening hours, store quality, and prices. The basic setting is based on that in Inderst and Irmen (2005). We assume two types of store quality: quality of product such as a private-label product; quality of service for customers' convenience. Retailers incur the cost of the investment in store quality. If retailers invest in quality of product, they incur the investment cost which is independent with opening hours. We then find that a retailer with longer opening hours chooses a higher quality of product, and charges higher prices. On the other hand, if retailers invest in quality of service for customers' convenience, they incur the investment cost which is positively correlated with opening hours. We then find that a retailer with shorter opening hours chooses a higher quality of service for customers' convenience, and charges lower prices. We also examine whether the liberalized or the regulated opening hours is desirable for social welfare. We find that the liberalized opening hours can yield higher social welfare, regardless of whether retailers invest in quality of product or in quality of service for customers' convenience. This is because store quality and demand in the liberalization of opening hours are greater than those in the regulation of opening hours.

Appendix

Corner solution in opening hours

In both scenario I and II, the second derivative with respect to y_i, $\frac{\partial^2 \pi_i}{\partial y_i^2}$, is given by

$$\frac{\partial^2 \pi_1}{\partial y_1^2} = \frac{16(1-K)^2 t}{9(K+(1-K)y_2)} > 0,$$

$$\frac{\partial^2 \pi_2}{\partial y_2^2} = \frac{4(1-K)^2 t(K+(1-K)y_1)^2}{9(K+(1-K)y_2)^3} > 0.$$

As the second derivative with respect to y_i is positive, we obtain corner solutions in opening hours.

lemma 1

In scenario I, we examine whether retailers have incentives to deviate in the following three possibilities of corner solutions: (a) $y_1 = 1$ and $y_2 = 0$; (b) $y_1 = 0$ and $y_2 = 0$; (c) $y_1 = 1$ and $y_2 = 1$.

In the pattern (a), we obtain:

$$q_1^{l*} = \frac{3rt(4-K)-K}{6r(9rt-K)}, \;\; q_2^{l*} = \frac{3rt(2+K)-K}{6r(9rt-K)},$$

$$\pi_1^{l*} = \frac{(18rt-K)(3rt(4-K)-K)^2}{36Kr(9rt-K)^2}, \;\; \pi_2^{l*} = \frac{(18rt-K)(3rt(2+K)-K)^2}{36Kr(9rt-K)^2}$$

We assume that retailer 1 deviates to $y_1 = 0$ given $y_2 = 0$ and $q_2^{l*} = \frac{3rt(2+K)-K}{6r(9rt-K)}$. Substituting $y_1 = 0$ into the first-order condition with respect to q_1, we have:

$$q_{1d} = \frac{K(6rt(27rt-1)-K(21rt-1))}{6r(18rt-K)(9rt-K)}, \;\; \pi_{1d} = \frac{K(6rt(27rt-1)-K(21rt-1))^2}{36r(18rt-K)(9rt-K)^2},$$

where d indicates that a retailer deviates $y_i = 0$ or $y_i = 1$. Comparing π_1^{l*} with π_{1d}, we have:

$$\pi_1^{l*} - \pi_{1d} = \frac{4(1-K)t(K^2 - 9Krt(2+K) + 54(2+K)r^2t^2)}{3K(18rt-K)(9rt-K)}.$$

Considering the assumption 1, we find that $\pi_1^{l*} > \pi_{1d}$. This indicates that retailer 1 has no incentives to deviate to $y_1 = 0$. We then assume retailer 2 deviates to $y_2 = 1$ given $y_1 = 1$ and $q_1^{l*} = \frac{3rt(4-K)-K}{6r(9rt-K)}$. Substituting $y_2 = 1$ into the first-order condition with respect to q_2, we have:

$$q_{2d} = \frac{6rt(27rt-2)-K(15rt-1)}{6r(18rt-1)(9rt-K)}, \;\; \pi_{2d} = \frac{(6rt(27rt-2)-K(15rt-1))^2}{36r(18rt-1)(9rt-K)^2}.$$

Comparing π_2^{l*} with π_{2d}, we have:

$$\pi_2^{l*} - \pi_{2d} = \frac{t(-(1-K)K^2 + 18K(1-K^2)rt - 27(4+K(8-(13-K)K))r^2t^2 + 486(4-K)(1-K)r^3t^3)}{6K(18rt-1)(9rt-K)^2}.$$

Considering the assumption 1, we find that $\pi_2^{l*} > \pi_{2d}$. This indicates that retailer 2 has no incentives to deviate to $y_2 = 1$. Thus, the pair of $y_1 = 1$ and $y_2 = 0$ is sustainable in equilibrium.

