Marketing to Competitors' Customers using Agent based Modelling and Simulation Driven Strategy

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Abstract
In a duopoly situation, one firm can gain competitive advantage by attracting the price-sensitive customers from its competitor leading to higher profits through higher sale revenue for the competing company. A simulation study in which there are two electric car manufacturers with agent based modelling was conducted in order to verify this contention. The first step consisted of defining the baseline. Simulations of 1000 times and agent-based modelling were conducted with the assumption that company 1 reduced its price to the maximum of 20% thereby contributing to the switch-over of a maximum of 40% of the price sensitive customers of company 2. The results of 1000 simulations and agent-based modelling highlighted that price reduction by company 1 resulted in a significant increase in the number of customers, presumably due to switch-over from company 2 and there was a corresponding increase in revenues from both of the sales avenues. Thus, Company 1 achieved competitive advantage by marketing its cars to the customers of Company 2 using price reduction strategy to attract them. This study has ramifications for companies that aim to sway the price sensitive customers from a competitor.

Keywords: *Enterprise performance improvement, agent based modelling, simulation, marketing systems, marketing campaigns*

1. Introduction

There are several optimization models some of which include the traditional optimization model, optimization model with endogenous change and agent-based model (ABM). Research suggests that these may be used in multiple contexts and their utilisation is not fixed to any one context [1]. In the context of this research, a hierarchical multi agent framework, which employs a machine learning approach, may be adopted in order to optimize price-sensitive demand loads of agents at multiple levels simultaneously. This was highlighted by the research of [2] who found that there tends to be uncertainty with regard to consumer behaviour with profit maximisation for all levels of agents. Thus, there is potential to utilise the agent-based modelling for optimisation of interested variables. In this paper, an application of agent-based modelling for price optimisation is tested for outcomes.

The paper will discuss the following:

1. A duopoly (electric car company 1 and 2) has been considered with very similar offerings.
2. Agents are individuals who purchase cars through a dealership or online.
3. Both companies have very similar offerings and pricing, along with a combination of loyal and price sensitive customers.
4. Is it possible for electric car company 1 to market its electric car to the customers of Company 2 by price reduction strategy to gain competitive advantage using agent based modelling and simulation? If yes, what outcomes may be expected?

2. Literature Review

[3] utilised two case studies in order to elaborate the use of agency-based simulation and optimisation for water resources planning in a situation wherein active and reactive agents are present. The factors that determine the diffusion of technologies is another avenue in which ABM may be used, as was demonstrated by [4] in the case of alternate vehicle diffusion. [5], took their research further in the context of full market share of electric vehicles in Iceland which they found, was likely to happen with increasing gasoline price, decreasing EV price without tax and absence of recharging problems. On the other hand, if the price of gasoline decreases, measures such as tax exemption and the removal of other anxieties of consumers were found to be essential in order to push consumer demand for electric vehicles. It may be surmised, therefore, that ABM allows for realistic insights in the context of complex interactions among different market participants and various market factors possible. This was further highlighted in the research conducted by [6] in the case of market optimisation of wind

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generated electricity. Wind forecasting has the scope to be made more precise leading to reduced market clearing price and earning maximisation. An ABM was applied by [7] in order to depict that strategic behaviour and transmission constraints (impact on prices also) resulted in serious concerns in German electricity market's future. The potential impact of changing power plant outages and price setting rules on electricity market prices were researched by [8] using an e-laboratory, Electricity Market Complex Adaptive Systems (EMCAS) model, which was designed by the authors. However, there was no attempt made to study the optimisation of any of these variables. In a review, ABM and its application for activities such as scheduling, supply chain and logistics problems were studied by [9]. In their research, however, price optimisation was lacking. Validation and benchmarking of the results were identified as the two key unsolved issues. According to [10] an ideal ABM design would consist of the facility of direct optimization of an objective function. However, this is hindered by the complexity of markets and traders' behaviour, with a very restricted possibility to use optimisation in special circumstances. A branch of ABM, called Agency-based Computational economics is found to be usable for applications in constructive understanding of production, pricing, and trade processes; the essential primacy of survival; strategic rivalry and market power; behavioural uncertainty and learning; the role of conventions and organizations; and the complex interactions among structural attributes, institutional arrangements, and behavioural dispositions. Pricing, survival, strategic rivalry and market power are factors nearer to determining price optimisation as per examples of price discovery process given in the paper [11].

