Duration of Price Promotion and Retail Profit: An In-depth Study Based on Point-of-Sale Data

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Duration of Price Promotion and Retail Profit: An In-depth Study Based on Point-of-Sale Data

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Abstract

Anecdotal evidence has shown that retail price promotions can help small and medium-sized retailers enhance their sales, and thus, retail profits. However, most marketing managers usually stop a promotion after a certain duration. This study aims to explain why these retailers discontinue their price promotion. Our approach posits that the promotion's overall contributions to the total retail profit progressively diminish with time. We present a theoretical framework to explain the relationship between duration and profit effects of price promotions and propose a statistical model to empirically examine this framework using point-of-sale (POS) data. Our findings provide empirical support that the overall profit effects of price promotions have a downward trend with elapsed time, upholding the hypothesis. The results are helpful for marketers to understand how price promotions dynamically influence retail profits and when the promotion should be terminated.

Keyword: *Duration of Price Promotion, Elapsed Time, Retail Profit, Customer Traffic, Product Loyalty, Point-of-Sale Data*

1 Introduction

It is widely and frequently observed that many small or medium-sized retailers, such as supermarkets, regularly reduce the price of some products at irregular times to promote their sales, a process known as a price promotion. Then, after a duration of the price promotion, marketing managers restore the price to the regular level. *Why do they terminate the price promotion? Furthermore, when should they raise the price back to its original level?*

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Many studies have attempted to provide a reasonable explanation for the above questions. However, the literature reports mixed results with respect to the effects of price promotions. On the one hand, some studies have shown that price promotions might be adverse to retailers' interests under certain conditions (e.g., Alvarez Alvarez and Vázquez Casielles, 2005; DelVecchio et al., 2006; Dodson et al., 1978; Moore and Olshavsky, 1989). Although price promotions can contribute to customers' purchase likelihood in the short-term, an excessive price-cutting strategy may negatively influence their brand choices in the long term. That is, an inappropriate price promotion might reduce product loyalty, weaken consumer perceived value and prospects, lower the reference price, and even erode customer trust in product quality (e.g., Fibich et al., 2007; Kahneman and Tversky, 1979; Manning and Sprott, 2007). On the other hand, extensive evidence exists showing the positive effects of price promotion on product switching, retail profit, product loyalty, and customer traffic (e.g., Ailawadi et al., 2009; Mela et al., 1997; Gupta, 1988). Specifically, price promotions can effectively boost the likelihood of customers' visits, increase the sales volume, and promote the overall retail profit of retailers (e.g., Blattberg and Neslin, 1990; Walters and Rinne, 1986).

Previous studies have focused on determining the optimal level of price cutting without distinguishing between the positive and negative effects, (e.g., Campo and Yagüe, 2007; Cui et al., 2016; Martín-Herrán et al., 2010; Weathers et al., 2015), but few such studies have investigated the optimal duration of price promotion or discussed factors for deciding when a promotion should be concluded (e.g., Tsiros and Hardesty, 2010; Bogomolova et al., 2017). From an economics perspective, some evidence exists suggesting that sales price fluctuations are determined by production costs and supply capacity (Corbett and De Groote, 2000; Viswanathan and Wang, 2003; Wee, 1999). However, because of difficulties in explaining the characteristics of promotion duration, those studies do not provide further insight into why retailers do not continue a price promotion over the long-term or when the promotion should be terminated.

The general purpose of this paper is to elucidate the dynamics of the effects of price promotions. We posit that the overall contributions of price promotions to retail profits progressively decrease with time elapsed after the promotion started. Marketing managers should end the promotion if the effect of price discounts becomes negative. To that end, this study has two main objectives: (1) confirm whether the total benefits of price promotions wane over time and (2) investigate how the impacts of price promotions on retail profits change as time goes on, if any. We present a theoretical model that yields some predictions and propose a statistical model to empirically examine the dynamic relationship between elapsed time of price promotion and its effects on marketing outcomes, which include retail profit, customer traffic, and product loyalty. Continuous point-of-sale (POS) data for a well-known brand of yogurt in medium-sized chain of supermarkets located in Japan are used in this study. The key finding suggests that the effects of price promotion on all the abovementioned marketing outcomes exhibit a trend of decays with elapsed time of the promotion.

This study contributes to the existing literature (Esteban-Bravo et al., 2005; Tsiros and Hardesty, 2010), by explaining why and when retailers should end a price promotion, from both theoretical and empirical perspectives. We provide strong empirical evidence for the decay of promotion effects, which supports that the overall profit effects of price promotions exhibit a downward process with elapsed time. Moreover, this study's findings can help marketing managers understand how price promotions dynamically influence retail profits and thus how to reasonably and effectively determine the optimal price promotion duration.

The remainder of this paper is organized as follows. Section 2 describes our theoretical model for the relationship between duration and profit effects of price promotion, and then offers related empirical hypotheses. We introduce the methodology, which includes the dataset, measurements, and empirical model, in Section 3, and present the data analysis and findings in Section 4. Section 5 concludes the paper by discussing the contributions of this study and the managerial implications and points out further research directions.

2 Theoretical Model Analysis

The problem of determining the optimal stopping time has attracted considerable attention from researchers in many scientific disciplines (Myneni, 1992). In our case, retailers face two possible actions: (1) continue the promotion or (2) stop it.

As described above, although price promotions can have somewhat negative effects on product loyalty or perceived value (Dodson et al., 1978; Jia, 2008; Kahneman and Tversky, 1979), they mainly benefit retailers by promoting retail profit and attracting customer traffic (Walters and Rinne, 1986). Our approach posits that the benefits of price promotions to retailers decay over time. Thus, because the retail profit earned in the promotional period will gradually fall, retailers will end a promotion when such profit becomes lower than their expected profit without the promotion.

