

A Model for Creative Products to Forecast and Its Production Plan Solved by ACO

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Abstract—Creative product is special product, which has characteristics like short product life cycle, big market risk and so on. The market is changed very soon, and the needs of customers are changed quickly, too. In order to increase the profit and decrease the cost, it is necessary to forecast the demand and make production plan. The product plan is developed according to the quantity of demand, but creative product has no historical sell data to base on, what's more, the demand is unknowable, the information of market is delayed, so it's difficult to forecast accurately. Trend Extrapolation is a way to forecast, and there are many models such as The Gompertz Curve and Pearl curve. The Gompertz curve is used to analysis the development, progress, maturity and decline of new products which is consist with the several stage of product life cycle, the author will use it to forecast, then make production plan of it and use ant colony optimization (ACO) to find the best answer.

Index Terms—creative product, short product life cycle, production plan, Ant colony optimization (ACO)

I. INTRODUCTION

Developing with the economy and the improvement of technology, markets have changed from product-oriented to customers-oriented. The requirements of customers are more complex and various than before. Customized product is becoming more and more common. This market circumstances increase the risk of investment, manufacturers must to estimate the need of customers and design their products according the need. Only in this way can they achieve the biggest return on investment and decrease the risk. Increasing the production flexibility and responsiveness are important to manufacturer.

For example, the industry of garment, due to be influenced by foreign successful brand such as ZARA, many of them joined the fast consumer goods market. The result of the imitate competition is that a lot of enterprises are falling into the "Stock Crisis". Gang Ma who is a clothing analyst said that if we want to sell all of the clothing in the national inventory, it will take more than 3 years [1]. Clothing is one of the short life cycle products, and she has same characteristics with creative

product. Both of them have short life cycle, uncertain customer demands, before they appear on the market, there is no way to forecast the sales volume, and the sales volume are influenced by many factors. Inventory backlog was caused by the uncertain factors. A large number of inventory occupied producer lots of costs of capital. For example, HeiLan home, the inventory quantity book value is 1,305 billion, 1,693 billion and 3,863 billion by the end of 2009, 2010, 2011, respectively, which was accounted for 50.21%, 44.41%, 56.82% of the total assets of that year [1]. Had to say this is a sizeable capital possession, so control output, reduce inventory is very important.

II. LITERATURE REVIEW

American professor Fisher perspective of supply chain, compared the difference of demand and supply and the characteristic of product life cycle, divided the product into functional product supply chain and innovative product supply chain. Compared with the functional product supply chain, the significant characteristic of innovative product is shorter product life cycle, such as high-end computer, fashion goods which have a seasonal demand pattern. There are two reasons which contribute to the short life cycle. First, these products normally have a high turnover of seasonality. Second, due to the high rate of profitability a firm can attain in a short period of time due to the high new product turnover rate [2].

A. Short Life Cycle Product

For the present, the mainly research about short life cycle product in china is qualitative and the main direction is management. Such as Guang-Jun Liu and Qing-Chen Li [3], who came up with the concept of short life cycle supply chain management and analyzed the characteristic of it and the problems which may come across in the process of management. They gave the short life cycle products supply chain management simulation framework, too. Wei-Hong Qian [4] researched how to establish a rapid and effective supply chain management system of short life cycle product. Others researched the short life cycle product from the supply chain combined contract, such as Li-Jun Ding and Yin Zhou [5].

B. Short Life Cycle Product Demand Forecast

Short life cycle products demand forecast research is lack of pertinence, no mater in china and abroad, there is no forecast model which can be accepted by most researchers. The literatures include two kinds [6]. One is prediction research for the new products, the other one is for a certain product which belongs to short life cycle product. New products are combined with management to forecast for industry. The main method is diffusion model.

The literature of demand forecast was based on the Bayesian method, but the study mainly from the angle of industry. It is the total market research industry, can only give industry macroscopic guidance, for the enterprise has not much meaning [7]. Just for the innovation products, there are many studies in foreign. Bass model is one of it. Bass model was come up with by Frank. Bass in 1967, the model was first used to predict the diffusion of resistance consumption goods in the first service cycle. Because of the success, the model is gradually used in various fields, especially the new and high technology fields, such as broadband. Resent years this model also be used for the short life cycle product demand forecast, and has made great result.

But there are hundreds of demand forecast model which are based on Moving averages models, Exponential smoothing models and linear regression models. The extended practical models include: seasonal index prediction method, winters models, arma models, gray control theory (GM), Cubic curve prediction models, and so on.

