THE EFFECT OF PRICING STRATEGIES ON RETAILERS: AN AGENT-BASED MODELING APPROACH

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ABSTRACT

Setting the prices for products is an essential approach for retailers to define their business success. However, there is a high uncertainty that characterizes pricing decisions. Interdependent behavior between retailer and customers making it hard to analyze the effect of a pricing strategy on retailers. The complexity increases when the customer behavior can be influenced by pricing strategies implemented by the competitors. This study examines the impact of pricing strategies on retailers by using agent-based simulation. The pricing strategies investigated are related to price promotion, which is defined based on the promotion frequency and the level of the price cut. Two types of agent are defined in the model, namely retailer and customer. The customers have a particular buying preference and a dynamic utility function, while the retailers apply either a similar pricing strategy (homogeneous agents) or different strategies (heterogeneous agents). A functional product market is considered, which represents items that are bought regularly for daily needs, such as foodstuff and toiletries. Preliminary results presented in this paper are reported for the purpose of illustration. These show that the bounded-rationality of each agent drives the emergent outcomes, and each pricing strategy results in a different impact on retailers, in terms of market share. The contribution of this study is to offer a new point of view in understanding the impact of pricing strategies on retailers.

Keywords: pricing strategy, promotion, agent-based simulation, competition

1. INTRODUCTION

Retailers have an important role in supply chains. They act as intermediaries who pass on the supply from manufacturers or suppliers and meet it with consumer demand (Zentes & Morschett, 2007). They interact with the end customers of the supply chains directly, and their business decisions influence consumer satisfaction. This role makes the retailer's decisions have effects on the profitability of the supply chain.

One of retailer strategic decisions is pricing. Pricing is considered as a method used by a firm to set the value in the exchange of goods and services. An appropriate pricing strategy can lead a retailer to increase its sales as well as winning the market share. However, many challenges must be considered when making pricing decisions, some of which are understanding consumer behavior and competition between retailers.

Consumer behavior is influenced by consumer preference, which drives customer actions in choosing retail and determining the buying quantity (Bell, 2015). Consumer preferences can be defined as a priority order of consumers (Tadellis, 2013), where each consumer has a different preference from one another. The preferences could be from many factors, considering socio-demographic, personality, and interaction (Zhang & Zhang, 2007). Some examples of socio-demographic-related factors are age and income. while the instances of personality factors are sensitivity to price, distance and quality. As for the interaction, it is described as an exchange of information received from the retailer regarding the price of the product offered by the retailer.

A pricing method that is most used by retailers to attract more consumers is price promotion strategies. Even though this strategy is temporary, it is found to be effective to influence consumer behavior in making their buying decisions (Sivakumar, 1996; Breugelmans & Campo, 2016; Hitsch, Hortacsu, Lin, & Hortaçsu, 2017). The strategy is also considered as an approach to achieve marketing success (Zentes & Morschett, 2007). The price promotion strategy is determined by the frequency of the promotion and the level of price reduction (Sivakumar, 1996), but there are still limited studies that analyze how the frequency and level of price discount affect retailer performance.

Several previous studies have addressed the issue of pricing strategies. Kwon, Im, & Lee (2007) proposed a mathematical model to determine pricing strategies by paying attention to the effects of competition. Hall, Kopalle, & Krishna (2010) conducted a study on determining the optimal price concerning the brand of goods. Raghubir (2004) examined the effect of price discounts on profits. Binkley (2003) studied the impact of additional costs that apply to different consumer characteristics. However, these studies use mathematical methods that do not allow modeling the interactions between consumers and retailers.

This study aims to investigate the effect of price promotion strategies on retailers by using agent-based simulation. The simulation approach is considered as the problem involves consumer behavior and competition between retailers, so that the scope is complex due to its dynamic interactions. As suggested by Fassnacht & El, (2013), the appropriate responses to measure the retailer performance as intermediaries is profit. Therefore, profit and sales are taken into account to evaluate the resulting emergent behavior. In this research, a functional product market is considered, which characterize items that are bought regularly for daily needs, such as foodstuff and toiletries. This paper presents several preliminary results of the agent-based model, and it is intended to provide a novel approach to understand the effect of pricing strategies on retailers.

