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Product Life Cycle: From the Eyes of Fuzziness

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Abstract:
Any product after being introduced in the market goes through its growth maturity and decline phases. In which the sales of the product first increases, attains a constant or nearly constant value and then starts declining respectively with respect to time. This paper uses fuzzy logic in all of the above mentioned phases of the product. Fuzzy logic was introduced by Professor Lotfali Askar Zadeh (born February 4, 1921), better known as Lotfi A. Zadeh, is a mathematician, electrical engineer, computer scientist, and a professor of computer science in the University of California, Berkeley. In broader senses it can be said that fuzzy logic is the branch of mathematics which deals with the cases in between happenings and non happenings. In other words fuzzy logic is the branch of mathematics which tries to find the logical output of input data in between "0" and "1" and including "0" and "1" too. Using fuzzy logic, computers can be made to operate including '0' and '1' and in between them also. Using fuzzy logic the important decisions regarding the product as at what time the product is to be lifted off from the market or when more volume of the product should be introduced to the market e.t.c. can be taken and that too with proper mathematical justifications. Thus fuzzy logic can be utilized inseparably in the introduction, growth and decline phases of a product.

Key words *Product life cycle, Decisions, Fuzzy logic*
JEL classification C6, E1

1. Introduction

As per Sir Philip kotler to say that a product has a life cycle is to assert four things

- Products have a limited cycle
- Products sales pass through distinct stages each posing different challenges, opportunities and problems to the seller.
- Profits rise and fall at different stages of product life cycle.
- Products require different marketing, financial, manufacturing, purchasing, and human resource strategies in each life cycle stage.

Most product life cycle curves are bell shaped. This curve is typically divided into four stages, introduction, growth, maturity and decline

- Introduction: - a period of slow sales growth as the product is introduced in the market profits are nonexistent because of the heavy expenses incurred with the product introduction.
- Growth: - A period of rapid market acceptance and substantial profit improvement.
- Maturity: - a period of slowdown in sales growth because the product has achieved acceptance by most potential buyer. Profits stabilize or decline because of increased competition.
- Decline: - the periods when sales show downward drift and profits erode.

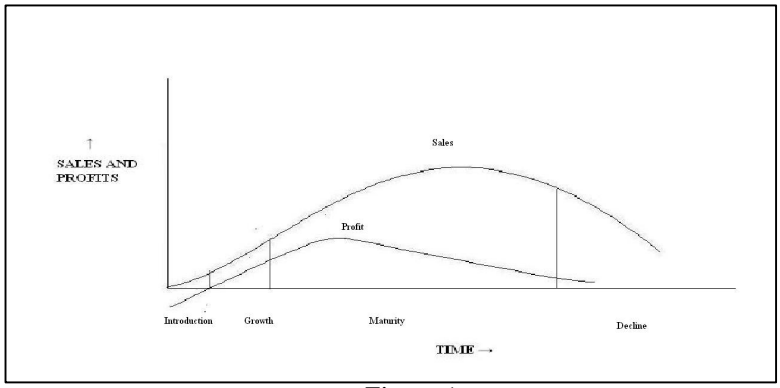

Figure 1

This paper deals with the most common form of product life cycle (PLC). Before describing fuzzy logic we need to understand fuzzy sets and before understanding about fuzzy sets we need to refresh a little set theory definition.

Sets To distinguish between fuzzy sets and classical (non fuzzy) sets, we refer to the latter as crisp sets. The letter X in this paper denotes the universe of discourse, or universal set. This set contains all the possible elements of concern in each particular context or application from which sets can be formed. The set that contains no members is called the empty set and is denoted by Φ. To indicate that an individual object x is a member or element of a set A, we write x Є A whenever x in not an element of a set A we write x does not belong to A. There are three basic methods by which sets can be defined within a given universal set X.

- A set is defined by naming all its members (the list method). This method can be used {a1,a2,a3,…..,an}
- A set is defined by a property satisfied by its members (the rule method. A common notation expressing this method is A = {x|p(x)} where the symbol "|" denotes the phrase "such that" and p(x) designates a proposition of the form "x has the property p". That is, A is defined by this notation as the set of all elements of x for which proposition p(x) is true. It is required that the property p be such that for any given x Є X, the proposition p(x) is either true or false.
- A set is defined by a function usually called a characteristic function, that declares which elements of X are members of the set and which are not. Set A is defined by its characteristic function μ_A as follows
  $\mu_A(x) =$ 1; for x Є A
  0; for x does not belong to A

The characteristic function maps elements of X to elements of the set {0, 1}, which is formally expressed by $\mu_A: X \rightarrow \{0, 1\}$. For each x ЄX where $\mu_A(x) =1$, x is declared to be a member of A; when $\mu_A(x) =0$, x is declared as a nonmember of A.

As defined the characteristic function of a crisp set assigns a value of either 1 or 0 to each individual in the universal set, thereby discriminating between members and nonmembers of the crisp set under consideration. This function can be generalized such that the values assigned to the elements of the universal set fall within a specified range and indicate the membership grade of these elements in the set in question. Larger values denote higher degrees of set membership. Such a function is called membership function, and the set defined by it a fuzzy set.