III. THE MODEL FOR CREATIVE PRODUCT

Creative products contain higher technology and art than ordinary products, such as high-end phones, handicraft and fashion. The main consumption group is the one who has special need. It is difficult to develop manufacturer schedule, because of shorter life cycle, quickly changing of the market and influenced by the society. But the manufacturer is critical in the supply chain, who decides the number of production.

A. Analysis of the PLC Characteristic of Creative Product

Product Life Cycle (PLC) is the product’s market life, that is, a new product from began to enter the market until the end be eliminated from the market [8]. Raymond Vernon considered that the product life cycle is the marketing life of the product in the market. A product life cycle is commonly divided into four stages Market development, market growth, market maturity and market decline stages (Levitt, 1965) [9]. The normal product life cycle pattern was shown like figure 1.

At market introduction, there is no same product with it, but the demands are developed at this stage. The sellers should try their best to advertise and possess sales channels, open the potential market, enlarge the publicity of the new product and gain recognition of the customers. Time goes to the market growth. Demand accelerates in the market growth stage leading to larger sales revenue. Inventory and capacity expansion issues are of prime

concern during this time. In the market maturity stage, the competitor will appear, no matter the same product or similar product, they will seize the market, and how to maintain the original market share is most important question to consider of the manufacturers. In decline, the demand decrease until disappeared. In this stage how to recovery cost as much as possible quickly and effectively is important; at the same time they should develop other new product to seize the market. Now the product life cycle has some transformation, some product will exit the market in the introduction period, or they don’t have the growth period.

There are many differences between the ordinary products and the creative products when they enter the market, which are caused by the characteristic of themselves. What’s more, the creative product is forward-looking, which is inexistence in the market before, so the life cycle of the creative product is more complex. Just like the figure 2.

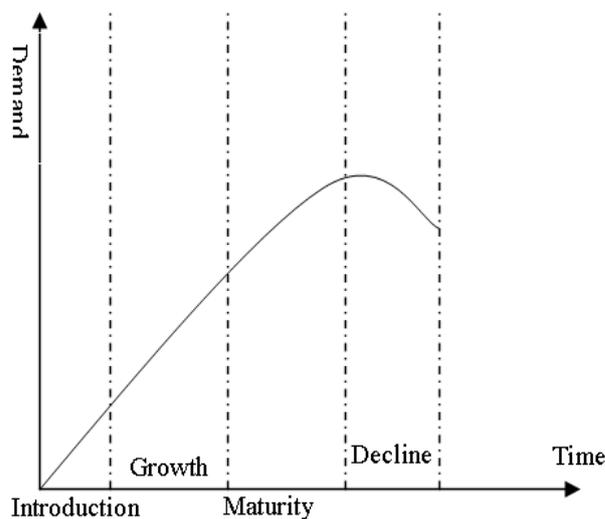


Figure 1. Normal product life cycle

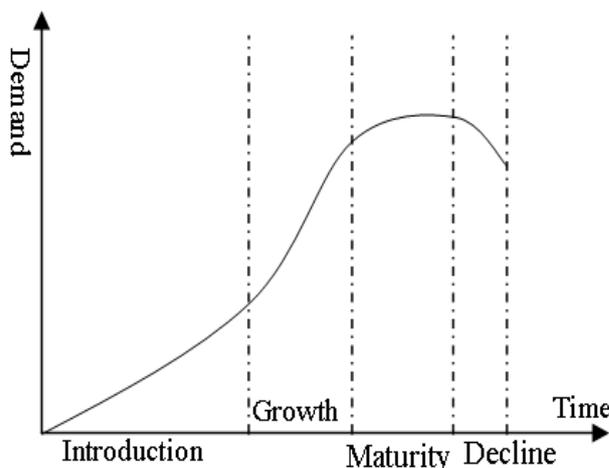


Figure 2. The PLC of creative product

(1) A longer introduction period, the main reason is that there are no same or similar products for the customers to refer to, so they couldn’t make a decision

where buy or not. Only the same kind can be found when they enter the market, but the help is little, so it's difficult to open the market.

(2) A shorter growth period than ordinary products. Once the market is opened, the demand of the products will increase quickly just like the exponential curve. In this period the product will seize the market, and then enter to maturity fast.

(3) Almost no decline stage, after the maturity the demand of customers is closing to saturation, needs decrease rapidly, only a few customers have demand, so there is no decline stage to the creative products or the decline stage is short. The product will withdraw from market quickly.

