

Establishment of Elastic Control Limit in each stage on PLC

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Abstract

본 연구는 관리한계설정을 위한 새로운 방법을 제시한다. 일반적 관리한계는 중심선(Central Line)과 표준편차(Standard Deviation)에 기인한다. 그러나 본 연구에서는 제품수명주기(PLC)의 각 단계상 발생되는 손익분기점(Break-even Point)과 한계이익곡선 특성을 통하여 탄력적 관리한계(Elastic Control Limit ; ECL)를 구축하고자 하였다. 탄력적 관리한계와 한계이익곡선의 관계에서 중심선은 최대이익, 3 σ 한계는 최대이익점과 가장 근접해 있는 (상위/하위)손익분기점까지의 거리로 파악할 수 있다. 그리고 총 변동은 {상위손익분기점(UBEP) - 하위손익분기점(LBEP)}으로 고려할 수 있다.

전개과정으로서는

1. 각 제품별 수명주기(PLC)를 각 단계별로 구분한다.
2. 각 단계별 총이익곡선(TRC)과 총비용곡선(TCC)을 구한다.
3. 한계이익곡선상의 최대이익지점을 구한다.

이러한 연구는 제품성장단계별 평균과 분산의 변동을 동시에 고려하여 탄력적 관리가 가능하다는 장점이 있다. 나아가 마케팅과 소비자 행동의 분석으로 확대될 수 있다.

1. Introduction

Modern Management is bounded by complex factors attributable to structural changes over space and time. It is essential therefore to ensure the high degree of Flexibility and Elasticity in order to adjust readily as well as efficiently to changing external or internal environments.

In this viewpoint, this paper describes a new method on the establishment of Elastic Control Limit, which is capable of grasping the variation of \bar{X} and σ simultaneously. If many study in this parts were made, although this methodology has limits partially, the Elastic Control Limit based on maximum profit following the Break-even Point(BEP) might be applicated in many fields related Marketing and Consumer Behavior.

2. Characteristics of PLC

Products, like all living things, are conceived of as having life cycle, going from birth to youth to maturity to old age. As with different species of animal life, products vary enormously in age. But these outward similarities between animal physiology and products are only analogous, useful for proposes of exposition.^[12] A Product's Life Cycle is usually discribed in terms of sales over time. From a statistical viewpoint, it is a time series. Therefore it gives usually the functional relationship between the sales of a product, the dependent variable, and time, the independent variable. PLC has following three hypothesis.^[4]

First, no product is durable eternally

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Second, product profit can be forecasted following each stage of PLC

Third, different Marketing stratages including Production and Finance should be made in each stage of PLC for products.

It can be represented to diverse forms according to type of product and properties of market. In this paper, following K. Brockhoff model is considered.^[12]

$$S_t = at^b e^{-ct} + dR_t$$

S_t : the amount of sales

R_t : the sum of sales of related products sold by the same company

t : time

a, b, c, d : parameters

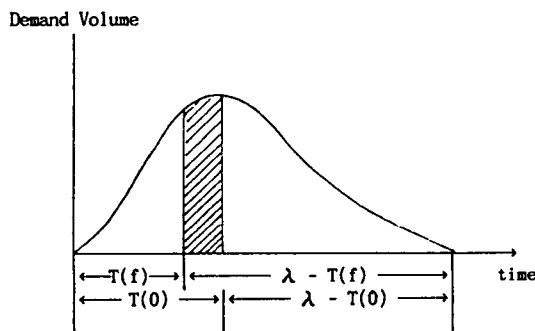
Variation in the parameters has the following consequences ;

- i) as parameter a becomes larger, every point of the function(except 0) grows larger;
- ii) as parameter b increases, the upswing tend to be faster, and the maximum of sales S_t is reached later ;
- iii) as parameter c becomes larger, the decline tends to be faster, and the maximum of sales S_t is reached earlier ;
- iv) if parameter d is positive which means that this is complementary products, sales tend to be greater,
if it is negative which means that this is substitutable products, they are smaller.

The plots differ radically for different products both in duration and shape. At the risk of neglecting these difference, the life cycle concept can be generalized in the form of a parabola or second-degree polynomial. This model visualizes four stages to the cycle : Introduction(I), Growth (II), Maturity and Saturation(III), and Decline Stage(IV).