In the case of companies manufacturing similar products of similar prices, innovative pricing strategy is one major method of achieving competitive advantage [12]. Price reduction may be considered as an innovative strategy in duopoly situations. Seeking cost advantage may indirectly led to price reduction which can be used for marketing to customers of competitors and thus becomes a competitive advantage [13]. Price differentiation strategy is advantageous in duopoly situations [14].

For some commoditised essential items such as drinking water and healthcare products, dealership or manufacturer differences are unlikely to impact customer decisions. In such cases, only price differences drive sales by influencing customer decisions on from where to purchase. The research conducted by [15] established that an effective price sensitive linear demand exists when competitor prices and sales through a common retailer exist. However, this model is impeded by the fact that the retailer will attempt to sell more of the products which provides them with a higher return even if that product has a higher price.

According to [16] in the case of cruise line business, price discrimination profitably may be employed by the firms as the competition intensity increases. In addition to this, it was found that the average price of price-sensitive and -insensitive consumers increases when competition decreases. Cruise liners employ only third degree price discrimination (different prices for different consumer groups). This may be the reason for this result being different from the commonly reported finding on the effect of competition on price reductions.

In a duopoly situation, the demand for each company's products is contingent upon its own price and the differences in prices of the competitor. When companies compete only on the basis of prices, the results are similar to Bertrand's game. This analysis was highlighted and discussed by [17]. In Bertrand's game, it was elucidated that the simplest case for price competition is that of a duopoly and in such a context, it was found that both would result in identical products. Firms compete by setting prices simultaneously. The consumers will potentially buy from the firm which offers a lower price, even though the products are similar. However, if the two companies decide to charge the same price, consumers' demand will be split evenly between them. However, these results hold true for any number of companies greater than one.

In their research conducted on duopoly internet markets, [18] found that two factors drive this business: connection quality and price. Customers tend to prefer either of these two unless the best connection is not available at lowest prices. Price reduction for higher connection quality may be possible when technology becomes available to improve it without significantly increasing the cost. However, this is rare and prices tend to be higher due to investment costs of technology.

In contexts such as when two firms produce a homogenous good ex ante but where there is ex post product differentiation due to consumer switching costs, price discrimination has been found to be the most effective way of addressing this concern. However, lowering the price can lower profits without necessarily benefiting consumers. Under the dynamic situation of both firms engaging in price wars, there is too much of price-sensitive consumer switching between firms depending on which firm offers a lower price for identical products. These points were discussed by [19].

3. Methodology and Results

This paper assumes that electric car company 1 and electric car company 2 sell their products through two avenues, namely, either through a dealership or online.

3.1 Simulation

The assumed means and standard deviations for the sale price through the two avenues are depicted below in Table 1.

Table 1: Assumed means and SD for electric car company 1 and electric car company 2 sales through a dealership or online.

	Electric Car Company 1		Electric Car Company 2	
	Dealership	Online	Dealership	Online
Assumed Mean	$100,000	$90,000	$100,000	$90,000
Assumed SD	$20,000	$18,000	$20,000	$18,000

The assumed basic prices of electric cars by both companies before simulation has been presented in Table 1 above. The assumption is that both start the same point of sale prices for both outlets.

One thousand instances (rows of data) were simulated for dealership and online avenues for both electric car company 1 and electric car company 2 using the SIPmath Modeler add-in in MS Excel. The values were simulated assuming a normal distribution and as per the means and SDs mentioned in Table 1. These 1000 rows of simulated data per company can be equated to individual dealerships and online stores. The summary statistics for the simulated values is depicted below in Table 2.