The remainder of this paper is organized as follows. Section 2 describes the model design, including the conceptual and computer model. Section 3 explains the experiments and shows some preliminary results of the effect of a price promotion strategy to retailers. Finally, section 4 concludes the paper.

2. MODEL DESIGN

In this section, the model developed in this study is described. We adopt the modelling framework suggested by Robinson (2014), which addresses the following elements of a conceptual model: the model contents, inputs or experimental factors, outputs or responses, assumptions and simplifications of the model. Meanwhile, the model content incorporates the

main features of the agent-based modeling approach accounted by North and Macal (2007) and Robertson and Caldart (2009), which describes the model's scope and level of detail.

The contents of the model consist of the agent, the environment, the interaction, and the behavioral rules. Two types of agents are simulated in this model: retailers and customers. They are located in an environment where the distance between agents affects the consumer's decision making. The retailers are located to be relatively close to each other, while the customers are located randomly and dynamically in the environment. The agent's behavior is constructed based on several economics theories: consumer price reference theory for the gain and loss aspect, the theory of consumer behavior, and the price promotion theory.

Two retailers are modeled, which can be set to have either homogenous or heterogeneous behavior in making pricing decisions. The retailer's pricing decisions are related to price promotion, that is defined by the frequency and the price reduction level. The pricing method applies a cost-plus strategy, while the price promotion reduces the target profit. The promotion strategy is defined into three levels, which are high-shallow, moderate, and low-deep (Sivakumar, 1996). The high-shallow strategy represents the high frequency and shallow price cut, where the price reduction is around 20% with 40% of occurrences. The moderate strategy reflects the moderate frequency and moderate level of a price cut, which provides a price reduction of about 40% in 20% of chances. The low-deep strategy stands for low frequency and deep price cut, which represents a price cut of about 80% in 10% of probability of occurrences. When they are set to be homogenous, that means both retailers adopt a similar price promotion strategy. Otherwise, when the retailers are arranged to be heterogeneous, that means the retailers apply different pricing strategies.

Meanwhile, each customer agent is characterized by its buying preferences. The preferences include price, distance, gain and loss tolerance, and budget. Each consumer possesses different weight for each type of preference, so the consumers are set to be heterogeneous. For example, some consumer agents can be highly sensitive to price, but others can have different features. Consumers also have various budgets that follow a normal distribution, so that each consumer has a diverse budget. This rule makes each consumer has a different level of demand, i.e. each consumer can generate a different number of items to buy.

The interactions between agents are illustrated as follows. The consumer agents select a retailer that fits their preference. For instance, if a consumer agent considers price to be the most sensitive aspect compared to retailer distance, then it needs to consider the gap between the desired price and the lowest price offered by the retailer. If the gap is still within its loss tolerance, so the consumer will select the retailer that provides a lower price. Otherwise, the consumer will not decide to buy in any retailer. When the consumer decides to buy in one of the two retailers, the next decision made is determining the number of items to buy. This decision depends on the budgets of the consumer. This consumer's autonomy can be presented in a simple chart shown in Figure 1.