Traditional product strategy was based on accelerating through Stage I into the late stage II, then extending the "cash cow" nature of the stage III as long as possible.^[6] The Stage IV is to be avoided, if possible, but shortened if inevitable. As the PLC is especially shortened due to stiffer competition, which reduced life cycle translates into less time to pay back the development effort, company has to make efforts in enhancing the Flexibility and Elasticity.

As a result of shorten PLC, companies are faced with the challenge of planning for facilities whose useful lives are much longer than the life cycle of any individual product it manufactures. From the McKinsey & Co. Consultants data,^[11] we could see that a product which is six months late to market will miss out on one-third of the potential profit over the product's lifetime. This properties are shown <Figure 1>.



<Figure 1> Shorten PLC Property

Here,

λ is Average length of the life cycle of each product to be manufactured over the useful life of the facility

$T(f)$ is Average changeover time for a facility ; expressed as a function of the level of flexibility

$T(0)$ represents the average changeover time of the least flexible facility, i.e. when $f = 0$

For any $f > 0$, it is assumed that $T(f) < T(0)$ holds so that higher flexibility is associated with lower changeover time.

Because of this short PLC trend continuously progress, company's adequate action is needed. Generally we can find the reason of short PLC in many case.^{[7] [10]}

But this paper treats only two factors.

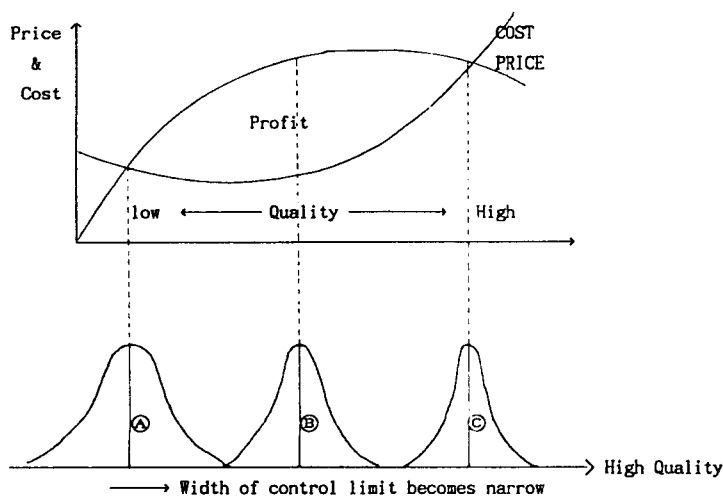
First, Change of consumption pattern

Second, Increase of competition inter-company

As we can't separate these factors as a main or sub factor, diverse effort are required for confront to get hold of these factors simultaneously. This paper especially dissert to establish of Elastic Control Limit according to characteristics of each stage on PLC as a confront action to second factor. Because it is studied previously^[1] that Consumer Behavior's Characteristics is connected with Human Behavior's Characteristics and results in Beta distribution and Eigenvalue problem, as an another approach, it is useful to study for confrontation of company according to variation of PLC.

3. Establishment of Elastic Control Limit in each stage on PLC

Many problems of today's company are caused by management policy which have couldn't grasp the various needs of mass consumer. This paper propose to surmount it through a method. This is to establish the Elastic Management Model considering characteristics in each stage of PLC that indicate needs variation of consumers consequent on time. <Figure 2> shows the general relationship of price, cost and quality, so that we observe the dynamic changability of quality accompanied by quality improvement. Its properties are as follows.^[4]



