

# **THE DECISION OPTIMIZATION OF PRODUCT DEVELOPMENT BY CONSIDERING THE CUSTOMER DEMAND SATURATION**

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## **Abstract**

*On the basis of satisfying basic customer demands in the process of product development, strengthening meet the personalized customer demands which has high attention can improve the market adaptability and competitiveness of products. First of all, investigate to obtain the customer demand information, and then quantify customer demands weights by using variation coefficient method. Secondly, analyses the relationship between customer demands and product development time and cost based on the quality function deployment and establish corresponding mathematical model. On this basis, put forward the concept of customer demand saturation and optimization decision method of product development, and then apply it in the notebook development process of a company. Finally, when customer demand is saturated, it also needs to prove the consistency of strengthening satisfies customer demands and high attention degree customer demands, and the stability of customer demand saturation under different parameters. Prove the correctness and effectiveness of concept of customer demand saturation and the decision method in the end.*

*Keywords: Customer demand, Development cost, Development time, Demand saturation, Product collaborative innovation, Excessive demand, Genetic algorithm*

## INTRODUCTION

In recent years, with the increasingly fierce market competition, enterprises pay more attention to the needs of customers in the product development process, and look forward to enhancing market flexibility and product competitiveness by strengthening meet the customers' individual demands, which have high attention.

Therefore, many scholars have research on customer demands from different perspectives. Through the analysis of customers' individual demands, people like Anshuman, Costas and Cono (2000) used a chance constraint programming approach in conjunction with a two-stage stochastic programming methodology for capturing the trade-off between customer demand satisfaction (CDS) and production costs, and the results indicate that significant improvement in guaranteed service levels can be obtained for a small increase in the total cost; Some people highlight some weaknesses in the JIT approach for meeting the changing customer demand (John, Richard & John, 2000); Ren and Qiu (2013) point out that with configurable products increased in size and complexity, interdependencies between customer demands and product structures also strengthening. They used fuzzy AHP method and multi-level matching algorithm to realize the transformation of multi-level model between customer demands, technology and product structure; Based on the semi-structured customer demand information including fuzzy semantic description which is fuzzy, not easy to handle, and difficult to be transformed into precise product functional requirements etc; Jean, Saif and Francis (2009) consider a make-to-stock supplier that operates a production facility with limited capacity, which can solve the problem of production-control and inventory-allocation; JING and Dan (2011) research out of the expression and conversion processing method of semi-structured customer demand, and through the four processing steps, fuzzy semantic analysis, fuzzy inference, weighted optimization and defuzzification, it realized the transformation of the semi-structured customer demand to the exact product functional requirements; With using QFD (Quality Function Deployment), Crostack, Hackenbroich, Refflinghaus & Winter (2007) get the high precision customer demands; The same as F. De Felice and A. Petrillo (2010); Based on the customer demand characteristics of mass customization production, Dean (2009) used the previous production data to estimate the manufacturing resource requirements and its' clusters, and built linear and nonlinear relationships between customer demands and necessary resource requirements for production by using linear regression and neural networks, then forecasted the manufacturing the resources needed to customer demands; Combined with quality function deployment method, YAN and ZHAO (2011) presents a method for mapping customer requirements, so as to get the product module configuration scheme set under the customer demands; Scholz and Kück (2013) proposed control scheme for Nonlinear Dynamics method to

improve the accuracy of demand forecasts, which solved the problem of highly unstable about intermittent customer demands; Tan (2013) designed a questionnaire for electric features to capture customer demands, through fuzzy logic processing, he got the explicit ones; some people assumed that fully meet customer demands in order to improve customer satisfaction, they redefined the rough numbers to effectively analyze customer needs and fully express customers' perceptions (ZHAO, ZHANG & Zhen, 2011); ZHU and YANG (2012) revised the customers demand important by the concept of DEMATEL and entropy, with a view to display diverse customer demands objective and reasonable in the research and development; people like Ertian, Huanhuan and Daqiang (2013) proposed a customer segmentation method based on fuzzy clustering and trigonometric functions, through the trigonometric function model design, this method can realize the conversion of customer demands for design knowledge; DAN and YAO (2010) presented a product configuration method based on ontology mapping method for the product development process of fuzzy customer requirements to product configuration issues, and finally realized the multiple match between customer demand characteristics parameters and the instances characteristic parameters; On inventory management, Dutta and Chakraborty (2010) described the uncertainty in customer demand using knowledge and information, they presented a policy to address the single-period product inventory problem under uncertainty of customer demands, which called "two projects one-way alternatives"; From the perspective of cloud computing, with analyzing cloud computing platform architecture and characteristics of mass customization in customer service, GUO and WU (2011) proposed customer demand-response model of mass customization based on cloud computing, which solved problems effectively of addressing customer demand information in the mass customization.