The retailer's behavior is presented as the pricing strategy used. The promotion strategy is set to be the key input or experimental factor of the model, which affects the consumer's buying behavior. In this study, the emergence outcome of the simulation is measured by three indicators, which are the retailer's profit, total sales, and market share. The time unit used is weekly, and the number of replications is 100 with simulation length of 52 weeks. The software used in this study is NetLogo and the computer representation of the agent-based model is presented in Figure 2. We compare the resulting emergent behavior to the result of Hotelling's model (Hotelling, 1929) as the basis of model validation. It is shown that when both retailers have a homogeneous competitive behavior, the emergent outcomes are in accordance with the Hotelling's law.

```
Start
 For each consumer
   set preference price = α1
   set preference distance = α2
   set preference gain = α3
   set preference loss = α4
Start buying cycle
   set budget round random-normal (100,20)
   set p1 [price] of retailer 1
   set p2 [price] of retailer 2
   set d1 [distance] from retailer 1
   set d2 [distance] from retailer 2
Calculate the gain and loss consumers than are obtained from each retailer
Set gain for retailer 1 = max {reference price - p1,0}
Set loss for retailer 1 = max {p1- reference price ,0}
Set gain for retailer 2 = max {reference price - p2,0}
Set loss for retailer 2 = max {p2- reference price ,0}
   Calculate the price normalization from each retailer
   Yp1= P1/ P1+ P2
   Yp2= P2/ P1+ P2
   Calculate the distance normalization from each retailer
   Yd1= d1/ d1+ d2
   Yd2= d2/ d1+ d2
   Calculate the gain normalization from each retailer
   Yg1= g1/ g1+ g2
   Yg2= g2/ g1+ g2
   Calculate the loss normalization from each retailer
   Yl1= l1/ l1+ l2
   Yl2= l2/ l1+ l2
Calculate each retailer's score
Set Retailer 1's score = α1*Yp1 + α2*Yd1 - α3*Yg1 + α4*Yl1
Set Retailer 2's score = α1*Yp2 + α2*Yd2 - α3*Yg2 + α4*Yl2
If Retailer 1's score < Retailer 2's score
   Choose Retailer 1
Else
   Choose Retailer 2
Buy product at retailer with quantity = Budget / price of selected retailer
Leave retailer
Repeat the buying cycle
End
```

Figure 1. The rule of consumer agents

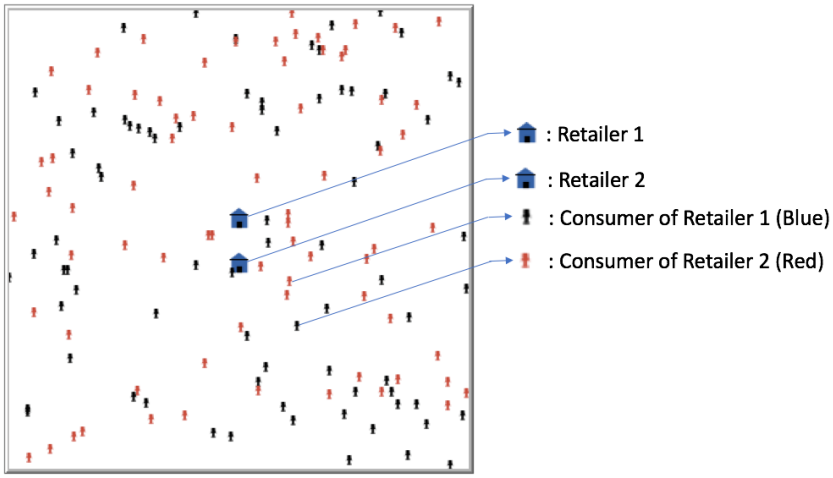


Figure 2. The computer representation of the simulation

3. EXPERIMENT AND PRELIMINARY RESULTS

This paper presents the preliminary results of the model, which only covers a few numbers of experiments in analyzing the effect of price promotion strategy on retailers. The design of the experiments conducted is described as follows.

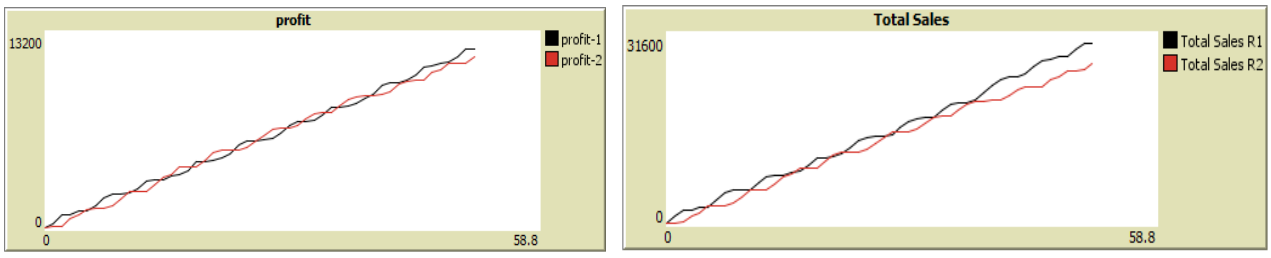
There are six scenarios performed in this study. All scenarios allow retailers to use a price promotion strategy. Scenario 1 (S1) represents both retailers apply the high-shallow strategy. Scenario 2 (S2) describes both retailers adopt the moderate strategy. Scenario 3 (S3) depicts both retailers use the low-deep strategy. Scenario 4 (S4) reflects a retailer use moderate strategy while the other employs a high-shallow strategy. Scenario 5 (S5) indicates a retailer make use of the high-shallow strategy and the other applies the low-deep method. Lastly, scenario 6 (S6) deputizes a retailer utilizes moderate strategy while the other use the low-deep approach. The summary of these scenarios is presented in Table 1, and the results of each scenario are discussed as follows.

