Optimum Pricing Strategy for Maximization of Profits and Chance Discovery

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Abstract

The objective of this paper is to present and discuss methods for formulating optimum pricing strategies for maximizing store profit levels using consumer purchase data. We have used a very large amount of consumer purchase behavior data in order to clarify the effects on store-level profits of a wide range of specific products to develop a support system for pricing specialists. At the end of this paper, we analyze the framework that has been presented for the system from the standpoint of its utility for discovery of new business chances and discuss the need to clarify the problems connected with the use of data mining-based pricing strategies.

Keywords: optimum pricing strategy, maximization of profits, consumer behavior, logit model.

1. Introduction

During the current deflationary period, there has been continuous and growing price competition among retailers aimed at capturing and keeping customers. Thus, special sales are being carried out everyday at super markets. However, in the case of food retailing in Japan, it is very rare that a retailer will scientifically analyze such sales in advance, using data from previous sales, for the purpose of establishing pricing strategies. In most cases, previous experience and the sales strategies of other rival retailers are used for the purpose of setting the prices of the products that are featured during such special sales. This paper proposes using very large amounts of customer purchase data to develop optimum pricing strategies for supermarkets.

Consumers have different needs and, therefore, have different standards [5] for judging the attractiveness of the special sales prices for different products. So, it is only natural that the reactions of different consumers to specific sales will differ. Thus, lowering prices may not, in given situations, result in increases in sales. The store marketing personnel that decide on product item prices must utilize suitable pricing strategies [4] based on an in-depth understanding of consumer purchase behavior. For this purpose, it is important to pay attention to the implications of accumulated data collected with the use of customer membership cards for the purpose of understanding consumer purchase behavior. However, regrettably, there are numerous studies on the sales and profit levels pertaining to certain product items, but virtually no studies on the creation of pricing strategies from the standpoint of optimizing profits for each given store as such. The price of a given item can often affect the sales and profits of other items so that there is a need for each store to clarify these complicated relationships between items in order to maximize the profit levels of each store.

The objective of this paper is to discuss analytic methods for formulating optimum pricing strategies for maximizing outlet profit levels using consumer purchase data. This study is a typical example of using data mining methods for marketing applications. Therefore, looking that this process from the standpoint of chance discovery [3], there are several problems that must be dealt with. For example, in this paper, the suggested methods of analysis tend to be based on statistical evaluation criteria. Thus, in the case of relatively small quantity phenomena in the pricing data, i.e., hard to notice, exception-related phenomena concerning related products, the important potential effects of these phenomena may not be noticed, or may be ignored. In reviewing the various cases in this study, it is necessary to keep in mind the possible problems related to the development of data mining oriented methods of pricing, and we wish to present and discuss the possibilities connected with using chance discovery techniques when formulating pricing strategies.

2. A framework for optimum pricing strategy for maximization of profits

Our development of pricing strategy for maximizing profit is based on a framework that consists of 4 stages. The first 2 stages are not concerned directly with analysis of pricing as such. Rather, they consist of the general content required for the analysis of customer purchase data. At the first stage, the data that is

to be subject to analysis is cleaned and error data and noise are processed. At the second stage, the basic analysis of the specific outlets and customers included in the research is carried out, and the data is inspected to check whether or not the overall data includes areas or specific outlets that have unique features widely differing from the other areas and outlets that appear in the data.

Step three consists of discovering the specific groups of related products or product categories that will be effective for use for special sales aimed at increasing the sales of the given outlet. Within the vast number of different items handled by a retail outlet, there are categories of products that are effective for raising sales and other categories that are not. In order to make selections of product items that are effective for building optimum pricing strategies, we must select groups of products for special sales based on indices of customer response to specific sales. Stage 4 is the stage where pricing strategies for the specific product items (Or, item categories) are chosen for maximizing profit. If the sales of a single given product are to be maximized, it is sufficient to sell that product at the lowest possible price. However, this approach cannot be said to be acceptable for the goal of maximizing profits of the given outlet itself. Lowering the price for a given product will not only have the effect of lowering the contribution of the related products to total store profits, but will also have an effect on the sales of competing product items that are being sold at their usual price levels. For the purpose of maximizing the profit of the individual store, we think that it is necessary to include all groups of products that contain product items that are likely to be affected by the lowering of prices of the special sale items in the analysis for the formulation of the pricing optimization strategies to be used [1]. For this purpose, the past purchase records of individual customer respondents are used and this makes it possible to provide a proper framework for the formulation of the pricing optimization strategies.

Regarding the first stages, since there are many factors contained in the data for individual consumers that are similar to standard consumer research operations, this paper will be focused on the last two stages of the optimization process.

