An Analysis of Sales Promotion 'Discount' Using Game Refinement Measurement

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Long Zuo[1] and Hiroyuki Iida[2]

Japan Advanced Institute of Science and Technology
1-1 Asahidai, Nomi, Ishikawa, Japan 923-1211
{zuolong, iida}@jaist.ac.jp[1,2]

Abstract. This paper explores a promising rate of discount as sales promotion, whereas game refinement measurement is employed for the assessment. Computer simulation was performed to collect data for the analysis, and real data from well known companies such as Amazon JP was used. The results indicate that a reasonable discount zone from the customer's point of view is ranged from 49% to 64% off.

Keywords: Sales promotion, Discount, Game refinement measurement

1 Using Game Refinement Theory to Analyze Discount

Classical game theory originated with the idea of the existence of mixed-strategy equilibrium in zero-sum game. It has been widely applied as a useful tool in many domains such as political science, economics and computer science [1]. Game refinement theory is another theory focusing on the attractiveness and sophistication of a game based on the game outcome uncertainty . Many efforts have been made to the study of the attractiveness in the domain of board games, sports and video games [3], which indicates that measurement for game refinement of sophisticated games is located somewhere between 0.07 and 0.08 regardless of different types of games, as shown in Table 1.

Table 1. Measures of game refinement for sophisticated boardgames and sports

Boardgames/Sports	GR
Chess [2]	0.074
Go [2]	0.076
Basketball [3]	0.073
Soccer [3]	0.073

The next challenge is to apply the game refinement measurement to serious game domains such as education and business. In this study we have chosen 'discount' as sales promotion in the business domain. If the rate of discount is reasonable from the perspective of customers, the game of discount would have a comfortable zone value of game refinement like sophisticated boardgames and sports.

2 Mathematical Model and Data Analysis

Usually customers have little knowledge about the cost of a product of interest[4]. It implies that the cost may be not so essential for customers. They would care about the price of the product, i.e., how much money can be saved by the discounting. Thus, the money saved by the sales promotion 'discount' is considered as the benefit for customers. The total benefit of the shopping activity for customers in a certain time is predictable. The game progress [3]can be constructed by two factors: the total benefit of a certain product (say B) and the total normal price without discount (say P). However, the game information progress is unknown during the in-game period. The presence of uncertainty during the game, often until the final moments of a game, renders exponential game progress. Hence, a realistic model of game information progress is given by Eq. (1).

$$x(t) = B(\frac{t}{P})^n \tag{1}$$

Here n stands for a constant parameter which is given based on the perspective of an observer in the game considered. Then acceleration of game information progress is obtained by deriving Eq. (1) twice. Solving it at $t = P$, the equation becomes

$$x''(P) = \frac{Bn(n-1)}{P^n}P^{n-2} = \frac{B}{P^2}n(n-1) \tag{2}$$

Hence, it is reasonably expected that the larger the value $\frac{B}{P^2}$ is, the more the game becomes exciting due to the uncertainty of game outcome. Thus, we use its root square, $\frac{\sqrt{B}}{P}$, as a game refinement measure for the discount. To normalize this model, we assume that the benefit of a product is ranged from 0 to 100 and the normal price is 100. When there exits a percentage off of discount, there also exists a 100 normal price in our mind since it is expressed as a percentage. Then the game refinement measurement for customers can be shown in Eq. (3) and we get the GR_c of different extent of discount for customers, as shown in Table 2. Here d stands for the discount coefficient. For example, if the discount is 10% off, the discount coefficient is 0.9.

$$GR_c = \frac{\sqrt{B}}{P} = \frac{\sqrt{100(1-d)}}{100} \tag{3}$$

Table 2 shows that GR_c values are ranged from 0 to 1. However, it is important to identify a reasonable discount zone for customers. It is expected that lower GR would be less attractive for customers, whereas higher GR would be of some concern about quality and hard for the sustainability of seller. To identify the reasonable discount zone, we need to apply the data for the analysis. The data are collected in two ways. One is to optimize the seller's total profit within a certain time with the genetic algorithm by computer simulation, which is performed from the seller's point of view with the maximum total sales volume. Another way is to collect the data from the real business, via the on-line

