A New Approach to a Marketing Decision Model via the Fuzzy Expert System

A.Samet Hasiloglu
Department of Computer Engineering,
Ataturk University, Erzurum, Turkey,
asamet@atauni.edu.tr

Umit Gul
Vocational College of Narman,
Ataturk University, Erzurum, Turkey

Abstract: This paper proposes a new forecasting method for a marketing decision model. To support the modeling process, a fuzzy expert system was designed to determine whether a new product should enter the market. The fuzzy expert system based model presenting of a new product to the market at the best time will provide an advantage to the companies in competitive environment and increase their share of the market. In the final stage of this framework, algorithms for building fuzzy expert systems are explained and applied to a case study. The proposed method was tested with an actual data load of product life cycle.

Keyword: fuzzy expert system; product life cycle; marketing decision model

Introduction

Real-world decision-making is much too complex, uncertain and imprecise to lend itself to precise, prescriptive analysis. It is this realization that underlies the rapidly growing shift from conventional techniques of decision analysis to technologies based on fuzzy logic. Fuzzy logic was originally proposed as a means of representing uncertainty and formalizing qualitative concepts that have no precise boundaries. So far, of fuzzy logic has gained much more attention in engineering applications than in business and finance applications, but an even larger potential exists in the latter fields (Facchinetti et al., 2003 & Yavuz et al.).

Fuzzy logic is an excellent way to combine Artificial Intelligence methods (Zadeh, 1993). Fuzzy set theory and fuzzy logic provide a general method for handling uncertain and vague information, which unfortunately are unavoidable in many real world decision-making processes (Frantti & Mahonen, 2001). Fuzzy logic avoids the abrupt change from one discrete output state to another when the input is changed only marginally. This is achieved by a quantization of variables into membership functions (Herrmann, 1995).

Expert systems were designed to reason through knowledge to solve problems using the same methods that humans use. A fuzzy expert system is an expert system that utilizes fuzzy sets and fuzzy logic to overcome some of the problems which occur when the data provided by the user are vague or incomplete.

In this paper, we illustrate that the fuzzy approach may be useful in industrial economics. In particular, a fuzzy expert system has been adapted for product life cycle management. The well-known product life cycle approach describes the changing features of markets during their evolution. It may therefore serve as a theoretical framework within which market changes can be explained (Klepper & Graddy, 1990). To support the decision process, a fuzzy expert system was designed to determine whether to enter of a new product into the market. Finally, when operating the fuzzy expert system, three different deductions can be made: the preservation of the present status, the introduction of the new product to the market and the withdrawal of the product from the market.

The organization of this paper is organized as follows: Section 2 briefly summarizes the basic principles of the product life cycle. Section 3 provides an overview of the Fuzzy expert systems. In section 4 (the main part of this paper), the major modeling issues of the study are examined, based on a fuzzy expert system. This paper concludes with a summary of the findings and directions for future research.

Product Life Cycle

All products and services have certain life cycles. Life cycle refers to the period from the product's first launch into the market until its final withdrawal. The life cycle is split up in phases. Since an increase in profits is the major goal of a company that introduces a product into a market, the product's life cycle management is very important (Komninos, 2002). New product failures may occur because of an overestimation of market size, product design problems, Incorrectly positioned, priced or advertised products, costs of product development and / or competitive actions (Kotler & Armstrong, 2001).

Although the life cycle varies in accordance with the product and sector base, the product's life cycle – period usually consists of five major phases as shown in (Fig. 1). The first period is the product development phase, the second period is the entrance phase, the third period is the growth phase, the fourth period is the maturity phase and the fifth period is the satisfaction phase. The product development phase begins when a company finds and develops a new product idea. The entrance phase is the period of a product's presentation to the market and the effort spent for its acceptance. Generally, this is the period of catching up at par point. The growth phase is the best step, where the product has reached its maximum profit and has been through its brightest period. In the maturity phase, problems gradually arise up and in sales start to decrease. Despite this sales decrease, companies try to keep their sales high by using other marketing activities, called sales efforts. In that period increase in sales like jumping sales (comb tooth) occur. It is generally agreed that innovation, performance, and competition depend significantly on the maturity of the markets (Dosi, 1997). The Satisfaction phase is the period that the companies prefer not to be in because they will start to lose in a while.

