

Modeling of the Shrinking Product Life Cycle

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Abstract

Generally, it is considered that the products have five phases in their life cycle, namely, introduction, growth, maturity, saturation and decline. But with the rapid advancement of technology and globalization, the product life has dwindled. This paper studies the life cycle of the products whose life cycle has been reduced to only three phases. The life cycle of the various products especially electronic goods (mobile phones) has been studied and it has been observed that life span of these products has been reduced drastically. Another observation is that the introduction and the growth phase have been clubbed into one. Many of the products either will have the growth in the initial part of their life cycle or will be unable to survive, so there is no possibility of the other phases of life cycle. This study formulates a model for the products having only three phases of the life cycle and having a very short life span. While the earlier models have considered five phases of product life cycle with longer duration. The mathematical model considered here has only three phases of life cycle which matches with the life cycles of the electronics products, whose demand increases rapidly during the growth period and declines exponentially during the decline phase.

Keywords

Product Life Cycle, Innovation, Demand & Supply, Industry Dynamics, Yield Management

1. Introduction

Product life cycle is defined as the progression of product at various stages of life. In general it is considered that most of the products have five phases in their life, although some of the products may not see all the phases of their life. With innovation in products and industrial dynamics, duration of the product life cycle is decreasing and even the number of phases has been reduced to three. Most of organizations want to make their maximum yield from this short dura-

tion of the product life cycle.

Levit [1] was the pioneer in studying the product life cycle followed by Vernon [2] who analyzed the international trade and international investment in the product life cycle. Polli and Cook [3] worked on the validity of the product life cycle. Grantham [4] also worked on the validity of the product life cycle in the high-tech industry. Asiedu and Gu [5] have done the review of the product life cycle cost analysis.

One of the reasons for shrinking of life cycle is introduction of more innovative products in the market at a rapid phase and changing business environment. Winter, Kaniovski and Dosi [6] have formulated a model considering industrial dynamics and innovative entrants. Filson [7] has studied how the product and process innovations impact the life cycle of an industry. Werker [8] also studied product life cycle considering innovation, market performance, and competition. Rogers [9] has provided the case of how rapidly the dissemination of ideas and technology is happening among various cultures in his book, titled *Diffusion of Innovations*. Oh, Han and Yang [10] have developed a fuzzy based decision-method to study product discontinuity at the transition state.

The proposed study throws light on the drawbacks of the earlier proposed product life cycle which has five phases. It has been observed that most of the organizations are spending lots of money on research and development to provide innovative products to its customers, therefore life of products has shrunk. Even the companies themselves are shrinking the life cycle of their products by introducing the products at a rapid phase. This study focuses on the introduction of innovative products at a very rapid pace along with the dynamic business environment. This paper suggests that the life cycle of the most of products has been reduced to three phases only, namely, growth, maturity and decline. Although the product life cycle is still a relevant concept, it does not have all the five phases and should be studied considering only three phases. This paper also proposes a mathematical model for the products which will have these three phases in their life cycle. There is a requirement of balancing demand and supply to get the optimal yield from the product. The numerical illustrations have also been provided to prove the usage of the model.

2. Assumptions

- 1) The products considered in this study are mostly innovative products as most of the companies are introducing innovative products to capture the market share.
- 2) In today's scenario with rapid development of the technology, the present business environment is very dynamic.
- 3) The customer has lot of choices and they don't want to wait therefore to gain maximum yield from the market, shortages are not allowed.
- 4) For the new innovative products, demand increases rapidly during the growth phase, hence the demand rate at growth stage is considered to be ex-

- ponentially increasing.
- 5) As observed in the earlier studies on the product life cycle that after certain time the demand for the products becomes static. In this study also the demand remains constant during the maturity period.
 - 6) As the product life cycle is shrinking, therefore the demand would start decreasing drastically after the maturity phase; hence in this study it has been proposed that demand would be exponentially decreasing demand.
 - 7) As demand would be decreasing exponentially therefore after the decline phase the demand for the product would be negligible.

3. Mathematical Model and Analysis

Author has proposed a mathematical model for the three phases of the product life cycle considering the assumptions mentioned above. The demand equation for the growth phase would be given by

$$Ae^{\mu t_1} \text{ for period } = Ae^{\mu t_1} \quad (1)$$

here D is the demand with respect the time t , the demand rate considered here is exponentially increasing demand, where A is constant and μ is the rate of increase which varies from product to product. t_1 is the time period up to which the demand would be increasing for the product and then stabilizes.