3. Discovering the optimum product items

For achieving optimum pricing, before prices as such are considered, we think that there is a need to determine whether lowering the prices for a given group of products will actually cause an increase in sales or not. Within the vast array of products being sold, it is necessary to clarify the aims of the strategy and on which products the lowered pricing is to be focused. Concerning this point, it is necessary to carefully classify all products to determine which products are more suited for weekend special sales and those that are more suited for weekday special sales.

Here, we examine a specific product "A" as the possible focus of a special sale. In the case of this paper, the most frequent price of the product "A" (The price that appears most frequently on register receipts) is defined as the "normal price" of the product and prices lower than this price are "special sale prices". The specific days upon which these lower prices are used are defined as "sales days". Further, in order to discover whether product "A" is more suitable for a weekday or for the weekend, the 1-yen increment Product Indexes are used. PI value is the amount of the product sold per 1000 visitors to the store. The reason for the use of this index is that the rise and fall of sales volume (PI) in increments of a single yen makes it possible to remove the effects of the size of the particular outlet being examined from the calculations. The calculation that is used is as follows:

$$\frac{p_a(d) - p_a(r)}{r - d}$$

Pa= sales quantity per 1000 visitors
Pa (x) = product "a" x yen/time PI value
r = Normal price in yen
d = special sales price in yen

These calculations are carried for each product in each product category, making it possible to discover the products that are the most suited for special sales.

Using the method indicated above, from customer purchase data for supermarkets located in Japan's Kanto Region, effectiveness of specific product categories for both weekdays and weekends were calculated. The results of the calculations showed with relatively great degrees of significance that there were many examples of lack of effect in changing product prices. In other words, there cases when lowering the price actually caused sales to decrease rather than increase. The definition of a product that is suitable for special sales is a product the sales of which will increase when the price is lowered. Likewise, on a specific category basis, more than 50% of the products in the category must be suitable for special sales for the category to be a "suitable category for special sales". Using these definitions, it became clear that on weekdays, vegetables and confectionary products are a suitable category for special sales and that instant food and processed meats are effective product categories for weekends.

4. Optimized pricing for maximized profits

In order to discuss optimized pricing, we aim for the maximization of total profit for the entire outlet. If we try to optimize pricing of each product from the point of view of the marketing staff of the maker of each product, we would probably have to sell each product for the lowest possible price. However, each outlet is handling many different products, and the prices of some products have an influence on the sales than other products. Thus, to comprehend the situation for the entire store, it is necessary to take into consideration many very complicated factors. Therefore, we present a framework for optimizing prices that clarifies the complicated relationships between the different products by using the purchasing histories of individual customers.

4.1. Predictions of purchasing probability by using customer data

First, in the case of the logit model, the model for forecasting the purchase probability for purchase ratios is derived for the product "A" using individual customer purchase histories for product "A" for the desired variables. Consumer purchase behavior is affected not only by price, but also such factors as purchase loyalty. In addition, the prices of competitive products and other factors also affect purchase. Since it impossible to include all of these variables in a single model, for the basis of the statistical indices, the factors included were narrowed down to 10－20 significant factors and the variables were chosen according to the stepwise method to build the forecasting model. The result was that we became able to forecast, based on certain conditions, whether an individual customer will buy a given product or not and using these predicted figures, we are able to estimate the sales for a given product. In addition, using the purchase probability prediction model to analyze competing products as well, we are able identify product groups that will affect the pricing for product "A".

4.2. Sales forecasts and maximization of store profit

Using the predictive model referred to above, base on certain conditions, in other words price levels set for the different prices set for items contained in a specific product item category, it is possible to calculate the level of probable purchase for individual customers and using these estimations, it becomes possible to forecast the sales for a given store. In the category, "soy sauce", in the case where the sales of the leading brand "K" were predicted, the prices of the all other brands of K were fixed and when the price of K was varied, the results were as shown in Figure 1. The x-axis indicates prices for K in 10-yen increments. The y-axis indicates the predicted sales quantities for K and indicates the rate of growth in sales. As can be seen from the Figure, the more the price of K is lowered, the more sales increase. However, with each 10-yen cut in the price, the rate of sales increase slows and the sales increase effect of price-cutting decreases.