During the maturity period, significant changes are made in the way that the product is behaving in the market. Presentation of a new product to the market at the best time will provide an advantage to competing companies and increase their share of the market (Leenders & Wierenga, 2002).

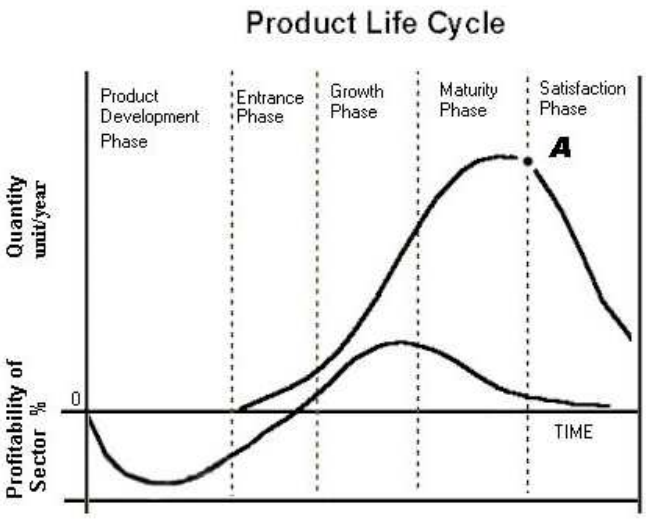

Figure 1: Life cycle period of a new product

In the conventional product life cycle, introduction of a new product to the market corresponds point "A" in (Fig. 1) (http://www.otterbein.edu/home/fac/brccbly/courses/images/plc.gif). When a company comes to this point at the end of the maturity period, it has to choose one of these alternatives: new product, new market, or withdrawal of goods from the market, so as not to enter into the 5-th period.

As shown in Point "A" (McDonald, 1995) the existing system is considered to be late for the new product to enter the market. This point is the period in which the company withstands a number of costs called other sales efforts (promotion, excess goods, discount, etc.) to keep the sales active. It is plain to see from a review of the conventional life cycle that profit has started to fall in spite of the increase in sales.

The proposed system attempts to determine the point specified as point "A" in (Fig. 1) by means of the expert system. In this proposed structure, point "A" can be taken to an earlier time than in the existing policies. In the operation of the system, product life cycle maturity period characteristics will be reviewed and efforts will be made to determine the most suitable time for presentation of the product to the market by evaluating the factors called as macro and micro market indicators.

There are some major product life cycle management techniques that can be used to optimize a product's revenues in respect to its position in a market and its life cycle. These techniques are mainly marketing or management strategies that are used by most companies worldwide and include the know-how of product

upgrade, replacement and termination.

Nevertheless, a product manager must know how to recognize which phase of its life cycle a product is in, regardless of the problems in the model discussed above. To do that, a good method is the one which follows (Komninos, 2002):

a. Collection of information about the product's behavior over a period at least of 3–5 years. (Information will include price, units sold, profit margins, return of investment – ROI, market share and value).

b. Analysis of competitor short-term strategies (analysis of new products emerging into the market and competitor-announced plans about production increase, plant upgrade and product promotion).

c. Analysis of the number of competitors in respect of market share.

d. Collection of information of the life cycle of similar products that will help to estimate the life cycle of new products.

e. Estimation of sales volume for 3 – 5 years from product launch.

f. Estimation of the total costs compared to the total sales for 3 – 5 years after product launch (development, production, promotion costs).

Strategies that must be applied as soon as the phase of product life cycle is recognized are given in the (Tab. 1) (Komninos, 2002).