2.1 A Dynamic Model of Price Promotion

We consider a retail store S which sells a product at a regular price of p. This product is durable and assumed to be consumed in T periods (days). We assume that there exist two groups of consumers: general customers and price-sensitive customers. The mass of all potential consumers is normalized to 1. Denote by α the fraction of the consumers who are general customers and by $1-\alpha$ the fraction of the consumers who are price-sensitive customers.

Suppose that the same town also contains a big-box supermarket, which sells the same product at a lower price $(1-r)\,p$, where $0 < r < 1$, due to economies of scale. Store S fights against the larger rival by offering a price discount during a certain period. The store can offer a $100r\%$ discount on the regular price for t periods in order to equalize its price with that of the rival store.

The general customers are assumed to purchase the product at store S.[1] In contrast, price-sensitive customers do not purchase at the regular price p and then head to the far-away big-box supermarket in the pursuit of a lower price.[2] However, price-sensitive customers will purchase at store S if it offers a price discounted to the same level as the price set by the big-box supermarket, which they determine by checking prices prior to shopping.[3] We use π to represent the probability that price-sensitive customers check the price in store S per period.

We consider the profit-maximization problem of store S with respect to the price discount duration, t. Both the regular price and the discount rate are supposed to be exogenously given. Even if we examine a model in which p and r are also strategic variables, they are determined at a level where p and $(1-r)p$ come to equal to the willingness to pay of general and price-sensitive customers, respectively. Therefore, the extended analysis that endogenizes these variables has no influence on the subsequent analysis of this paper.

The profit function of store S is characterized as

$$\Pi(t) = (1-r)p \cdot \sum_{k=1}^{t} D_k + p \cdot \sum_{k=t+1}^{T} D_k, \tag{1}$$

where D_k is total demand in period k. Moreover, d_k denotes the demand of general customers in period k and δ_k denotes the demand of price-sensitive customers in period k, that is $D_k = d_k + \delta_k$.

To simplify the analysis, we assume that the same number of general customers visit store S every period. On the other hand, for $k \leq t$, δ_k can be expressed by the fraction π of price-sensitive customers who have not yet checked for a price discount up until period $k-1$. When $k > t$, no price-sensitive customers visit store S to buy because no price discount exists. In sum, the demand functions are given as follows.

$$d_k = \frac{\alpha}{T} \qquad \text{for} \quad k = 1, 2, \cdots, T \tag{2}$$

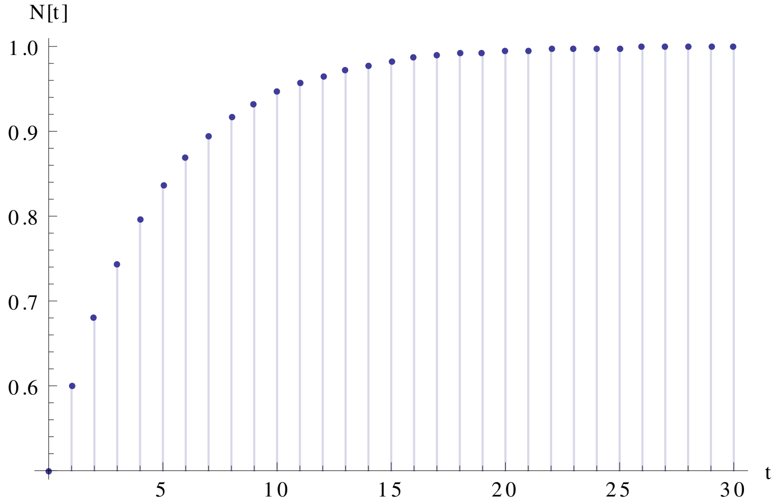
$$\delta_k = \begin{cases} (1-\alpha)\pi & \text{if} \quad k = 1 \\ (1-\alpha-\delta_{k-1})\pi & \text{if} \quad k = 2, 3, \cdots, t \\ 0 & \text{if} \quad k = t+1, t+2, \cdots, T \end{cases} \tag{3}$$

[1] One can consider that the big-box supermarket is located in the town's suburbs. Then, general customers incur a higher trip cost for traveling to the big-box supermarket than the price discount they will attain by shopping there.

[2] The trip cost of price-sensitive customers is less than the price difference between p and $(1-r)p$. Thus, these customers have an incentive to go to the big-box supermarket in order to save their money.

[3] If the same price is set for both stores, price-sensitive customers purchases at store S in an effort to save their trip cost.

Figure 1: Total demand function with respect to t



Note: $p = 1$, $T = 30$, $r = 0.7$, $\alpha = 0.5$, and $\pi = 0.2$

Thus, the total number of customers who visit store S during T periods can be written as

$$N(t) = \sum_{k=1}^{T} D_k = \sum_{k=1}^{T} (d_k + \delta_k) = \alpha + (1-\alpha)\{1-(1-\pi)^t\}. \tag{4}$$

We can derive the following proposition regarding the price discount's effect on customer traffic:

Proposition 1. *Although the implementation of price discounts does increase customer traffic, this increased effect declines over time.*

Proof. The first and second derivatives of the total number of customers become positive and negative, respectively, as follows:

$$N'(t) = (1-\alpha)(1-\pi)^t \cdot \log(1-\pi)^{-1} > 0$$
$$N''(t) = -(1-\alpha)(1-\pi)^t \cdot \left\{\log(1-\pi)^{-1}\right\}^2 < 0$$

□

Figure 1 graphically illustrates the result of the proposition 1.