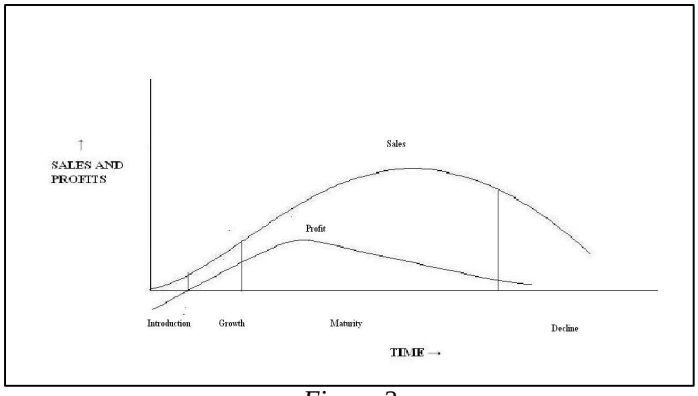

Figure 2

The most commonly used range of values of membership function is the unit interval [0, 1]. In this case each membership function maps elements of a given universal set X, which is always a crisp set, into real numbers in [0,1]. This can be depicted as $\mu_A: X \rightarrow [0,1]$.

2. Logic

Logic is the study of the methods and principles of reasoning in all its possible forms. Classical logic deals with propositions that are required to be either true or false. In logic and philosophy, the term proposition (from the word "proposal") refers to either (a) the "content" or "meaning" of a meaningful declarative sentence or (b) the pattern of symbols, marks, or sounds that make up a meaningful declarative sentence. The meaning of a proposition includes having the quality or property of being either true or false, and as such propositions are claimed to be truth bearers. Fuzzy logic is a form of many-valued logic derived from fuzzy set theory to deal with reasoning that is fluid or approximate rather than fixed and exact. The fundamental difference between classical propositions and fuzzy propositions is in the range of their truth values. While each classical proposition is required to be either true or false, the truth or falsity of fuzzy propositions is a matter of degree. Assuming that truth and falsity are expressed by a number in the unit interval [0, 1]. This paper uses one more thing known as linguistic hedge (or simply hedge).

3. Linguistic Hedge

Linguistic hedges are special linguistic terms by which other linguistic terms are modified. Linguistic terms such as very, more or less, fairly or extremely are examples of hedges. They can be used for modifying fuzzy predicates, fuzzy truth values and fuzzy probabilities. E.g. the proposition Y is old which is assumed to mean Y is old is true may be modified by the hedge " very" in the following three ways.

Y is very old is true

Y is old is very true

Y is very old is very true

Hedges are not applicable in crisp predicates, truth values or probabilities e.g. very horizontal or very rectangular are not meaningful. Any linguistic hedge may be interpreted as a unary operation h, on the unit interval [0, 1]. Since each element of a fuzzy set is associated with some membership grade (μ) with it thus this paper uses linguistic hedges to operate on their membership grades. Very is often interpreted as μ^2, fairly is interpreted as $\mu^{1/2}$ and so on.

4. Methodology

The below mentioned is a general product life cycle. When the product is declining let the maximum sales be 1 (irrespective of the actual value). This step is being done so that each sales value can be associated with a value a membership value in the range [0, 1]. The membership grade of any sales value can be calculated in terms of the maximum sales value by using the formula given below.

max sales=1 (assumption irrespective of the actual maximum sales value); max sales means maximum sales

μ(sales(t))=[{1/(max sales)}*sales(t)]; where sales(t) is sales at time t

The membership grades can be assigned by using any other standard method too.

Now we can form a fuzzy set of sales as {(sales(t1), μ(sales(t1))), (sales(t2), μ(sales(t2))), (sales(t3), μ(sales(t3)))…. (sales(tn), μ(sales(tn)))}.

Now if $\mu(sales(t2))= [\mu(sales(t1))]^2$

And $\mu(sales(t3))= [\mu(sales(t2))]^2$ and so on where t1<t2<t3…..<tn

Or if $\mu(sales(t2))= [\mu(sales(t1))]^{1/2}$

And $\mu(sales(t3))= [\mu(sales(t2))]^{1/2}$ and so on where t1<t2<t3…..<tn

Then the manufacturer can immediately say that the decline of product is very fast or fairly fast respectively. Hence the nature of decline rate is predicted mathematically. This method can be extended to a number of time periods. Hence the important decisions can be taken regarding the product. Similar discussions also holds for the growth phase of product but in this case since the product has not attained its maximum sales value yet so the maximum sales should be taken as the last known value of the sales in the growth phase in this case also t1<t2<t3…..<tn. Using the above stated methodology the nature of growth can also be predicated mathematically and hence the important decisions can be taken for the product as whether more volume should be introduced to the market or not. Some other important decisions regarding the product may also be taken by using these facts. This method can also be used (if needed) in the similar way for the maturity phase in order to get an idea of nature of maturity phase. A similar discussion holds for profit also.

5. Conclusion

This paper is using fuzzy logic to provide the mathematical foundation on which important decisions regarding the product can be taken in its growth phase as when to provide more volume in the market. On the other hand what is the nature of growth of the product whether it is growing fast, very fast, or fairly fast, can be seen. In the decline phase important decisions such as when to wind off the product from the market or should the product be continued in the market any more? can be taken. On the other hand the nature of the decline rate of the product i.e. is the product declining fast or is it declining very fast or it is declining fairly fast can be seen. Thus we believe if this paper is considered and taken into account by the manufacturers it will be a certain and before hand information regarding withdrawal or continuation of the product to create an alertness regarding the product

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