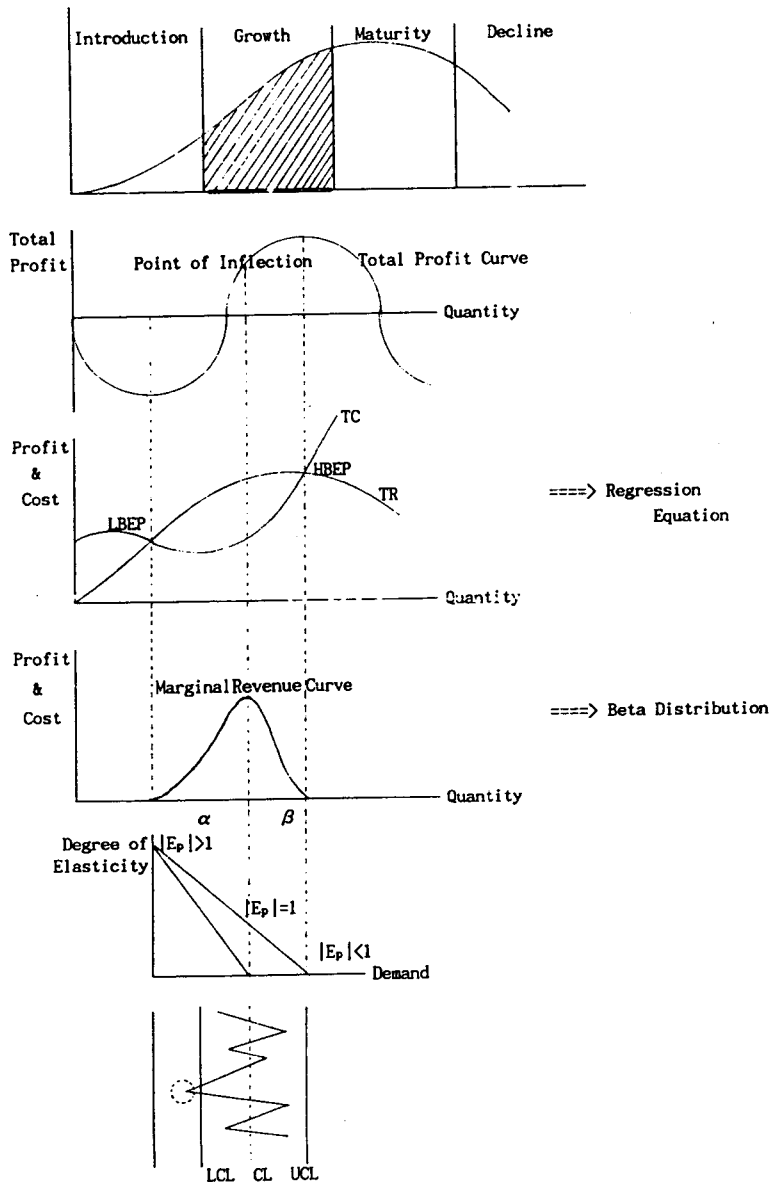
<Figure 2> The relation of price, cost and quality

- ① Vertical line means variation of price and cost, horizontal is variation of quality level.
- ② a, b, c formulate Normal Distribution in each points.

- ①-② If the quality go down more than limits, price becomes lower than cost. Therefore it becomes cost down.
- ③-③ In this point, price can't increase due to market pressure even if cost increase. Therefore it shows cost up.
- ④-④ This point appears the control criterion of quality. It shows maximum profit.

Considering the above statements, we can establish the Elastic Control Limit that premise the Break-even Point(BEP) which is composed of profit/cost curve on each stage of PLC, the maximum profit curve. For this object, the procedure is as follows.

First, it is necessary to divide the PLC of product with Introduction(I), Growth(II), Maturity/Saturation(III) and Decline stage(IV)^[3]



<Figure 3> The procedure on the establishment of Elastic Control Limit

Second, calculate the profit/cost curve on this each stage

Third, by these procedure, seek the BEP

After that, we attain the control limit of product on each stage through the transformation of Upper-BEP and Lower-BEP. <Fig. 3> shows this procedure.

<Fig. 3> treats only product's Growth stage(II), it can be extended another stage. In case of profit/cost curve is deduced by Regression Equation using previous data, the Introduction stage has no data. Thus we should utilize other previous data and another company's data. And practically, the BEP are not proposed only distinguishable two point(as Upper/Lower BEP) in TC/TR curve like above figure. <Figure 3> exhibit an standard expression for convenience's sake. The BEP can vary in number : one, two, more and none, etc. But the decreasing of profit is reasonable accompanied TC curve grow up by increasing fixed cost like in these days independant with the type of BEP.

Additionally, Marginal Revenue Curve expressed by this TC/TR curve's difference have different form, so that Elastic Management is required. This MR curve have the type of Beta distribution. In above figure, we infer the case of $\alpha > \beta$. Based on the establishment of product control limit on $\mu \pm 3\sigma$, we can examine the traits of Mean and Standard Deviation according to proportion of α , β . In establishment of Elastic Control Limit, the characteristics of Mean and S.D. which based on parameters(α, β) are as follows.