Table 1. Simulation scenarios

Pricing Scenario	Description
S1	high-shallow vs. high-shallow
S2	moderate vs. moderate
S3	low-deep vs. low-deep
S4	moderate vs. high-shallow
S5	high-shallow vs. low-deep
S6	moderate vs. low-deep

The first three scenarios (S1-S3) represents homogeneous retailer agents, as both retailers employ a similar strategy. The results of the scenarios indicate that the difference in profit between the two retailers is insignificant. A similar emergent pattern also applies to the total sales. The reason for this small difference in profit and sales between retailers could be because of the identical price promotion strategy used by the retailers.

Meanwhile, the remaining scenarios (S4-S6) reflects the heterogeneous agents. As for S4 (moderate strategy vs. high-shallow strategy), the results show that each strategy alternates in dominating profit and sales during the simulation run. The example of this phenomenon is shown in Figure 3. However, if the simulation length is extended to be more than 52 weeks, the moderate strategy will be the dominant strategy toward the other one, in terms of profit and total sales. For scenario 5 or S5 (high-shallow vs. low-deep), the resulting outcome proves that high-shallow strategy leads to a higher profit and sales than low-deep strategy. Finally, the outcome of scenario 6 or S6 (moderate vs. low-deep) shows that no strategy always dominates profit and sales during the simulation run.



(a) (b)

Figure 3. An example of a single simulation result with scenario 4 - S4:
a) Profit accumulation and b) Sales accumulation

The profit summary for both retailers is shown in Table 1 and Table 2. From Table 1, it can be seen that retailer 1 reaches its highest profit under scenario 5 (S5), where retailer 1 uses high-shallow strategy and retailer 2 applies the low-deep approach. On the contrary, scenario 2 (S2) results in the lowest profit for retailer 1. In that scenario, both retailers employ a moderate strategy. Meanwhile, Table 2 shows that the highest profit of retailer 2 is achieved under scenario 1 (S1), where both retailers apply the high-shallow strategy. The lowest profit for retailer 2 is experienced under scenario 5 (S5). As scenario 1 to scenario 3 (S1-S3) take a similar strategy for both retailers and the results differences seem to be not significant, the result of S1-S3 can be neglected for the analysis. Therefore, from Table 2 and Table 3, it can be concluded that scenario 5 (S5) provides a significant difference in both retailers' profit.

Table 2. Profit summary for retailer 1

Profit	***Retailer 1***					
	S1	**S2**	**S3**	**S4**	**S5**	**S6**
Mean	$11.809,9	**$11.026,9**	$11.564,0	$12.025,1	**$15.256,0**	$11.740,5
Median	$11.818,1	**$11.019,5**	$11.545,9	$12.015,5	**$15.262,1**	$11.734,5
Minimum	$11.410,6	**$10.586,6**	$11.266,1	$11.803,0	**$14.965,4**	$11.496,0
Maximum	$12.214,4	**$11.335,8**	$11.960,4	$12.276,0	**$15.585,8**	$12.039,0

Table 3. Profit summary for retailer 2

Profit	***Retailer 2***					
	S1	**S2**	**S3**	**S4**	**S5**	**S6**
Mean	**$11.783,6**	$10.997,1	$11.533,4	$11.449,9	**$7.938,5**	$10.790,1
Median	**$11.775,8**	$10.990,6	$11.546,3	$11.443,5	**$7.925,7**	$10.790,5
Minimum	**$11.368,1**	$10.650,9	$11.104,7	$11.232,0	**$7.622,7**	$10.466,0
Maximum	**$12.155,5**	$11.503,5	$11.876,2	$11.691,0	**$8.296,0**	$11.150,0

The summary of the total sales for each scenario is presented in Table 4. From the table, it is shown that scenario 5 (S5) results in significant difference in sales. The scenario provides the highest sales for retailer 1 and the lowest sales for retailer 2. Even though this result seems to be consistent with the profit analysis, by comparing Table 4 with Table 2 and Table 3, we can see that a higher sales level does not always lead to a higher profit. For example, retailer 2 has the highest profit with scenario 1 (S1), but the highest level of sales for retailer 2 occurs in scenario 6 (S6).