In the pattern (b), we have:

$$q_1^{l*} = q_2^{l*} = \frac{K}{6r},$$

$$\pi_1^{l*} = \pi_2^{l*} = \frac{K(18rt - K)}{36r}.$$

We assume that retailer 1 deviates to $y_1 = 1$ given $y_2 = 0$ and $q_2^{l*} = \frac{K}{6r}$. Substituting $y_1 = 1$ into the first-order condition with respect to q_1, we have:

$$q_{1d} = \frac{6rt(4 - K) - K^2}{6r(18rt - K)}, \;\; \pi_{1d} = \frac{(6rt(4 - K) - K^2)^2}{36Kr(18rt - K)}.$$

Comparing π_1^{l*} with π_{1d}, we have:

$$\pi_1^{l*} - \pi_{1d} = \frac{4(1 - K)t(K^2 - 6rt(2 + K))}{3K(18rt - K)}.$$

Considering the assumption 1, we find that $\pi_1^{l*} < \pi_{1d}$. This indicates that retailer 1 has incentives to deviate to $y_1 = 1$. Thus, the pair of $y_1 = 0$ and $y_2 = 0$ does not appear in equilibrium.

In the pattern (c), we have:

$$q_1^{l*} = q_2^{l*} = \frac{1}{6r},$$

$$\pi_1^{l*} = \pi_2^{l*} = \frac{18rt - 1}{36r}.$$

We assume that retailer 2 deviates to $y_2 = 0$ given $y_1 = 1$ and $q_1^{l*} = \frac{1}{6r}$. Substituting $y_2 = 0$ into the first-order condition with respect to q_2, we have:

$$q_{2d} = \frac{6rt(2 + K) - K}{6r(18rt - K)}, \;\; \pi_{2d} = \frac{(6rt(2 + K) - K)^2}{36Kr(18rt - K)}.$$

Comparing π_2^{l*} with π_{2d}, we have:

$$\pi_2^{l*} - \pi_{2d} = \frac{(1 - K)t(K - 6(4 - K)rt)}{6K(18rt - K)}.$$

Considering the assumption 1, we find that $\pi_2^{l*} < \pi_{2d}$. This indicates that retailer 2 has incentives to deviate to $y_2 = 0$. Thus, the pair of $y_1 = 1$ and $y_2 = 1$ does not appear in equilibrium.

lemma 2

In scenario II, we examine whether retailers have incentives to deviate in the following three possibilities of corner solutions: (a) $y_1 = 1$ and $y_2 = 0$; (b) $y_1 = 0$ and $y_2 = 0$; (c) $y_1 = 1$ and $y_2 = 1$.

In the pattern (a), we have:

$$q_1^{l**} = \frac{3Krt(4-K)-K}{3Kr(18rt-1-K)},\ \ q_2^{l**} = \frac{3rt(2+K)-K}{3Kr(18rt-1-K)},$$

$$\pi_1^{l**} = \frac{(18rt-K)(3rt(4-K)-1)^2}{9Kr(18rt-1-K)^2},\ \ \pi_2^{l**} = \frac{(18rt-1)(3rt(2+K)-K)^2}{9Kr(18rt-1-K)^2}$$

We assume that retailer 1 deviates to $y_1 = 0$ given $y_2 = 0$ and $q_2^{l**} = \frac{3rt(2+K)-K}{3Kr(18rt-1-K)}$. Substituting $y_1 = 0$ into the first-order condition with respect to q_1, we have:

$$q_{1d} = \frac{K(3rt(54rt-3K-4)+1)-6rt}{3Kr(18rt-1)(18rt-1-K)},\ \ \pi_{1d} = \frac{(K(3rt(54rt-3K-4)+1)-6rt)^2}{9Kr(18rt-1)(18rt-1-K)^2}.$$

Comparing π_1^{l**} with π_{1d}, we have:

$$\pi_1^{l**}-\pi_{1d} = \frac{(1-K)(K-6(3+K(3K+8))rt+9(80+K(116+K(9K+32)))r^2t^2-162(64+K(17K+48))r^3t^3+23328(2+K)r^4t^4)}{9Kr(18rt-1)(18rt-1-K)^2}.$$