After simplifying, the profit function can be rewritten as follows:

$$\begin{aligned}\Pi(t) &= (1-r)p\left[\frac{\alpha}{T}\cdot t + (1-\alpha)\left\{1-(1-\pi)^t\right\}\right] + p\cdot\frac{\alpha}{T}\cdot(T-t)\\ &= p\left[\alpha\left(1 - r\cdot\frac{t}{T}\right) + (1-r)(1-\alpha)\left\{1-(1-\pi)^t\right\}\right]\end{aligned}$$

and the first-order conditions for profit maximization are characterized as follows:

$$\Pi'(t) = p\left[-\frac{\alpha r}{T} - (1-r)(1-\alpha)(1-\pi)^t \cdot \log(1-\pi)\right] = 0 \tag{5}$$

Equation (5) implies that the optimal strategy for discount period t is independent from the regular price, which is assumed to be exogenous in this section. From equation (5), we obtain the following proposition concerning the equilibrium discount term:

Lemma 1. *If the fraction of general customers is small enough to satisfy*

$$\log(1-\pi)^{-1} > \frac{1}{T} \cdot \frac{\alpha}{1-\alpha} \cdot \frac{r}{1-r}, \tag{6}$$

the retailer introduces the price promotion for t^* periods that satisfies the following condition:

$$(1-\pi)^{t^*} \cdot \log(1-\pi)^{-1} = \frac{1}{T} \cdot \frac{\alpha}{1-\alpha} \cdot \frac{r}{1-r} \tag{7}$$

Proof. It is readily apparent that solving equation (5) with respect to t yields the equilibrium condition (7). Condition (6) is necessary for t^* to be positive:

$$\begin{aligned} t^* > 0 &\iff (1-\pi)^{t^*} < 1 \\ &\iff (1-\pi)^{t^*} \cdot \log(1-\pi)^{-1} < \log(1-\pi)^{-1} \\ &\iff \frac{1}{T} \cdot \frac{\alpha}{1-\alpha} \cdot \frac{r}{1-r} < \log(1-\pi)^{-1} \end{aligned}$$

Furthermore, the second-order condition is satisfied for all t. □

Lemma 1 implies that the equilibrium discount term t^* is increasing in T and decreasing in r and α. As one would expect, the more durable a product (i.e., larger T), the longer the required discount term. Furthermore, the higher the price discount needed to compete with the rival store (i.e., larger r), the shorter the offered discount term. More interestingly, as the fraction of general customers increases (i.e., larger α), the retailer should decrease the duration of its price promotion. Price promotions have the positive effect of enhancing the demand of price-sensitive customers while also allowing general customers to obtain an unexpected price discount.

Next, we look at the marginal effect of extending a discount period from t to $t+1$, which is denoted by

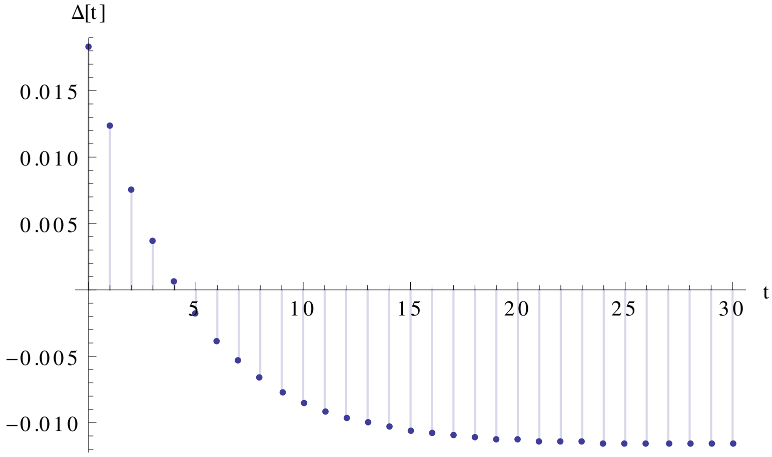
$$\Delta(t) \equiv \Pi(t+1) - \Pi(t) = p\left[-\frac{\alpha r}{T} + (1-r)(1-\alpha)(1-\pi)^t \pi\right]. \tag{8}$$

We introduce the following assumption to ensure the incentive compatibility for store S to discount its product for at least one period:

Assumption 1. $\pi > \frac{1}{T} \cdot \frac{\alpha}{1-\alpha} \cdot \frac{r}{1-r}$

Because $(1-\pi)$ is smaller than 1, the function $\Delta(t)$ is decreasing in t. The following proposition summarizes the preceding analysis:

Figure 2: Marginal effects of extending price promotion periods



Note: $p = 1$, $T = 30$, $r = 0.7$, $\alpha = 0.5$, and $\pi = 0.2$

Proposition 2. *Suppose that Assumption 1 holds. Although the implementation of a price discount increases the store's profit, this effect diminishes over time.*

Proof. Assumption 1 ensures that $\Delta(0) > 0$, thereby implying that store S offers a price promotion for at least one period. The derivative of $\Delta(t)$ is negative for all t as follows:

$$\Delta'(t) = (1-r)(1-\alpha)(1-\pi)^t \pi \cdot \log(1-\pi) < 0$$

□

Building on this result, we posit that the price promotion will be ended if the marginal effect of extending its duration falls below a reference point (usually 0). Figure 2 shows a numerical example of the marginal effects of extending the price promotion duration. It is noteworthy that $\Delta(0)$ takes a positive value, which means that implementation of a price promotion essentially boosts the retailer's profit. Meanwhile, the marginal return of a price promotion has a decaying trend with elapsed time. Thus, the price promotion will be ended at t^* for which the subsequent $\Delta(t)$ becomes negative. In this numerical example, the optimal duration of price promotion is four days (i.e., $t^* = 4$).