<Table 1> Change of control limit accompanied parameters

	$\alpha < \beta$	$\alpha = \beta$	$\alpha > \beta$
Mean	Left Mode	Central Mode	Right Mode
S. D.	$\alpha/3$	$\alpha/3 = \beta/3$	$\beta/3$
Dist. Pattern	Beta($\alpha < \beta$)	Normal dist.	Beta($\alpha > \beta$)

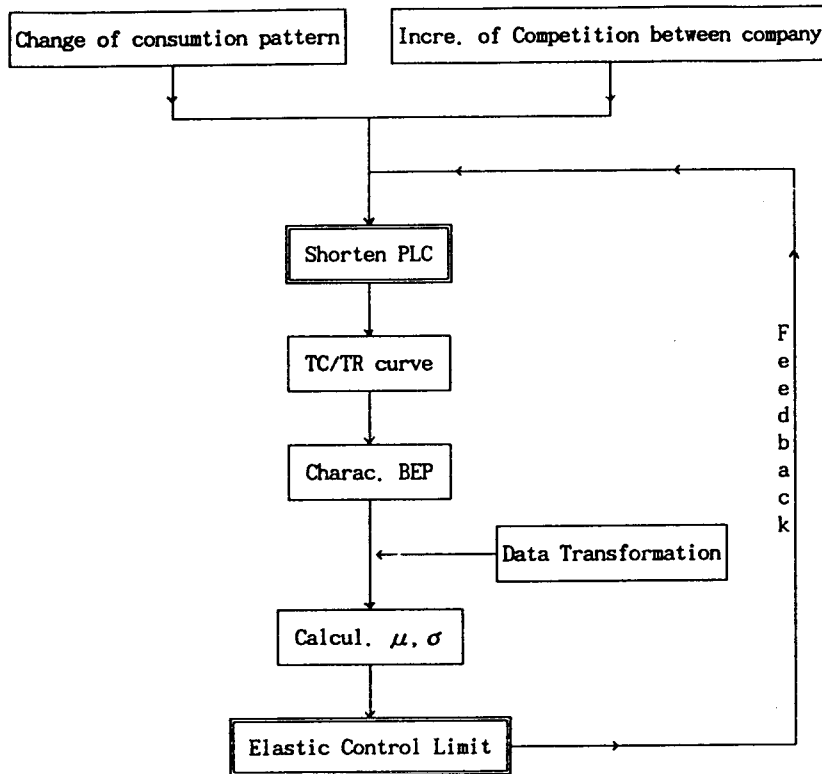
In <Table 1>, although the Standard Deviation is expressed as $\alpha/3$ or $\beta/3$ for convenience's sake, it can be different in real situation. Though the value sought by the MR curve is Quantity originated by the change of profit, the control limit of product is not quantity. Main factor of control limit assumed to Quality characteristics on products itself. It is important to compare and analyze according to situation using the value of MR curve and previous data on product characteristics. We remark it as a Data Transformation, it requires many cautions in application

4. The Outlines and Related Methodology

The procedure of calculation can be outlined as <Fig. 4>

This process bears on the analysis method of Regression Equation, Beta distribution and Elasticity. Total Cost/Total Revenue(by Human Production Behavior) is related and regressed to Market Behavior. Therefore regression and factors analysis of these behaviors are valuable for the users. Beta Distribution extends to PERT Algorithm. Its mean in parameter α , β is same type of Laplace's natural probability, Golden Section Rule and Median. These relations is a help to understanding the framework between Production Behavior and Beta Characteristics.

Elasticity can be adapted to analysis of variation and sensitivity in varing production environments. Comprehensive and Elastic management for the long-term Stability/Gross of enterprise is essential to the organizational-power promotion, reinforcement of forecasting-ability and increasing the reliability. The Elasticity bears on Organization, Forecasting and Reliability. Analysis of Elasticity offers the numerical resourcement for the elastic production behavior.



<Figure 4> The procedure of calculation

5. Conclusion

Many authorities have suggested that perhaps the greatest significance of the life cycle concept is its potential value in product planning. It also implies an ability to forecast the shape and timing of cycle. In this study, we can find its validity especially in establishing of Elastic Control Limit based on PLC and its applications. In addition to it may be extended to Human Behavior related consumer behavior and Marketing under diverse variation of production environments.

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