Table 2: Summary statistics for simulated sale price values

	Electric Car Company 1		Electric Car Company 2	
	Dealership	Online	Dealership	Online
1000 Trial Mean	$100,067	$89, 323	$99,908	$90,169
1000 Trial SD	$8,782	$8, 138	$8,953	$8,194
1000 Trial Min.	$66,793	$62,974	$74,250	$61, 400
1000 Trial Max.	$128,251	$121, 518	$129,483	$118, 060

The number of agents assumed are derived from a pool of 10000 people for dealerships, and 3000 people for online, which was equally divided between the two companies - that is, 5000 each for dealership and 1500 each for online store for each of the 1000 simulations.

Therefore, dealerships for electric cars both company 1 and company 2 for the first trial will have 5000 agents (customers) on an average. Similarly, for ownership outlets, the two companies will have 1500 agents (customers) for the first trial.

The number of agents for each of the three avenues belonging to both the companies for each of the 1000 trials were simulated using a Poisson distribution. The Poisson lambda value specified for each of the three avenues belonging to the two companies, and the summary statistics for the simulation are depicted below in Table 3.

Table 3: Summary statistics for simulated agent (or customer) number values

	Electric Car Company 1		Electric Car Company 2	
	Dealership	Online	Dealership	Online
Poisson Lambda	5000	1500	5000	1500
1000 Trial Mean	5000.57	1500.52	4999.15	1501.31
1000 Trial SD	67.93	38.46	71.25	40.10
1000 Trial Min.	4810.00	1385.00	4718.00	1386.00
1000 Trial Max.	5188.00	1620.00	5224.00	1620.00
1000 Trial Sum.	5000569.00	1500519.00	4999146.00	1501313.00

The total revenue generated by each electric car company for each of its sales avenue was computed as the grand total of the product between the mean sale price for each trail and the number of agents for each trial. The total sales from all avenues of each company were added to calculate the total revenue of both the companies. The company by avenue and total company sales are depicted below in Table 4.

Table 4: Company by avenue and total company sales

	Electric Car Company 1		Electric Car Company 2	
	Dealership	Online	Dealership	Online
Revenue	$463,374,032, 120	$130,087,511, 598	$499,461,456,189	$135,363,342, 530
Grand Total	$593,461,543,717		$634,824,798, 719	

Based on the above simulation scenarios, an ABM was done to study the influence of price reduction by company 1 in attracting price-sensitive customers from company 2 for sale revenue increases.

3.2 Agent based modelling

It has been assumed that 60% of a company's customers (or agents) for an avenue are loyal customers while the remainder are price sensitive customers. Hence, there is scope to sway a maximum of 40% of price sensitive customers to a comparable brand with a lower price. Additionally, it has been assumed that a company would be willing to reduce its price by a maximum of 20% in order to attract customers away from its main competitor.

Each instance where the mean car price for a particular trial for a particular avenue associated with electric car company 1 was greater than the same trial for that same avenue associated with electric car company 2 was shortlisted. Such instances were selected because the sales prices can be manipulated in such instances by electric car company 1 with the aim of swaying price sensitive customers away from electric car company 2. In addition to this, an inverse relationship between the magnitude of price drop and the number of customers that could be swayed was also assumed.

The revised summary statistics for electric car company 1, after the prices were dropped for some trials, are depicted below in Table 5.

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Table 5: Revised summary statistics for sale prices of electric car Company 1 and Company 2.

	Electric Car Company 1		Electric Car Company 2	
	Dealership	Online	Dealership	Online
1000 Trial Mean	$92,660	$86,702	$99,908	$90,169
1000 Trial SD	$8,782	$8,138	$8,954	$8,194
1000 Trial Min.	$59,385	$60,353	$74,250	$61,400
1000 Trial Max.	$120,844	$118,896	$129,483	$118,060

The resultant mean reduction in price achieved for the dealerships was $7407 (or 7.4%), and $2621 (or 2.9%) for online.

The revised customer numbers for electric car company 1 and electric car company 2 by avenue are depicted below in Table 6.