2.2 Hypotheses

We speculate that the benefits of a price promotion on customer traffic and retail profits tend to diminish with elapsed time. Using an elementary model in the previous subsection, we derived a theoretical hypothesis. Propositions 1 and 2 revealed an interesting effect of price discounts on the number of customers and retail profit, respectively. Therefore, we advance the following hypotheses:

Hypothesis 1. *Although the implementation of a price discount increases customer traffic, this ability diminishes over time.*

Hypothesis 2. *Although the implementation of price discount increases the store's profit, this boost diminishes over time.*

In addition, although previous research examining the negative impact of a price promotion on product loyalty focused on the depth of the price discount (Dodson et al., 1978), this study posits that this potential negative impact may also depend on the time span of the promotion.

Hypothesis 3. *Elapsed time of a price promotion relates negatively to product loyalty after a certain duration.*

3 Methodology

In this section, we introduce the dataset and variables' measurements for the entire study. We also construct the statistical models used in the data analysis.

3.1 Dataset

The data in this paper were collected through a point-of-sale (POS) system at a food-based medium-sized supermarket group, which has about 70 chain stores in the Kansai area of Japan. This group provided their in-house data for this study's analysis. To understand the relation between the duration of price promotion and retail profit, we decided to focus on one product, a family-sized pack of yogurt, after a fundamental analysis of these POS data. This product was chosen because of its sales volume and frequency of inclusion in promotions.

In the data pre-processing stage, we cleaned and assembled the data on customers' consumption records from 67 stores and obtained a total of 44,588 aggregated daily sales records for the target product covering a continuous period from April 2011 to March 2013. Based on the results of the fundamental analysis, we excluded 11 stores' data, which were found to have serious noise, to avoid sample bias and invalid data caused by system error. The final sample for this study thus contains a total of 37,010 daily sales records from 56 stores. In addition, on the basis of the price changes present in the original data, promotion-related information in this period was also analyzed and integrated into our dataset.

3.2 Measurements

3.2.1 Discount Rate

The discount rate is the most direct manifestation of a price promotion, and it intuitively reflects the difference between the regular and current price. Prior research has significantly demonstrated the influence of the discount amount on corresponding product's sales volume, brand loyalty, and customer traffic (Gupta, 1988; Walters and Rinne, 1986). In this paper, the regular price is denoted as the mode[4] of the sales price during whole period, whereas the current price is actually assigned as the mode of all unit prices in a day's receipts records.[5] Fundamental analysis of our dataset revealed that the regular price of the corresponding product is 168 yen, but the current price mainly takes four values: 148, 138, 128, or 98 yen. Therefore, the price discount is calculated using the following equation:

$$dis = \frac{168 - P}{168} \times 100\% \tag{9}$$

where P represents the current price and dis indicates the discount rate.

3.2.2 Retail Profit

Daily profits in this study are calculated by subtracting daily costs from daily revenues. Daily revenues are the sum of the sales amount per day, which can be calculated from our dataset. However, data on costs is difficult to obtain because of trade secrets. Therefore, relying on previous experience, we assume that a product's unit cost is half of its regular price. Therefore, daily profits can be processed using the following equation:

$$\Pi = TR - TC = TR - 84 \times Q \tag{10}$$

where Π, TR, and TC represent daily profits, revenues, and costs of the product, respectively, and Q identifies the sales volume.

3.2.3 Duration and Elapsed Time of Promotion

This study aims to investigate the dynamic relationship between elapsed time and profit effects of price promotions. We define a dummy variable D^p, which takes the value of 1 if a price promotion occurs. The occurrence of a promotion is determined by whether the current price is lower than the regular price. In our whole sample, the mean of D^p is 0.28 and the standard deviation is 0.45. The duration of promotion is defined as the length of time from the promotion's start to the time when the retailer restores the regular price. We count the elapsed time of promotion by calculating the interval between the current date and the promotion start date. However, the possibility exists that during a promotion's duration, the retailer may set separate prices on different dates. In that case, we recount the elapsed time only if the current price is lower than the price on the previous day. Table 1 offers a simple example showing the duration and elapsed time of a price promotion, and Table 2 describes the promotion duration and frequency within the studied time period.

[4] The mode is the value that appears most often in the dataset.

[5] The supermarket may carry out a special sale for the products near a guarantee period.

Table 1: Example of Promotion Duration

Date	Regular Price	Current Price	D^p	Elapsed Time
2012/02/01	168	168	0	0
2012/02/02	168	148	1	1
2012/02/03	168	148	1	2
2012/02/04	168	128	1	1
2012/02/05	168	128	1	2
2012/02/06	168	148	1	3
2012/02/07	168	168	0	0
2012/02/08	168	168	0	0
...	...	...	...	...

Table 2: Duration and Frequency of Price Promotion

	Duration	**Frequency**	**Percent**	**Cumulative Percent**
Regular Price	1 day	108	77.1%	77.1%
168 Yen	2 days	17	12.1%	89.2%
Total Num. of Stores	3 days	7	5.0%	94.2%
56	4 days	3	2.1%	96.4%
Period	5 days	2	1.4%	97.8%
2011.4 – 2013.3	6 days	1	0.7%	98.5%
	more than 6 days	2	1.4%	100%