Table 2. GR_c

Discount	GR_c
0% off	0
10% off	0.032
20% off	0.045
30% off	0.055
40% off	0.063
50% off	0.071
60% off	0.077
70% off	0.084
80% off	0.089
90% off	0.095
100% off	0.1

Table 3. Simulation

Ranking	Discount
1	39% off
2	36% off
3	35% off
4	29% off
5	31% off
6	27% off
7	31% off
8	26% off
9	21% off
10	37% off

Table 4. Amazon JP

Ranking	Discount
1	53% off
2	53% off
3	42% off
4	59% off
5	56% off
6	58% off
7	58% off
8	59% off
9	50% off
10	56% off

retailers to find the most popular product, where this data collection considers from the customer's point of view [5]. We observed all the category of the best seller and selected the Bento Boxes & Water Bottles. The reason we select this category is that all the top 10 products have a relatively high level of discount and we would like to see the ranking if there exists a higher discount.Then, we set a fictitious market which intends to sell $10,000$ products within a year. The total amount sale is determined by two factors: quantity and price. The discount coefficient will be changed every week and range from 0 to 1. The demand of product follows the F distribution and the customers follow the Poisson distribution. So we put the discount coefficient into each room of chromosome. After crossover(0.8), mutation(0.2) and over 500 times iteration, the best solution was found. We show, in Table 3 and Table 4, the discount rate by simulation and real data of Amazon JP, respectively. The discount rate of simulation is ranged from 21% off to 39% off, whereas the top sales product of Amazon JP is ranged from 42% off to 59% off. We should note that the results of simulation must be the best solution for the seller but considers little about customers. However, GR_c of Amazon JP is ranged from 0.065 to 0.077, which is located in the zone value. Thus, we see that simulation concerns about sustainability of the game and Amazon JP concerns about popularity of the game under the assumption that the sales promotion 'discount' is a fascinating game.

3 Finding Comfortable Discount Zone

The attractiveness of games often comes with approximately 0.07 to 0.08 GR values and its corresponding discount zone is ranged from 49% off to 64% off, as shown in Table 5. The essence of game refinement theory is to find a comfortable acceleration (the sense of thrill) for game players. Hence, the discount rate should not be too high. For example, too high GR_c may also cause some concern such as quality of a product of interest. This is why some shopping festivals like "Black Friday" in America and "1111 shopping festival" in China both set their discount rate 50% off since this discount rate falls on the comfortable zone in the sense

of game sophistication. Higher GR_c means higher entertaining impact and more popular which would be able to highly motivate customers to buy more.

Table 5. Discount rate and measures of game refinement (GR_c) for Amazon JP, Simulation and Recommend

	Discount rate	GR_c
Amazon JP	42% off-59% off	0.065-0.077
Simulation	21% off-39% off	0.046-0.062
Recommend	49% off-64% off	0.07-0.08

We evaluated the game refinement values of different extent of discount which is considered as the game of sales promotion in business, while using the game refinement measurement derived from the game information progress model. This is because the acceleration of game information progress is related to the emotional impact such as entertainment and engagement which may correspond to the force in our mind. In the business domain, the seller sets the discount rate and the customers will be encouraged to buy more due to the attractiveness. Thus, this study quantified the game refinement value of discounting and recommended the seller to set the discount rate which is ranged from 49% off to 64% off. According to the proposed discount zone, the seller may select its own discount strategy, i.e., the dynamics of discounting.

This paper provides a perspective that discount as sales promotion can be considered as entertainment. Thus, in this paper, we only focused on the attractiveness of discount without considering the cost, the value of item and the motivation of customer. The essential idea of this paper is to offer an appropriate discount zone based on the previous knowledge from the well refined game as we consider that discounting is a kind of game thinking in the business domain. This is the first attempt to apply game refinement theory to the domain of business with a focus on sales promotion 'discount'. Future works may consider other sales promotions such as coupon and freebie.

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