Because there is no historical data to base on, we can't use the historical factors model or time factors model to make predict of the demand, it's difficult. And there is no relevant evidence to proof that one factor, which can be calculated, has directly or indirectly causal relationship with the sales volume. In my paper we will use Trend Extrapolation to forecast. Next introduce the Trend Extrapolation.

B. The Model for Forecast

Trend Extrapolation is a way which bases on the historical data and pre-existing data to explore the change rule as time goes on, and then speculate the future situation. The Gompertz curve is one of the Trend Extrapolation, which are mainly used to analysis the development, progress, maturity and decline stages situation of new products [10]. The character of this curve is consistent with the creative product life cycle well.

The Gompertz Curve model:

$$\hat{y} = ka^{bt} \quad (1)$$

where k , a , b are undetermined, which are determined by the product.

The Gompertz curve also base on the historical sales data to forecast, but the creative products don't have, so we should make some change. We choose the similar products sales data instead. There are two reasons:

1) They belong to the same category, so they may have the same customers group.

2) Both of them are creative products. There is no reason to deny that they will meet the same situation when they enter the market.

Next we will deal with the raw data. There are also two steps to manage the data. Firstly, we need to divide the data into several parts, because the Gompertz Curve is also a kind of time series forecast method, Due to the characteristic of creative product life cycle we divide the data into 3 parts. Secondly, eliminate some accidental interference factors in different period. Now we finish the prepared work what we should to do is according the data to calculate the model and forecast.

We should make the product planning before the business begins. All the companies want to win profit, but there is no investment without risk. When making a plan it's important to find the point where can minimize total

cost and gain profit as far as possible. To achieve the goal, we take manufacture as the centre enterprise, and take minimize the total cost as the objective function. The costs of manufacture include costs of production, raw material costs, inventory costs and costs of backlog or stock out. The total cost is given by:

$$TC = C * Q_P + M * Q_M + I * Q_I + S * Q_S \quad (2)$$

where the TC stands for the total cost of one period; C , M , I and S stand for the cost of make a unit product, the cost of a unit raw material, the cost of inventory for a unit product and the cost of stock out or backlog for a unit product, respectively.

While the Q_P stands for the number of produced of one period; Q_M , Q_I , Q_S stand for the number of raw material, the inventory at the end of one period and the stocked out or backlogged at the end of period.

However, $Q_M = KQ_P$ (K stands how much raw material used for a unit product), $Q_I = D - Q_P$, $Q_S = D - Q_P$ (D stands demand, when $Q_S > 0$, $S=P$, or $S=0$). P stands for the price of the product, so the total cost can be given as follow.

$$TC = (C + KM + I) * Q - I * D + S * (D - Q) \quad (3)$$

where Q stands for the number of product of one period.

Constraint Condition: $0 < Q < Q_{MAX}$, the total quantity can not be bigger than the biggest production capacity;

$Q_{I(K)} = Q_{I(K-1)} + Q_K - D_K$, the inventory of the K period should equal to the $K-1$ period add the produce of K period and sub the demand.

IV. ANT COLONY OPTIMIZATION FOR SOLVING THE PROBLEM

Ant Colony Optimization (ACO) is a probability model, which is used to find the shortest distance between several points in the chart. Ants choose road on the basis of the pheromone, which were left by the passed ants, and find out the shortest distance to their food or the goal place [11]. ACO integrate the information of the partly and global, weight the important of the information, then choose the optimal path. This method can integrates the partly optimal path to the global optimal path and get the shortest distance, which has been widely used in many fields such as supply chain design [12-16], robot learning and planning [17,18], customer behavior analysis[19,20], job shop scheduling problem[21,22], financial forecast [23], signal processing [24], power system design [25], and so. In this paper we take the total cost as the total distance, take the several cost as points, the amount of the cost as the road distance which are vary with the candidate solution, using the ACO to calculate the best solution. The pseudo-code of the ACO is described as follows:

Step 1: Initial $T=0, NC=1$ (number of times), setting the pheromone of every point as $\tau_{ij}(0) = \tau_0$ and $\Delta\tau_{ij}(t) = 0$;

Step 2: For $s=1$ to m searching every candidate solution and calculate the objective function according to the TC , then update.

Step 3: Update the pheromone of every path; when the path is selected $\Delta\tau_{ij}(t) = Q/TC(t)$, or $\Delta\tau_{ij}(t) = 0$.