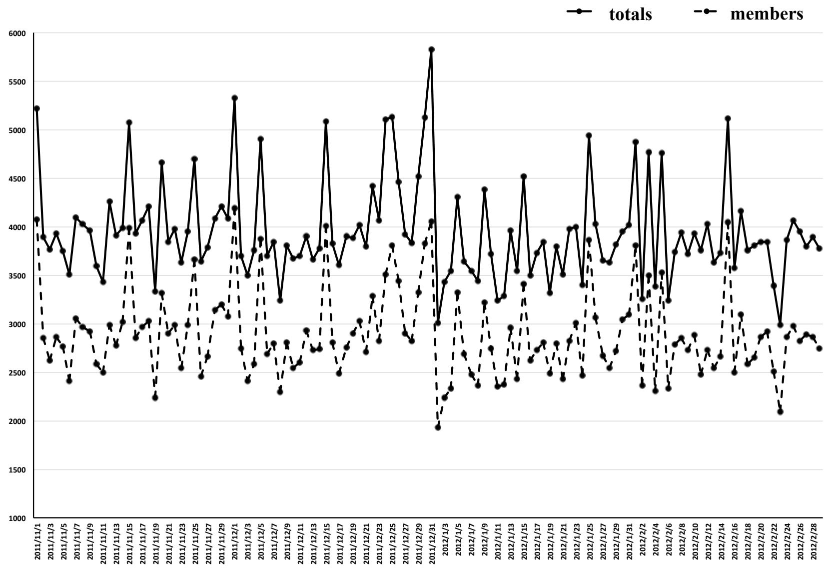
3.2.4 Customer Traffic

Customer traffic here refers to the total number of customer visits per day per shop. Many studies have suggested that a price promotion not only increases the sales volume of the target product but also attracts customer traffic (Gupta, 1988; Mulhern and Leone, 1990). In addition, there is much evidence that increasing the number of customer visits can indirectly help a retailer boost retail profits (Jia, 2008). This is because of the strong positive correlation between total product sales and customer traffic (Gomez et al., 2004). Here, we use the latter as a proxy for total demand. In our paper, customer traffic data were obtained by counting the number of receipts from each store per day. Furthermore, this study divides customers into two types, members and non-members. Comparison of the distribution of customer traffic (Figure 3) revealed no major difference in dispersion between these two customer types.

3.2.5 Control Variables

This study's control variables include a time factor and the size of the business's district, both of which aim to control the number of customer visits. In the literature on retailing, the number of customers is not only affected by price promotions but also by external factors, such as periodicity and location (Newing et al., 2013). For instance, the number of entering customers is larger for a store located in a downtown area or near a train station than for shops located elsewhere. In this paper, we identified each target store to determine their location and size. Figure 4 represents the location of a part of target stores on map, and Table 3 outlines the distribution of store sizes in our dataset based on the average

Figure 3: Distribution of Customer Traffic



Note: Period: Nov 1st, 2011 to Feb 28th, 2012; Store ID: 1023.

Table 3: Distribution of Store Sizes

Customer Traffic*	Num. of Stores
less than 1500	10
1500 $\sim$ 2500	22
2500 $\sim$ 3500	14
3500 $\sim$ 4500	7
no less than 4500	3

Note: The value in column "Customer Traffic" shows the average of number of customers per day.

daily number of customers in each store.

Likewise, the number of customer visits shows an obvious increase on days offering an extra member points promotion. A dummy variable D^d is defined in this study to denote whether extra member points were offered on the current day. The supermarket website states that customers can obtain five times the number of member points if they shop there on the "1st," "5th," "15th," and "25th" of each month. Our dataset indeed shows that customer traffic (i.e., number of receipts) exhibits a noticeable increase on those days.

3.3 Empirical Model

Figures 5 represents the relationships among current price, customer traffic and retail profit, which is calculated through fundamental analysis. This figure demonstrates that price promotions have certainly helped retailers attract customers to visit the store, and thus, have helped increase retail profits. This finding is consistent with the results in the literature. However, due to the limitations of data in terms of duration length, the declining trends of number of customers and profits over time remain unclear from the figure. Therefore, we build statistical models to examine this relationship.

Figure 4: Location of a Part of Stores

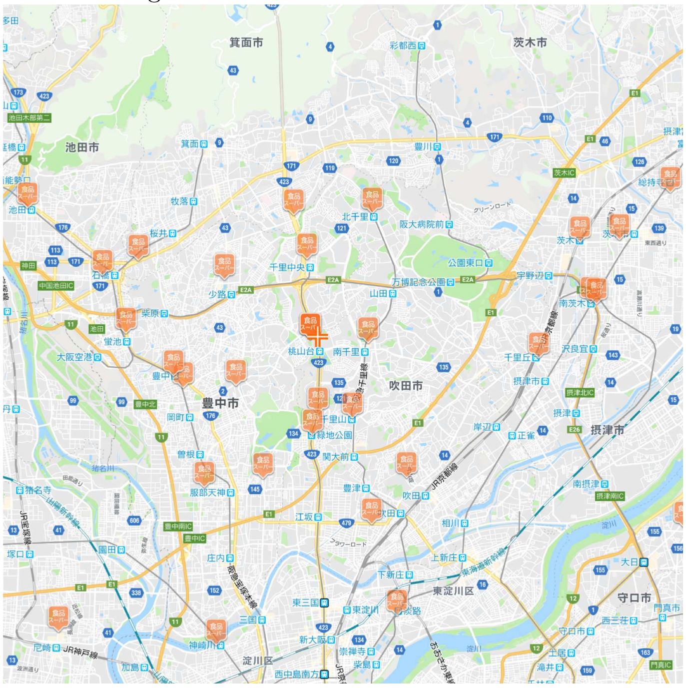
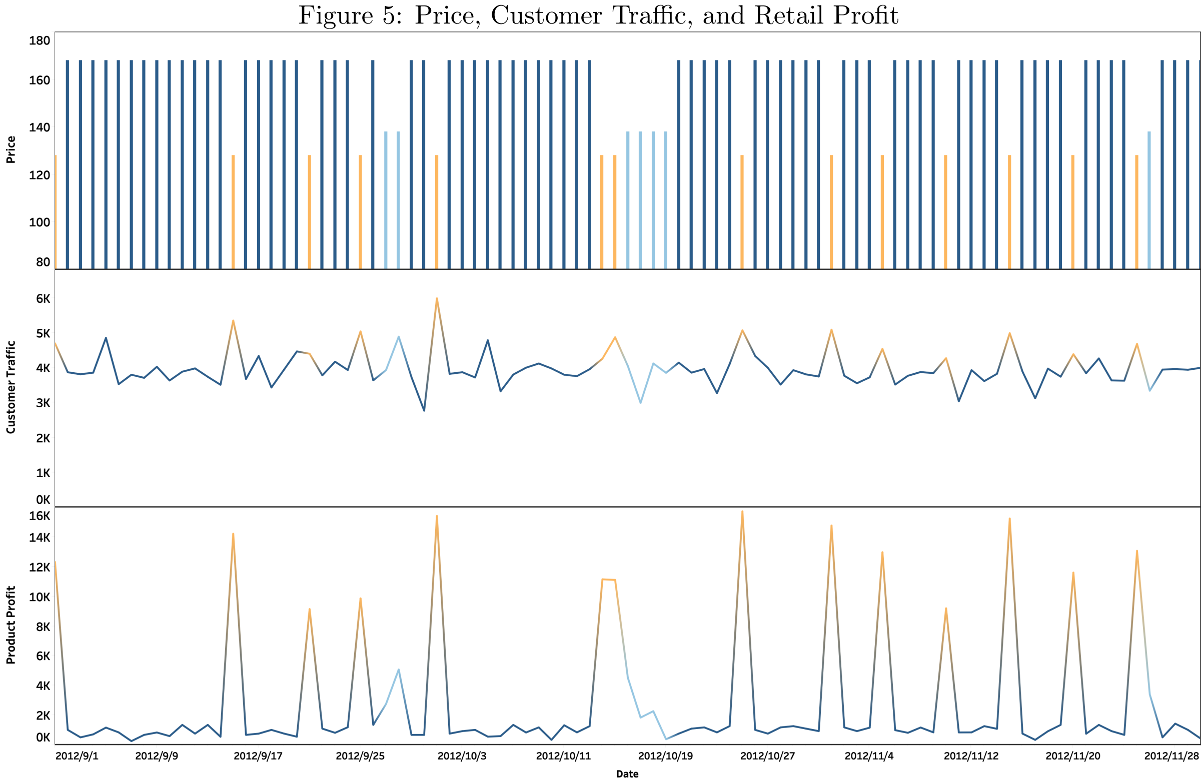