Considering the assumption 1, $\pi_1^{l**} > \pi_{1d}$. This indicates that retailer 1 has no incentives to deviate to $y_1 = 0$. We then assume retailer 2 deviates to $y_2 = 1$ given $y_1 = 1$ and $q_1^{l**} = \frac{3Krt(4-K)-K}{3Kr(18rt-1-K)}$. Substituting $y_2 = 1$ into the first-order condition with respect to q_2, we have:

$$q_{2d} = \frac{3rt(54rt-2K-7)+1}{3r(18rt-1)(18rt-1-K)},\ \ \pi_{2d} = \frac{(3rt(54rt-2K-7)+1)^2}{9r(18rt-1)(18rt-1-K)^2}.$$

Comparing π_2^{l**} with π_{2d}, we have:

$$\pi_2^{l**} - \pi_{2d} = \frac{(1-K)(-K+30Krt+9(K(4K-29)+4)r^2t^2-324(4-K)r^3t^3+2916(4-K)r^4t^4)}{9K(18rt-1)(18rt-1-K)^2}.$$

Considering the assumption 1, we find that $\pi_2^{l**} > \pi_{2d}$. This indicates that retailer 2 has no incentives to deviate to $y_2 = 1$. Thus, the pair of $y_1 = 1$ and $y_2 = 0$ is sustainable in equilibrium.

In the pattern (b), we have:

$$q_1^{l**} = q_2^{l**} = \frac{1}{6r},$$

$$\pi_1^{l**} = \pi_2^{l**} = \frac{K(18rt-1)}{36r}.$$

We assume that retailer 1 deviates to $y_1 = 1$ given $y_2 = 0$ and $q_2^{l**} = \frac{1}{6r}$. Substituting $y_1 = 1$ into the first-order condition with respect to q_1, we have:

$$q_{1d} = \frac{6rt(4-K)-K}{6r(18rt-K)},\ \ \pi_{1d} = \frac{(6rt(4-K)-K)^2}{36Kr(18rt-K)}.$$

Comparing π_1^{l**} with π_{1d}, we have:

$$\pi_1^{l**} - \pi_{1d} = \frac{(1-K)(-K^2+6K(3K+8)rt-288(2+K)r^2t^2)}{36Kr(18rt-K)}.$$

Considering the assumption 1, we find that $\pi_1^{l**} < \pi_{1d}$. This indicates that retailer 1 has incentives to deviate to $y_1 = 1$. Thus, the pair of $y_1 = 0$ and $y_2 = 0$ does not appear in equilibrium.

In the pattern (c), we have:

$$q_1^{l**} = q_2^{l**} = \frac{1}{6r},$$

$$\pi_1^{l**} = \pi_2^{l**} = \frac{18rt - 1}{36r}.$$

We assume that retailer 2 deviates to $y_2 = 0$ given $y_1 = 1$ and $q_1^{l**} = \frac{1}{6r}$. Substituting $y_2 = 0$ into the first-order condition with respect to q_2, we have:

$$q_{2d} = \frac{6rt(2+K) - K}{6Kr(18rt-1)}, \;\; \pi_{2d} = \frac{(6rt(2+K) - K)^2}{36Kr(18rt-1)}.$$

Comparing π_2^{l**} with π_{2d}, we have:

$$\pi_2^{l**} - \pi_{2d} = \frac{(1-K)(K - 12Krt - 36(4-K)r^2t^2)}{36Kr(18rt-1)}.$$

Considering the assumption 1, we find that $\pi_2^{l**} < \pi_{2d}$. This indicates that retailer 2 has incentives to deviate to $y_2 = 0$. Thus, the pair of $y_1 = 1$ and $y_2 = 1$ does not appear in equilibrium.

The impact on social welfare

Scenario I: the investment in quality of product

Substituting the equilibrium values in Eq.(34) and Eq.(35), and then, comparing social welfare in the liberalization of opening hours with that in the regulation on opening hours, we obtain the following value:

$$\begin{aligned}\triangle W_I \equiv W_I^{re*} - W_I^{l*} = & \frac{-6K^5 + 14K^6 - 2K^8 - 6K^9 + (3K^3 + 141K^4 - 342K^5 - 24K^6 + 57K^7 + 165K^8)rt}{72K^3r(9rt-K)^3} \\ & + \frac{(-54K^2 - 999K^3 + 2583K^4 + 558K^5 - 549K^6 - 1539K^7)r^2t^2}{72K^3r(9rt-K)^3} \\ & + \frac{(324K + 1296K^2 - 4455K^3 - 4293K^4 + 2025K^5 + 5103K^6)r^3t^3}{72K^3r(9rt-K)^3} \\ & + \frac{(-648 + 5508K - 11178K^2 + 10611K^3 - 2106K^4 - 2187K^5)r^4t^4}{72K^3r(9rt-K)^3} \\ & + \frac{(-36K^5 + 108K^6 - 36K^7 - 36K^8)rS + (864K^4 - 2700K^5 + 864K^6 + 972K^7)r^2tS}{72K^3r(9rt-K)^3} \\ & + \frac{(-6804K^3 + 22356K^4 - 6804K^5 - 8748K^6)r^3t^2S + (17496K^2 - 61236K^3 + 17496K^4 + 26244K^5)r^4t^3S}{72K^3r(9rt-K)^3}.\end{aligned}$$