	Product Development Phase	*Entrance Phase*	*Growth Phase*	*Maturity Phase*	*Satisfaction Phase*
Strategic Goal	Make your product known and establish a test period	Acquire a strong market position	Maintain your market position and build on it	Defend market position from competitors and improve your product	"Milk" all remaining profits from product
Competition	Almost not there	Early entry of aggressive competitors into the market	Price and distribution channel pressure	Establishment of competitive environment	Some competitors are already withdrawing
Product	Limited number of variations	Introduction of product variations and models	Improvement – upgrade of product	Price decrease	Variations and models that are not profitable are withdrawn
Price Goal	High sales to middle men	Aggressive price policy (decrease) for sales increase	Re-estimation of price policy	Defensive price policy	Maintain price level for small profit
Promotion	Creation of public-market product awareness	Reinforcement of product awareness and preference	Reinforcement of middle men	**Maintain loyal to middle men**	Gradual decrease
Goal	Exclusive and selective distribution through certain distribution channels and creation of high profit margins for middle men	General and reinforced distribution through all distribution channels available	General and reinforced distribution with good supply to the middle men but with low margins of profit for them	General and reinforced distribution with good supply to the middle men but with low margins of profit for them	Withdrawal from most channels of distribution except those used in the development phase

Table 1: Strategies of each product life cycle phase

Fuzzy Expert Systems

A fuzzy expert system is an expert system that utilizes fuzzy sets and fuzzy logic to overcome some of the problems which occur when the data provided by the user are vague and incomplete. It consists of a fuzzification module, an inference engine, a fuzzy rule base and a defuzzification module. The fuzzification module pre-processes the input values submitted to the fuzzy expert system.

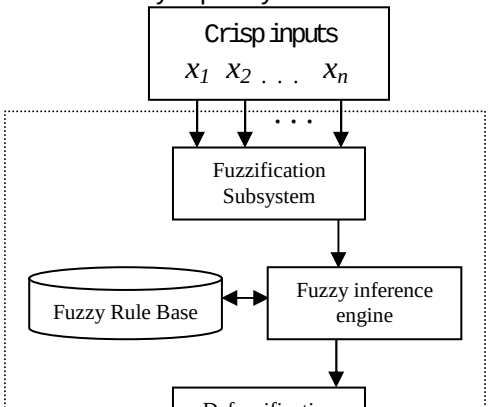

Figure 2: Structure of the fuzzy expert system

The inference engine uses the results of the fuzzification module and accesses the fuzzy rules in the fuzzy rule base to infer what intermediate and output values to produce. The final output of the fuzzy expert system is provided by the defuzzification module. The structure of the developed system is shown in (Fig. 2). This structure is common for fuzzy inference systems.

Developed Marketing Decision Model

In this study, a new marketing decision model was developed, whose structure identifies the fuzzy logic inference flow from the input variables to the output variables. The fuzzification in the input interfaces translates analog inputs into fuzzy values. The fuzzy inference takes place in rule blocks, which contain the linguistic control rules. The outputs of these rule blocks are linguistic variables. The defuzzification in the output interfaces translates them into analog variables. The decision tree of the model is shown in (Fig. 3).

$$Performance\_of\_product \begin{cases} Global\_Market \begin{cases} Economic\_conditions \\ Political\_Circumstances \end{cases} \\ Manufacture \begin{cases} Competition \\ Other\_Selling\_Efforts \\ Proportional\_Increase\_in\_Sells \end{cases} \\ Target\_Market \begin{cases} Manufacture\_Point \\ Renewal \end{cases} \end{cases}$$

Figure 3: Decision tree of the model

(Fig. 4) shows the entire structure of this fuzzy system including input interfaces, rule blocks and output interfaces. The connecting lines symbolize the data flow.

The fuzzification method, "Compute membership function (MBF)", is the standard fuzzification method used in almost all applications. This method only stores the definition points of the membership functions in the generated code and computes the fuzzification at runtime.