Figure 5: Price, Customer Traffic, and Retail Profit



Note: Period: Sept. 1st, 2012 to Nov. 30th, 2012; Store ID: 1023.

The literature has indicated that retail profits mainly depend on three factors: (1) consumer demand, (2) extent of price discounts, and (3) product loyalty (Jia, 2008). Correspondingly, the effects of price promotions on retail profit include (1) a direct effect by increasing purchase demand, (2) an indirect effect by attracting customer traffic, and (3) an indirect effect by influencing product loyalty (Gupta, 1988). Building on this idea, the present study establishes the following statistical model to test the hypotheses proposed in Section 2. To simplify the empirical model and intuitively focus more on the relation between retail profit and promotion duration rather than the size of the discount, we assume that the extent of discount has a linear impact on profit.

$$\Pi_i = \beta_0 + \beta_1 dis_i + \beta_2 dis_i * t_i + \beta_3 dis_i * t_i^2 + \beta_4 t_i + \beta_5 t_i^2 + \theta v_i + u_i \tag{11}$$

where Π_i represents the store's daily profits for observation i,[6] dis_i indicates the discount rate, v_i identifies customer traffic, t_i means the elapsed time from the start of the promotion, and u_i is the error term. We introduce the square of elapsed time (i.e., t^2) to examine whether the impact of price promotion on retail profit shows a decaying trend over time.

It is worth noting that in this study, the possibility exists that external factors such as periodicity and location may increase both customer traffic and retail profit. This situation can lead to correlation between the error term (u_i) and customer traffic (v_i), and make the parameter estimate biased and inconsistent because $E\left(u_i|v_i\right) \neq 0$, which is known as endogeneity (Zhang et al., 2009). Therefore, we developed the following models and estimated them using a two stage least-square method:

$$\Pi_i = \beta_0 + \beta_1 dis_i + \beta_2 dis_i * t_i + \beta_3 dis_i * t_i^2 + \beta_4 t_i + \beta_5 t_i^2 + \theta \hat{v}_i + u_i \tag{12}$$

$$v_i = \hat{v}_i + e_i = \alpha_0 + \alpha_1 dis_i + \alpha_2 dis_i * t_i + \alpha_3 dis_i * t_i^2 + \alpha_4 t_i + \alpha_5 t_i^2 + \gamma_1 D_i^d + \mathbf{store_i}'\phi + e_i \tag{13}$$

where, in these models, D_i^d is the dummy variable, which takes the value of 1 on a point-day with five times member points, $\mathbf{store_i}$ is a nominal vector that denotes the store ID, and the remaining variables have been defined previously. In what follows, we refer to the equations (12) and (13) as "Profit Model" and "Customer Traffic Model," respectively. D_i^d and $\mathbf{store_i}$ are two instrumental variables and $\hat{v}_i$ is the "instrumented" customer traffic.

Combined with the antecedent theoretical framework, $\left\{\beta_1 dis_i + \beta_2 dis_i * t_i + \beta_3 dis_i * t_i^2\right\}$ represents the direct effects of a price promotion on retail profit because it reflects both the discount rate and elapsed time; $\left\{\beta_0 + \beta_4 t_i + \beta_5 t_i^2\right\}$ represents the change in product loyalty over the elapsed time of the price promotion; and $\theta \hat{v}_i$ indicates the effect of "instrumented" customer traffic on retail profit, where $\hat{v}_i$ is a predicted value determined by price discount, elapsed time, and the two instrumental variables.

[6] In this study, i is from 1 to 37,010.