Table 6: Revised customer numbers for electric car company 1 and electric car company 2 by avenue

	Electric Car Company 1		Electric Car Company 2	
	Dealership	Online	Dealership	Online
Poisson Lambda	6580	1740	3420	1260
1000 Trial Mean	6580.66	1740.58	3419.31	1261.21
1000 Trial SD	77.92	41.41	58.94	36.75
1000 Trial Min.	6362.00	1617.00	3187.00	1155.00
1000 Trial Max.	6796.00	1869.00	3606.00	1370.00
1000 Trial Sum.	6580657.00	1740578.00	3419311.00	1261205.00

The base customer numbers for the dealerships and online avenues were 5000 and 1500 as was discussed above. After the ABM, the number of customers of dealerships and online customers had increased to 6580 and 1740, respectively for Company 1. This is an increase of 31.6% and 16% for the Company 1 dealerships and online avenues, respectively. On the other hand, in the case of Company 2, there was a decrease in distributorship customers from 5000 to 3420 and in the online customers from 1500 to 1261. The decrease in the customers of Company 2 for both avenues corresponds to increase in the customers of Company 1 for both avenues. This shows that the increase in customers of Company 1 due to price reduction was because of switching of some price-sensitive customers of Company 2 to Company 1. We had assumed that such customers are 40% of the total. Since the increase in customers achieved by Company 1 was only 31.6%, it shows that the balance 9.4% of price sensitive customers remained loyal to Company 2. Thus, the marketing to customers of the competitor using price reduction strategy has attracted about 32% of customers from Company 2 to Company 1.

The revised revenues resulting from this customer switchover for electric car company 1 and electric car company 2 based on Table 5 and Table 6 have been depicted below in Table 7.

Table 7: Revised revenues for electric car company 1 and for electric car company 2 by avenue

	Electric Car Company 1		Electric Car Company 2	
	Dealership	Online	Dealership	Online
Revenue	$609,788,193,416	$150,900,411,282	$341,621,969,595	$113,713,650, 454
Grand Total	$760,688,604,698		$455,335,620,048	

The combined revenue of electric car Company 1 increased from $593,461,543,717 to $760,688,604,698, which is an increase of 28.18%. Additionally, the overall revenue of electric car Company 2 decreased from $634,824,798,719 to $455,335,620,048, which was a decline of 28.27%. It is noteworthy that before price reduction, the total revenue of Company 2 was about 7% higher than that of Company 1 ($634,824,798,719 versus $593,461,543,717). Overall, the results of the analysis highlight that electric car Company 1 can use the marketing strategy of price reduction to the customers of Company 2 for higher competitive advantage, as indicated by the attraction of price sensitive customers from Company 2 to Company 1 leading to increased sale revenue of Company 1.

4. Discussion

The results of the simulation and ABM highlighted that a company use the marketing strategy of price reduction to sway price sensitive customers away from the competitor by utilising ABM, and thereby, increasing its revenue. Manipulation of prices by two competing electronic retail sellers in which one seller outperforms the other in sales and profit was researched by [20]. However, no customer shift was found in their research.

In this paper, electric car Company 1 benefited by a shift of price sensitive customers from electric car company 2 to electric car company 1 through a reduction in prices by 7.4% for dealerships and 2.9% for online stores. This way, Company 1 gained a competitive advantage. Such advantage should reflect in performance. The performance enhancement of Company 1 due to this competitive advantage was seen in the case of sale revenues from both avenues. The advantage was double as the sale revenue before the price reduction was lower for Company 1 than for Company 2. Thus, by its competitive price reduction strategy, Company 1 overtook Company 2 both in terms of customer numbers and sale revenues. The negative consequences of price wars and alternate strategies were highlighted in the research conducted by [21].

There is no indication of any difference of quality between the two companies. If the quality is higher for the product of electric car company 1 it is easier to gain sales from price-sensitive customers, as was found by [22]. In a similar scenario as this paper, [23] found that the manufacturer with higher customer loyalty sees a higher profit than the other and thus gain competitive advantage. The approach outlined in this paper pertains to the non-loyal group of customers to increase profitability; this is a practical approach and was also gleaned from the research conducted by [23].

In a duopoly situation like the present study, the competitive environment was simple. However, if there was a higher number of competitors or if electric car company 2 also reduced the prices, the price wars resulting from it may suffer negative consequences for all competitors, as stated by [21]. Thus, companies must take the competitive fabric into consideration while designing such pricing and marketing campaigns for competitive advantage.