Considering the assumption 1, we find that $W_I^{re*} < W_I^{l*}$ as the sign of $\triangle W_I$ is negative. That is, the liberalized opening hours yields greater social welfare.

Scenario II: the investment in quality of service for customers' convenience

Substituting the equilibrium values in Eq.(36) and Eq.(37), and then, comparing social welfare in the liberalization of opening hours with that in the restriction on opening hours, we obtain the following value:

$$\triangle W_{II} \equiv W_{II}^{re**} - W_{II}^{l**} = \frac{4K^3 - 12K^4 - 8K^5 + 12K^6 + 4K^7 + (-72K^2 + 36K^3 + 549K^4 - 261K^5 - 249K^6 - 3K^7)rt}{36K^3 r(1+K-18rt)^3}$$
$$+ \frac{(1872K^2 - 4968K^3 - 1638K^4 + 4536K^5 + 198K^6)r^2t^2}{36K^3 r(1+K-18rt)^3}$$
$$+ \frac{(-7776K^2 + 32400K^3 - 21060K^4 - 3564K^5)r^3t^3}{36K^3 r(1+K-18rt)^3}$$
$$+ \frac{(2592 - 22032K + 44712K^2 - 42444K^3 + 17172K^4)r^4t^4}{36K^3 r(1+K-18rt)^3}$$
$$+ \frac{(-36K^4 - 36K^5 + 36K^6 + 36K^7)rS + (-216K^2 + 324K^3 + 2052K^4 - 324K^5 - 1836K^6)r^2tS}{36K^3 r(1+K-18rt)^3}$$
$$+ \frac{(7776K^2 - 19440K^3 - 19440K^4 + 31104K^5)r^3t^2S + (-69984K^2 + 244944K^3 - 174960K^4)r^4t^3S}{36K^3 r(1+K-18rt)^3}.$$

Considering the assumption 1, we find that $W_{II}^{re**} < W_{II}^{l**}$ as the sign of $\triangle W_{II}$ is negative. That is, the liberalized opening hours yields greater social welfare.

References

Cancian, M., Bills, A., Bergstrom,T., 1995. Hotelling location problems with directional constraints: an application to television news scheduling. Journal of Industrial Economics 43, 121-124.

Clemenz, G., 1990. Non-sequential consumer search and the consequences of a deregulation of trading hours. European Economic Review 34, 1137-1323.

Clemenz, G., 1994. Competition via shopping hours: A case for regulation? Journal of Institutional and Theoretical Economics 150, 625-641.

Inderst, R., Irmen, A., 2005. Shopping hours and price competition. European Economic Review 49, 1105-1124.

Jacobsen, J. P., Kooreman, P., 2005. Timing constraints and the allocation of time: the effects of changing shopping hours regulations in The Netherlands. European Economics Review, 49, 9-27.

Kay, J. A. and Morris. C. N. , 1987. The economic efficiency of Sunday Trading Restrictions. Journal of Industrial Economics, 36.2, 113-129.

Morrison, S., Newman, R., 1983. Hours of operation restrictions and competition among retail firms. Economic Inquiry 21, 107-114.

Nillsen, T., 1997. Sequential location when transportation costs are asymmetric. Economics Letters 54, 191-201.

Shy, O., Stenbacka, R., 2006. Service hours with asymmetric distributions of ideal service time. International Journal of Industrial Organization 24, 763-771.

Shy, O., Stenbacka, R., 2008. Price competition, business hours and shopping time flexibility. The Economic Journal 118, 1171-1195.

Tanguay, G., VallZee, L., Lanoie, P., 1995. Shopping hours and price levels in the retailing industry: A theoretical and empilical analysis. Economic Inquiry 33, 516-524.

Wenzel, T., 2011. Deregulation of shopping hours: The impact on independent retailers and chain stores. The Scandinavian Journal of Economics 113 (1), 145-166.

Flores, M. and Wenzel, T., 2016. Shopping Hours and Price Competition with Loyal Consumers. B.E. Journal of Economic Analysis and Policy 16 (1), 393-407.