Table 4. Sales summary for retailer 1 and 2

Total sales	***Retailer 1***						***Retailer 2***					
(000 unit)	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**
Mean	**27**	28	28	30	**35**	28	27	28	28	26	**23**	**29**
Median	**27**	28	28	30	**35**	28	27	28	28	26	**23**	**29**
Minimum	**26**	27	27	29	**34**	28	26	27	27	26	**22**	**28**
Maximum	**28**	29	29	30	**36**	29	28	29	29	27	**23**	**30**

The type of price promotion strategy has an influence on the consumers' demand, particularly in the quantity or the number of goods purchased. When both retailers do not apply any promotion, the total consumer demand is about 52,000 units. The demand increases when the

price promotion strategies are applied in the market. Scenario 1 (S1), scenario 2 (S2), scenario 3 (S3), scenario 4 (S4), scenario 5 (S5), and scenario 6 (S6) generate demand for about 54,000 units, 56,000 units, 56,000 units, 56,000 units, 57,000 units, and 57,000 units respectively. If stated as a percentage increase in demand, then each scenario provides an increase in demand of: 3.9% for S1; 7.7% for S2, S3, and S4; 9.6% for both S5 and S6. In this context, scenario 5 (S5) and scenario 6 (S6) result in higher demand generation.

The market share between the two retailers is also analyzed, and it is summarized in Table 5. From the table, it can be seen that scenario 5 results in the most significant difference from the other scenarios. In that scenario, retailer 1 with high-shallow strategy dominates the market share (60.80% share), while retailer 2 with low-deep strategy becomes inferior (39.20% share).

Table 5. Resulting market share

	Market Share					
	S1	**S2**	**S3**	**S4**	**S5**	**S6**
Retailer 1	50.06%	50.07%	50.05%	53.15%	**60.80%**	49.56%
Retailer 2	49.94%	49.93%	49.95%	46.85%	**39.20%**	50.44%

These outcomes are resulted due to bounded-rationality of the agents in the model. The consumer agents update their behavior over time, but the retailers do not have any information about the future actions of the consumers. The consumers also cannot predict when the retailers apply the promotion so that the consumers refresh their decisions in every unit time of the simulation. Moreover, the retailers do not have enough information about the pricing decisions made by their competitor, or when the competitor apply its promotion strategy.

4. CONCLUSIONS

This paper presents an agent-based modeling approach to analyze the effect of pricing strategies on retailers for functional product markets. Price promotion problem is addressed as the focus of pricing strategies that are analyzed in this study. Three strategies are evaluated, involving high-shallow strategy, moderate strategy, and low-deep strategy. Some economics theories are taken into account to the model development, including the consumer price reference theory to determine the variable gain and loss for the consumers, the theory of consumer behavior based on distance, price, gain, and loss preferences, and the price promotion theory. These theories are proven to be able to develop the simulation model that is useful in providing information related to the analysis of price promotion strategies to retailers. The preliminary results show that not all price promotion strategy is effective in most circumstances. The high-shallow strategy is found to be the only approach that have a significant result in improving retailer's profit, sales, and market share. Nevertheless, this situation only applies when the other retailer adopts a low-deep strategy. This emergent behavior is shown due to the bounded rationality of the agents.

The model proposed has incorporated the market complexity that allows heterogeneous agents. It provides a new way to understand the impact of pricing strategies on retailers while consolidating various features of consumers. However, the heterogeneous agents make the analysis hard to trace which customer preferences are sensitive to each of these price promotion strategies. Another aspect that also needs to be considered for future research is the limited number of simulated retailers. More competing retailers may result in different emergent results.

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