For output variables, different defuzzification methods exist as well. The most often used method is center-of-maximum ("CoM"), which delivers the best compromise of the firing rules (Von Altrock, 1997; Bojadziev & Bojadziev, 1997).

In (Fig. 4), the rule block of the structure of the fuzzy logic system is shown. This block contains the rules of the system describing the control strategy. Rule blocks contain the control strategy of a fuzzy logic system.

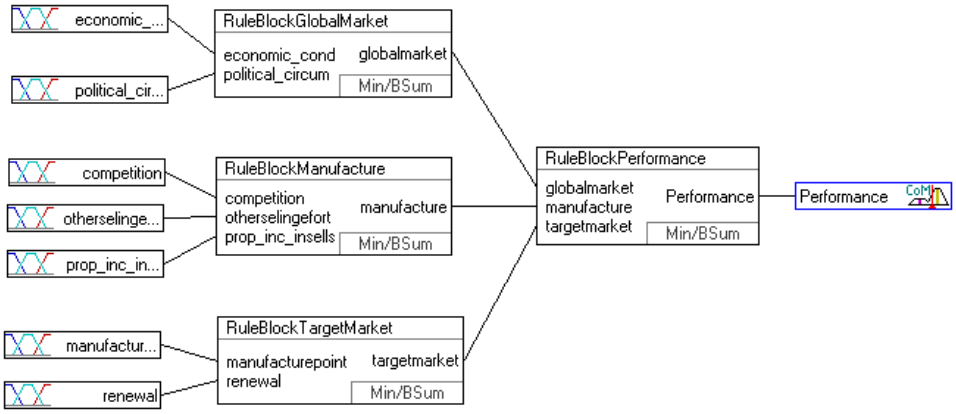

Figure 4: Structure of the fuzzy logic system

Each rule block confines all the rules for the same context. A context is defined by the same input and output variables of the rules. The 'IF' part of the rules' describe the situation for which the rules are designed. The 'THEN' part describes the response of the fuzzy system in this situation. The degree of support (DoS) is used to weigh each rule according to its importance, which ranges from zero to one.

Global market indicators, overall economic situation and legal and political circumstances prevailing in the market are the factors reviewed. The fuzzy expert rules of the global market can be summarized in (Tab. 2).

IF			THEN
Economic cond.	**AND**	*Political circums.*	*Global market*
Negative		Negative	Pessimistic
Negative		Ineffective	Pessimistic
Negative		Positive	Pessimistic
Ineffective		Negative	Pessimistic
Ineffective		Ineffective	Pessimistic
Ineffective		Positive	Optimistic
Positive		Negative	Pessimistic
Positive		Ineffective	Optimistic
Positive		Positive	Optimistic

Table 2: Rules of the rule block "RuleBlockGlobalMarket"

The target market indicator factors are a renewal of the product and manufacture point. Manufacture point is the comparison of performance of the products and its rivals. The result of this review reveals the probability that performance of the product can be lower or higher than or equal to that of the closest rival product. The condition of "manufacture point" has three condition domain factors:

m.p. < c.m.p., m.p. = c.m.p. and m.p. > c.m.p.

Above, "m.p." is the manufacture point of our product, "c.m.p." is the manufacture point of the competitor's product. The Fuzzy expert rules in the target market are summarized in (Tab. 3).

IF			THEN
Manufacture point	**AND**	*Renewal*	*Target market*
Mp<cmp		not_ok	Wait
Mp<cmp		Ok	Medium
Mp=cmp		not_ok	Wait
Mp=cmp		Ok	Impulsive
Mp>cmp		not_ok	Medium
Mp>cmp		Ok	Impulsive

Table 3: Rules of the rule block "RuleBlockTargetMarket"

The factors of manufacture indicators are "competition", "other selling efforts" and "proportional increase in sales". The most striking signs of the maturity stage are a decrease in competition, rivals' introduction of new products to different market sector and construction of existing market. The fuzzy expert rules of "manufacture" can be summarized in production rules in (Tab. 4).