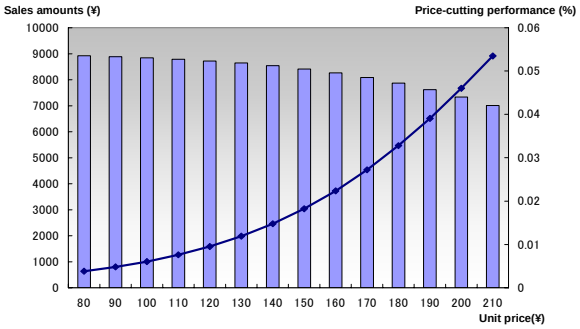


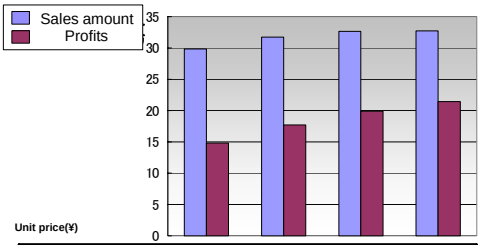
Fig 1: Changes in price and the effects on the sales of Brand K soy sauce

In this paper, the logit model was used as the purchase probability prediction model, but depending on the specific products for which this model is used, there are many cases where sufficiently useful predictions cannot be made. As an example of this, this model assumes the existence of a "reference price" [2] for category (or product) below which the consumer will make a purchase and that there exist certain prices levels where very significant increases in sales will occur. We identified these exceptional cases before carrying out calculations and used a separate framework for these calculations.

4.3. The case of Chinese cabbage-related product prices

As an example, we examined the situation for the pricing of the product group consisting of Chinese cabbage and closely related product items. At the store where the data was collected, the category also included related items consisting of half of a Chinese cabbage (Below, "H") and a quarter (Q). To maximize the profit of the store, it is necessary to set different prices for all of these items and, in practice, this is difficult. The related variables consisted of prices for a Chinese cabbage half (H) and (Q) and the prices for the other related products other than Chinese cabbage such as the prices for tofu and ponsu (A citrus-based liquid flavoring). The individual purchasing histories regarding frequency of purchase of seafood and vegetables were also extracted from the data for the calculations. When the model, using these variables, was used for the calculations, the optimum prices for Chi-

nese cabbage H and Q were 198 yen and 100 yen, respectively and the profit levels obtained were also at the maximum level.



ponsu	158	189	218	248
Chinese cabbage Q	100			
Chinese cabbage H	198			

Fig. 2: The pattern for prices for Chinese cabbage (H,Q) and ponsu aimed at the maximum level of store profit

It was possible to discover the price levels for the two Chinese cabbage items that maximized profit, but since the Chinese cabbage item prices affected the sales of the other products, in order to maximize store profits, it was necessary to formulate an optimal pricing strategy that included the other products as well. For example, the price of the Chinese cabbage was found to a strong influence on the sales of ponsu. In the case of the pattern encountered for Chinese cabbage prices shown above, the price for ponsu was 158 yen. However, when the level of profit contributed by the ponsu was included in the calculations and the calculations for the maximization of profit for the store were run, as shown in Figure 2, when the price of ponsu was 248 yen, the maximum profit contributed by the two Chinese cabbage items and ponsu was the point of maximum store profit. In order to carry out maximization of store profit pricing strategies, it is necessary to analyze the effects of not only a given product and its direct competitors, but also to sufficiently investigate the effects on the prices of other related products on the calculations.

5. Future topics and the study of business chance discovery

In this paper, methods were proposed to create optimized pricing strategies for the maximization of store profit. The paper contained concrete procedures and methods for achieving these aims. By means of simulations using actual retail store data, it was possible to demonstrate the effectiveness of using these methods. Store marketing personnel, using our methods, will be able to create optimal pricing strategies and will probably able to maximize store profits.

We are, as yet, left with many unsolved problems for which solutions must be found. In this paper, in order to predict purchasing probability, the model that was used was the logit model. When actual purchase data is used for applications using this model, there are occasions when the calculations do not produce sufficiently usable predictions. In the case of certain special products and categories, the calculations are strongly influenced by noise and the effects of abnormal values and the level of accuracy obtained was unstable. In this paper, aside from the example involving the logit model, regarding data mining algorithms, sufficient comparisons were not carried out. Therefore, we must find other algorithms that can attain a high and stable level of accuracy not affected by noise or subject to abnormal values.

All of the content of this paper is based entirely on knowledge gained from the use and analysis of data to obtain results related to pricing strategies and, because of that, the paper does not contain sufficient content having to do with chance discovery. The reason for this is that human beings (Experts) were not using their own perceptions and their abilities to notice factors and to integrate these inputs into the strategy creation process. In addition, the largest problems concerning the methods proposed in this paper related to creating optimized pricing are related to the selection of the variables for use with the prediction model and the reliance solely on statistical indices. Considering the matter of the discovery of new business chances, the chances are relatively high that the use of these methods alone will seldom result in such discoveries and that the important “chances” will get away. Regarding the product items pricing, there is a need, in the future, to find methods that lead to discoveries of new opportunities that would not be discovered under ordinary circumstances and to develop an integrated framework for such methods.

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