Table 4: Regression Results for Customer Traffics and Retail Profit

	Customer Traffics Model				Profit Model		
	Estmate		Std.Err		Estmate		Std.Err
dis_i $[\alpha_1]$	6.99	***	0.47	dis_i $[\beta_1]$	354.17	***	3.35
$dis_i * t_i$ $[\alpha_2]$	-2.09	***	0.62	$dis_i * t_i$ $[\beta_2]$	-159.79	***	4.88
$dis_i * t_i^2$ $[\alpha_3]$	-0.13		0.08	$dis_i * t_i^2$ $[\beta_3]$	13.94	***	0.68
t_i $[\alpha_4]$	-15.44	*	8.50	t_i $[\beta_4]$	855.44	***	67.64
t_i^2 $[\alpha_5]$	6.05	***	1.25	t_i^2 $[\beta_5]$	-117.19	***	10.12
	...			v_i $[\theta]$	1.24	***	0.01
Intercept $[\alpha_0]$	1856.11	***	12.45	Intercept $[\alpha_0]$	-1932.62	***	33.95
Adj R-sq	0.925			Adj R-sq	0.542		
F Statistics	7459.13 ***			Wald Statistics	41248.66 ***		

Note: N=37010, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

4 Results

In this section, we check the endogeneity of customer traffic and estimate the parameters of the statistical models to examine the relationship between the elapsed time and profit effects of a price promotion.

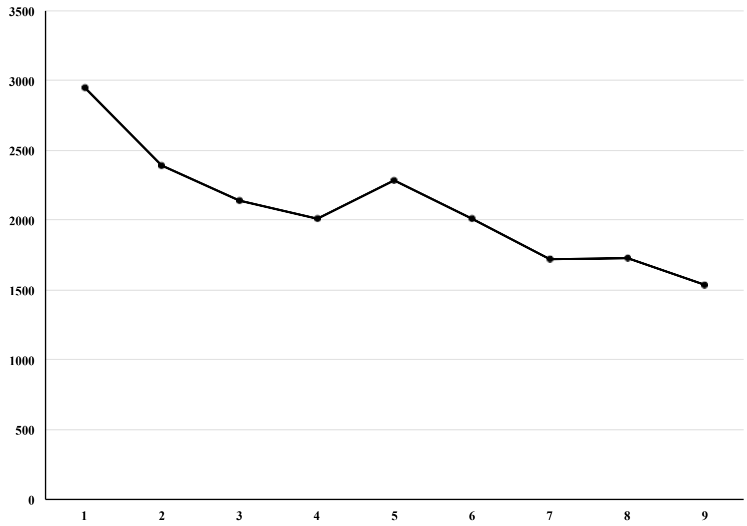
Results of the Durbin-Wu-Hausman test ($F_{(1,37002)} = 798.66$, $p < 0.01$) show that the variable of customer traffic (v_i) is endogenous in the profit model. In addition, we checked the validity of the instrumental variables by using tests for underidentification ($\chi^2 = 34000$, $p < 0.01$) and weak identification ($F = 7998.39$, $p < 0.01$). The results confirmed the effectiveness of the instrumental variables used in our model.[7] Therefore, the 2SLS model in our study is proven to be reasonable according to these statistical test indicators.

To investigate the dynamic effect of price promotions on retail profit, this paper focuses more on the time-related factors. Specifically, we perform a regression of customer traffic model to examine the relationship between the price promotion and customer traffic in the first stage, then plug the predicted value of customer traffic into the profit model and regress in the second stage to explore how a price promotion dynamically influences retail profit. Table 4 reports the estimation results of these models.

In the customer traffic model, the estimates indicate that price discounts have a significant impact ($\alpha_1 = 6.99$, $p < 0.01$) on customer traffic, with a higher discount resulting in a higher number of customer visits. This is consistent with the results of the fundamental analysis (see Figure 5) and the conclusions of prior research (Walters and Rinne, 1986). On the other hand, the coefficient of the interaction between discount and elapsed time is negative ($\alpha_2 = -2.09$, $p < 0.01$). This means that the effect of a price discount on customer traffic decreases over time. In addition, the coefficient on elapsed time is negative ($\alpha_4 = -15.44$, $p < 0.1$) but positive for time squared ($\alpha_5 = 6.05$, $p < 0.01$). However, the interaction between price discount and time squared failed to emerge as a significant variable. To intuitively show how the elapsed time of a promotion affects the number of customers, Figure 6 depicts the relationship between elapsed time and average number of customer visits, with a current price of 128

[7] The instrumental variables in our model are nominal variables, so the test for overidentification in this case is not very meaningful.

Figure 6: Effect of Elapsed Time on Customer Traffic



Note: Sales price is 128 yen, with the discount rate of 24%.

yen (i.e., discount rate of 24%). The figure indicates that *ceteris paribus*, the elapsed time of a promotion negatively influences customer traffic. Therefore, we are able to confirm that price promotions do serve to increase customer traffic, but this ability to increase traffic diminishes over time. In other words, Hypothesis 1 is supported.

To test Hypothesis 2, i.e., if a price promotion's impact on retail profit decays over elapsed time, we focus on the results in the part of $\{\beta_1 dis_i + \beta_2 dis_i * t_i + \beta_3 dis_i * t_i^2\}$. Similar to the model for customer traffic, the estimates in the profit model show that the coefficient on price discount is positive ($\beta_1 = 354.17$, $p < 0.01$), which means a present price discount can indeed help retailers increase profits. This estimated result is consistent with the finding in our earlier fundamental analysis (see Figure 5) and the literature (Jia, 2008; Walters and Rinne, 1986). With respect to the interaction of price discount with elapsed time and elapsed time squared, the estimated coefficient in the regression for the former is negative ($\beta_2 = -159.97$, $p < 0.01$) but positive for the latter ($\beta_3 = 13.94$, $p < 0.01$). These findings indicate the existence of a downward relationship between the profit effects of a price discount and elapsed time of the promotion. Therefore, Hypothesis 2 is also supported.