IF					THEN
Competition	**AND**	*Other selling efforts*	**AND**	*Prop. increase in sells*	*Manufacture*
Decreased		Decreased		Decreased	Poor
Decreased		Decreased		Increased	Good
Decreased		Increased		Decreased	Good
Decreased		Increased		Increased	Very good
Increased		Decreased		Decreased	Good
Increased		Decreased		Increased	Very good
Increased		Increased		Decreased	Very good
Increased		Increased		Increased	Very good

Table 4: Rules of the rule block "RuleBlock Manufacture"

As a result of a sales rates' decrease, a company will initiate other sales efforts to increase sales. These efforts will escalate the cost of other sales efforts. Thus, the profit rate will drop because a big portion of the profit is used to finance other sales efforts. The fuzzy expert rules in the "Performance" can be summarized in the production rules in (Tab. 5) and (Tab. 6) shows the summary of the project.

IF					THEN
Global market	**AND**	*Manufacture*	**AND**	*Target market*	*Performance*
Pessimistic		Poor		Wait	Bad
Pessimistic		Poor		Medium	Bad
Pessimistic		Poor		Impulsive	Passive
Pessimistic		Good		Wait	Bad
Pessimistic		Good		Medium	Passive
Pessimistic		Good		Impulsive	Passive
Pessimistic		Very good		Wait	Passive
Pessimistic		Very good		Medium	Passive
Pessimistic		Very good		Impulsive	Active
Optimistic		Poor		Wait	Passive
Optimistic		Poor		Medium	Passive
Optimistic		Poor		Impulsive	Active
Optimistic		Good		Wait	Passive
Optimistic		Good		Medium	Active
Optimistic		Good		Impulsive	Active
Optimistic		Very good		Wait	Active
Optimistic		Very good		Medium	Active
Optimistic		Very good		Impulsive	Active

Table 5: Rules of the rule block "RuleBlockPerformance"

	Input Variables	*Output Variables*	*Intermediate Variables*	*Rule Blocks*	*Rules*	*Membership Functions*
Global Market	2	1	1	1	9	6
Manufacture	3	1	1	1	8	7
Target Market	2	1	1	1	6	5
Performance	7	1	3	1	18	3
Result	7	1	3	4	41	21

Table 6: Summary of project

As a result of operating the expert system, three different deductions can be made: preservation of the present status, introduction of a new product to the market and the withdrawal of the product from the market, i.e.:

If PERFORMANCE = Active Then "Preserve the present status"

If PERFORMANCE = Passive Then "Introduce the new product to the market"

If PERFORMANCE = Bad Then "Withdraw the product from market"

Results

The fuzzy expert system-based marketing decision model, which defines the product life cycle, was implemented in an automated knowledge base. Our model was constructed using FuzzyTech as an expert system development tool for determining product life cycle. The Product life cycle maturity period characteristics were reviewed and efforts were made to determine whether to introduce the product into the market or not. As a result of operating the expert system, three different deductions can be made: "preservation of the present status", "introduction of the new product to the market" and "withdrawal of the product from the market".

Conclusion

In this paper, we propose a way to deal with product life cycle management. This new idea is to reproduce what fuzzy expert system does when they have to decide a new product's market entering time.

Values taken by these reviewed factors are interpreted by means of the fuzzy expert system and the best decision for the company is made. As a result of the study, the most suitable time for introduction of the product to the market can be determined, instead of withstanding the costs of other sales efforts and losing profit or risking the loss of market share during the product's maturity period.

In further research, to get a most realistic model, it is possible to add quantitative parameters to model such as production per unit time, wasting machine hours, labor hours, and raw material. Besides, to adapting this model to real life, general rules should be extended. For example, to define political circumstances of the target society, new rules set can be added to model.

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