The question that arises now pertains to how the price-sensitive customers of electric car company 2 were identified. Simple price reduction would not have resulted in them shifting from electric car company 2. One possible explanation may be in studying and assessing the shopping pattern variables of such customers of electric car company 2 from online and dealership data, which could have been accessible to Company 1 in a variety of ways. This method was found to be more successful as opposed to using demographic variables by [24].

In duopoly situations, companies tend to adopt specific strategies in order to guarantee that the competitor does not wean away its customers by offering price reductions and discounts or other incentives, as was noted by [25]. In addition to this, customers may choose to opt for the company that offers a lower price rather than staying with one company. The model of [26] provides possible explanations for this behaviour of customers. In this study also, not all customers permanently left electric car company 2. Some of them would have been those who sought the lowest price but may return if electric car company 2 lowers its price or electric car company 1 raises its price when it thinks that customers who switched over from electric car company 2 will remain with them although this may not happen. Then the competitive advantage gained by Company 1 will disappear. Repetition of reduction of price to attract customers and then increase the price will wean away even its own customers permanently. Thus, Company 1 is forced to remain as lower price

competitor and this will also change the customer profile of both companies in due course.

In competition, price discrimination enables the competing firm to gain market share at the expense of the discriminating firm. This may have occurred in this study, as electric car company 1 seems to have gained market share of distributor and online segments at the expense of electric car company 2 by reducing the price. With asymmetric competition, it may be the case that one firm would let the other firm assume the burden of price discrimination. It is not known whether electric car company 2 genuinely allowed electric car company 1 to bear the price discrimination burden or the other way, as electric car company 2 was disadvantaged. The recourse for electric car company 2 as some of its customers have gone to electric car company 1, is to adopt market segmentation, as the research of [27] indicates.

When there is price discrimination in duopoly situation, the dominating firm is likely to increase its profits at the expense of the rival firm. This observation made by [28] lends support to the findings reported here. Hence, price reduction by electric car company 1 benefited it at the expense of electric car company 2 in terms of switch-over of price sensitive customers from electric car company 2 resulting in an increase in its sale revenue.

The review of literature above has discussed how price discrimination may be used in order to increase profits in a situation of intense competition. We can only assume that the competition between electric car company 1 and electric car company 2 was intense in this study [16]. The average price of both price-sensitive and -insensitive consumers increase when competition is reduced. If this happens, prices of both companies will stabilise around the same value at a given time and level of competition.

In duopoly situations, found [17] the demand for each company's products is contingent both on its own price as well as on the extent to which the price of the competitor differs. Basic prices of cars of both firms were found to be similar. Only when electric car company 1 reduced the price, the price differences were exhibited. Naturally, the consumers will buy only from the firm with a lower price offer, since both are electric cars. Before the price reduction, the two firms charged the same price and the number of consumers were the same for both outlets indicating that their demand is split evenly between the two companies. Since quality was not considered, it is not possible to verify the observation made by [18] that higher quality will increase the price. But additional services available with the sales package may make a difference in the competition scenario, even if one firm reduces its price to compete with its sole rival.

Lowering the price may not always benefit the company. [19] reviewed instances when lowering the price lowered the profits of a number of companies. It was switching of price-sensitive customers, which attributed to the increase in sales revenue of electric car company 1. However, the sale revenue of electric car company 2 also increased, which is not explainable.

5. Conclusion

Based on the findings, it may be concluded that, in a duopoly situation, the marketing strategy of price reduction offer to the customers of the competitor firm can enhance the competitive advantage of the competing firm through price-sensitive customer switch over from the competitor to the competing firm leading to increased sale revenues. However, this conclusion has many riders like the reaction of the competitor, the capacity of the competitor to increase its income also in the shadow of price reduction by the competing firm and quality differences between products. Several other factors have also been discussed both in the literature review section and the discussion section.

There are a few limitations to this study. The 1000 simulation means were tested without setting any limit like the variables related to electric car company 2 should not increase. A natural extension of this is testing in multi-competitor situation and also see if the predicted behaviour actually occurs in real situations.

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