Hypothesis 3 predicts that the elapsed time of a price promotion relates negatively to product loyalty after a certain timeframe has elapsed. As mentioned in prior research, rises or falls in product loyalty are usually represented by the variation of the intercept in a regression model. As described above, the $\{\beta_4 t_i + \beta_5 t_i^2\}$ portion represents the effects of elapsed time of a promotion on product loyalty. In this study, the estimated results show that the coefficients of elapsed time ($\beta_4 = 885.44$, $p < 0.01$) and its square ($\beta_5 = -117.19$, $p < 0.01$) both have significant impacts on product loyalty. Due to the negative value of time squared, we assert that customer loyalty decreases progressively over time after a certain time threshold is passed. Further calculations indicate that product loyalty becomes negatively related to elapsed time after three or four days of the promotion. Hence, Hypothesis 3 is supported.

5 Discussion and Conclusions

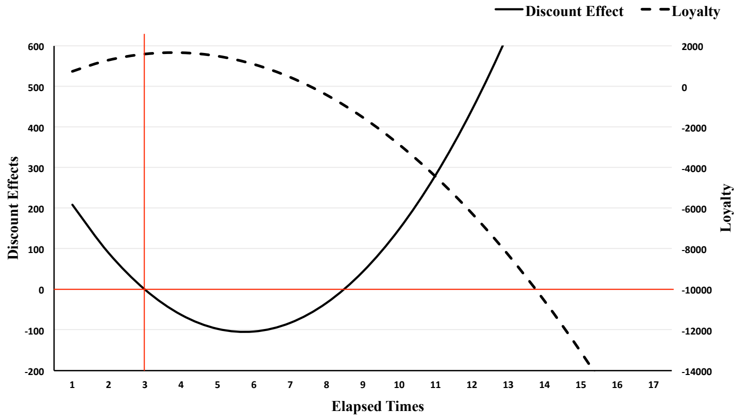
Prior research has indicated that price promotions contribute to retailers' retail profit, but few studies have provided much insight into why and when retailers choose to halt a promotion. This study answers these questions by demonstrating that the overall profit effects of price promotion have a downward trend with elapsed time. This paper has proposed a statistical model with two-stage least squares to empirically investigate the dynamic relationship between elapsed time of a price promotion and its effects on marketing outcomes, which include retail profit, customer traffic, and product loyalty. Continuous POS data for a well-known brand of yogurt sold in a medium-sized chain of supermarkets in Japan's Kansai area for the period from April 2011 to May 2013 were used in this study. The major results of the analysis suggest that the effects of price promotion on all three marketing outcomes have a process that decays with elapsed time of the promotion.

A fundamental analysis revealed that price promotions benefit the retailer by attracting customers to the store. Although the implementation of price discounts increases customer traffic, this study confirms that this positive effect decreases progressively with time elapsed since the start of the promotion. In other words, if a sale goes on for too long, the number of customers will not increase much in the later period. This might be because a longer promotion duration will also lower consumer perceived value by affecting the reference price, resulting in a decline in the intention of customer visits.

Prior research has also indicated that price discounts might decrease brand loyalty for the product (DelVecchio et al., 2006). However, it has been unclear whether product loyalty may change with the elapsed time of a price promotion. Figure 7 shows the relationship between the elapsed time of a price promotion and both discount effect and product loyalty. This study's findings have confirmed that although product loyalty experiences a slight boost at the beginning of a price promotion (about three days), this will diminish over time. In other words, an excessively long duration for a price promotion may further deteriorate brand loyalty for the product.

With respect to the dynamic profit effects of price promotions, the most important part is the relationship between elapsed time and price discount effects on profits. Retailers implement price promotions to increase retail profits; thus, a promotion will be halted if the price discount has a negative impact on profit. Figure 7 visually demonstrates that although the implementation of a price discount increases retail profit, its ability to produce such an increase shows a diminishing trend. In addition, in our case, the price promotion even has a negative side effect that decreases the retail profit, which began to appear about three days after the start of the promotion. This finding partially explains the reason why around 95% of promotions in our dataset last no more than three days.

Figure 7: Elapsed Time, Discount Effect, and Customer Loyalty



The main contribution of this study is to provide clear explanations for why and when retailers end price promotions from both theoretical and empirical perspectives. Unlike previous research studies that discuss the negative impacts of price promotions, focusing on the extent of discounts, this paper answers the research questions based on the dynamic relationship between elapsed time and the overall effects of the promotion on retail profit. The study's findings provide clear empirical support for the argument that the overall profit effects of price promotions have a downward trend with elapsed time. In addition, the use of point-of-sale data in our study also contributes to the existing literature by improving the accuracy and authenticity of the empirical results.

Important managerial implications can be drawn from our findings. First, regarding the extent of discount level, if a price promotion is implemented for too long of a time span, it can begin to have a negative impact on retailers' trade profit. Marketing managers should stop a price promotion at the point when their expected profits from the promotion drop below those expected at the usual price. It is intended that the analysis results of this study can help retailers set the optimal duration of price promotion reasonably and effectively.

Inevitably, our study suffers from a few limitations. First, this study focused on only one product to investigate the dynamic relationship between elapsed time and overall profit effects of price promotions. However, this relationship may be moderated by other factors, such as the product's characteristics. Therefore, more empirical data and work are needed to demonstrate the effectiveness and universality of our conclusions. It would be important to predict and control for this possibility in future research, which would better help retailers set the optimal duration of price promotions. The second limitation is that this study only considered the effects of a price promotion on the target product's profit. However, retailers sometimes also carry out price promotions to increase the sales volumes and profit for other complementary products, which will be discussed in our future study.

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