Step 4: Set $t=t+1, NC=NC+1$;

Step 5: If $(NC=NC \text{ (max)})$ or TC (no change in a long time) output the TC and exit. Else turn to second step.

As mentioned before, the expression of TC is given by (3), mainly contains two decision variables, Q and D , D can be predicted by expression (1). The best way to product is equal the demand, but the forecast always has error and the realistic situation is more complex, so in this paper we will give a variable region to the D as the Q 's variable range, and calculate the objective function to find out the best production planning.

V. CASE STUDY

At this section, we will have an example. Smart phone is one of innovation product, which is replaced by the new technology and the new design quickly. Next we will take the similar product's sales data to make predict and development a production planning [26,27].

The similar products' sales data is shown in Table 1. We chose 3 similar products, and then separate them to 3 periods (introduction, growth, maturity), because of the short decline period. We group the same period as one group to calculate parameters. The treatment of date is shown in Table 2.

TABLE I

THE SIMILAR PRODUCTS' SALES DATA, IN TEN THOUSAND

Kind 0		Kind 1		kind 2	
time	Sales data	time	Sales data	time	Sales data
0	7.5	0	8.2	0	9
1	9.5	1	9.6	1	10
2	11.4	2	11.8	2	12

TABLE II

THE TREATMENT OF DATE, IN TEN THOUSAND

time	Sales data(y)	lg(y)
0	7.5	0.8751
1	8.2	0.9138
2	9	0.9542
I		2.7413
3	9.5	0.9777
4	9.6	0.9823
5	10	1
II		2.96
6	11.4	1.1461
7	11.8	1.2553
8	12	1.3010
III		3.7024

Calculate the predict model.

1) Estimating parameters k, a, b , which are given as follows:

$$b^3 = \frac{III - II}{II - I} \tag{4}$$

$$\lg a = (II - I) * \frac{b - 1}{(b^3 - 1)^2} \tag{5}$$

$$\lg k = \frac{1}{n} (I - \frac{b^n - 1}{b - 1} \lg a) \tag{6}$$

where $b=1.5029, a=1.0451, k=7.6440$.

2) Substitute k, a, b , we can get the predict model $y = 7.6440 * 1.0451^{1.5029t}$.

3) Forecast. The result is showed in the Table 3.

TABLE III

PREDICT RESULT AFTER TEN THOUSAND ITERATIONS

time	demand(y)
0(introduction)	7.6440
1(growth)	8.1686
2(maturity)	8.7292

Considering the forecast error, we can give the predict quantity a variable range, by this way we can correct the result and decrease the error. We can use the Mean Absolute Deviation to correct. The MAD of different stages are 0.686, 1.5314 and 3, respectively [28,29].

The parameters are presumed. If we take $C=4, K=2, M=1, I=3, P=10$, the max capability of product is 100000. The value of D is predicted in advance [30]. The Q has variable area like those: Introduction $6.958 < Q < 8.33$, growth $6.6372 < Q < 9.7$, maturity $5.7292 < Q < 11.7292$. The production planning is shown in the Table 4.

TABLE IV

THE PRODUCTION PLANNING AFTER TEN THOUSAND ITERATIONS

time	production
0(introduction)	6.9
1(growth)	6.6
2(maturity)	5.7

As the TABLE 4 shows, at the introduction stage the manufacturer should produce many products, because of the unknown market, in the growth period they produce less than the first period, maybe the product is not popular in the market so the factory decrease output. On the maturity they produce less. Compared with the forecast demand data, we can find that the increase of this kind production is slowly, so we can say this product is not welcomed in the market, carrying out production plan like TABLE 4 will have less risk.

VI. CONCLUSIONS

This paper analyses the life cycle characteristics of creative products, use the Gompertz Curve model make a forecast, and combine with the cost, minimize the total cost as the optimize object function to make production planning. The main characteristics of creative products are uncertain demand and higher market risk. The gompertz curve model combines with the characteristic of

creative product well. Through we made many analysis before use the model, there are many problems haven't solved. When I use the model, there is no strict prove, and there may be some fault in the analysis. We hope you can give me some advice to amend and improve my paper.

In the future we can modify the model or add more parameters to the model, and we can consider the practical situation more when we make forecast.

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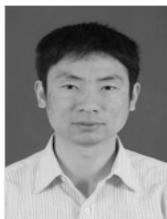
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