On solving Equation (1)

$$D = \frac{A}{\mu} (e^{\mu t_1} - 1) \quad (2)$$

In this scenario if companies are able to predict the time period t_1 *i.e.* growth period of product, they can create supplies accordingly by studying the increasing rate.

In this model, it has been assumed that the average demand during the maturity period becomes stable which would be equal to the demand at time $t = t_1$

$$= Ae^{\mu t_1}$$

Thus, during the maturity period the demand is given by

$$\frac{dD}{dt} = Ae^{\mu t_1} \text{ for period } t_1 < t < t_2 \quad (3)$$

Equation (3) yields,

$$D = Ae^{\mu t_1} (t_2 - t_1) \quad (4)$$

This period can be considered as the best period for the organization as managing demand and supply would be easy and hence by yield management, they could maximize their returns during the period. Only hitch is that they have to keep a watch on the duration of this period. Procuring more than required during this period may yield loss later. As after this period the demand for the product would fall rapidly.

In some of the cases the product might not have maturity phase and after growth immediately the decline starts, as happens in the case of electronic goods.

One more innovative product introduced in the markets result in rapid decrease of demand.

Considering $Ae^{\mu t} = X$ (constant average demand) during the maturity phase of the life cycle of the product.

During the third phase of the life cycle, the demand for the product would start decreasing rapidly; with exponentially decreasing demand rate after time period t_3 , the product is no longer a viable product for the organization as demand for it would be almost negligible.

$$\frac{dD}{dt} = X\chi e^{-\chi t} \quad t_2 < t < t_3 \quad (5)$$

which provides

$$D = X \left(\frac{1 - e^{-\chi t_3}}{\chi} \right) \quad (6)$$

4. Numerical Illustrations and Analysis

Case I Considering an electronic product (mobile phone) which has only three phases of the life cycle and it has been assumed in this case that the product has all the three phases and all of them are equally spanned. The life cycle of the product is considered to be one year; therefore each phase would be around four months. This case is to check how the organization should plan their supply to meet the complete demand without any shortages.

Let by initial analysis $A = 100$, $\mu = 2$, $\chi = 2$.

Total demand would be given by adding (2), (4) and (6).

Demand during growth period is 149,000.

Maturity Period demand is 1,192,400.

Demand during decline period is 148,999.9.

Total demand = 149,000 + 1,192,400 + 149,000 = 1,490,400 units.

The results obtained above prove that the maximum demand faced by the organization is during the maturity period, thus organizations have to plan their maximum supply during this period. Also, if we have considered the span and rate of increase and decrease of demand during growth and decline equal, it yields that demand during both the period is same. Hence it proves the validity of the model.

Case II Considering the same product considered in case I with growth period being the longest, while maturity period is the shortest. And the product with life cycle of 1 year out of which growth period is six months, maturity is 2 months and decline is 4 months. Considering the same rate of increasing and decreasing demand *i.e.* both $\mu = 2$ and $\chi = 2$ and $A = 100$.

Demand during the growth period is 8,137,700.

Demand during the maturity period is 32,550,958.

Demand during decline period is 16,270,019.

Total Demand = 5,69,58,677 units.

This proves that longer the growth period the more would be the demand for items. If we compare case I and II; in both the cases decline period is same but some of the period of maturity has been taken by the growth period which caused 400 percent increase in the demand. Therefore, organizations should work on increasing the span of the growth phase to the maximum extent.

5. Concluding Remarks

This paper studies the relevance of the concept of the life cycle of the product in the present dynamic environment. This study proposes that the life cycle of the products has been reduced to only three phases, which is true for most of the products. Also, the three-phase mathematical model has been developed considering exponentially increasing demand during the growth phase and exponentially decreasing demand during the decline phase. It also provides a model for products having only two phases, namely, growth and decline. Thus, by applying the proposed model the organizations can plan their production schedule and marketing strategy. The numerical illustrations prove utility of the model and also suggest that maturity period is the period where companies make maximum profit, and the longer the growth period is, the more the demand will be.

The proposed model has been built considering electronic goods, but the validity of the models for other products has to be checked. Another limitation of the model is to get complete details of demand for the new innovative products which are not possible. Most of the time companies will not share these details. This model can be further extended with some other demand patterns, also for the products which may have four phases of the product life cycle.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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