In response to the analysis of the domestic and foreign research results, it can be find that there have been given a lot of in-depth studies on diversification and individuality customer demands in the course of product development and many customer demand mining methods have been proposed. However, in the process of actual development, excessive attention and consideration of customer demands will lead to development costs and development cycle increasing, which reduces the efficiency of product development and economic benefits of enterprises. In this regard, the related research is still lacking, especially for the dynamic quantitative analysis between the degree of customer demand satisfaction and the product development cost and time.

Based on these above, this paper is organized as follows. Firstly, through the concrete research, obtain the customer demand information, and quantize customer demands weights by using the method of variation coefficient; Then, with the use of quality function deployment,

analyze the relationship between customer demands and product development time and cost, and establish the mathematical model; On this basis, construct conception of customer demand saturation, and put forward the optimal decision methods based on genetic algorithm under considering customer demand saturation; Finally, present satisfactory scheme to meet customer demand under the ideal product development time and cost. This paper will provide the decision for the enterprise to weigh the customer demand, product development time and cost in product development.

## CONCEPT CONSTRUCTION ON CUSTOMER DEMAND SATURATION

### Determine the weight of customer demands

In order to determine the differences between each customer demands and overall one, it is necessary to get weight analysis of the customer demands, to show the customer demand for the meeting space. When determine the weight of demand, the common methods which include methods of subjective (AHP and Delphi) and objective (fuzzy clustering, rough set and entropy), the subjective weighting methods have certain subjectivities, which influences decision accuracy and reliability (Tadic, Gumus & Arsovski, 2013; TIAN, ZHANG & WANG, 2004). Fuzzy clustering and rough set methods use the raw data to calculate weight, while avoiding the subjective, but weakness in calculating weights, namely in handling information. Although there is no systematic information on the loss, but unable to determine system weight of each property, and typically, the use of fuzzy distribution of weights usually need to provide a priori standard; Rough set method does not need to provide prior information, and also provides a tool to determine weight, but it uses range partitioning method for data processing, with neglecting more system information (HUANG, WU & ZONG, 2004; CHEN and XU, 2013).

However, the variation coefficient method based on objective statistical data can analyze the differences in response to customer demands (CHEN, 2012), with calculating the standard deviation, it can show the differences in customer demands. The average performance normal expectation of customer demands. Due to the size of coefficient is the ratio of the two above, and it reflects the general instance of customer demands in the market. Therefore, the method can be effective in highlighting the differences in demands, diversity and the importance of customer needs yet to be met, so it is reasonable to use variation coefficient method to determine the weight of customer demands in the product development process. The following is the specific calculation steps.

**Step1.** Collect customer demands, and calculate the variation coefficient. Assume that the number of customer demands is  $n$ , after statistical analysis, draw the average and the standard

deviation of each customer demand, and according to the obtained data derived before, the variant variables ( $V_i(i=1, 2, 3, \dots, n)$ ) of each customer demand is calculated as follows:

$$V_i = \frac{\eta_i}{X_i} \quad (1)$$

**Step2.** Calculate the weight of each customer demand. Use the variation coefficient method to

get the sum ( $\sum_{i=1}^n V_i$ ) of the coefficient of variation of customer demand. And based on the variation coefficient method formula, calculate weights of each customer demand ( $cd_i(\text{Customer Demands})$ ), weighting formula is as follows:

$$cd_i = \frac{V_i}{\sum_{i=1}^n V_i} \quad (2)$$

According to two steps above the demands of weight matrix is as follows:

$$CD(\text{Customer Demands}) = (cd_1, cd_2, cd_3, \dots, cd_i, \dots, cd_n)^T$$

**Step3.** Define customer demands meet program. According to customer needs weight matrix which is obtained, we define a demands active matrix, which is the customer demands meeting program ( $\sigma$ ). The matrix can represent the satisfied situation of demands, so that can show each customer demand realized or not:

$$\sigma = (\sigma_1, \sigma_2, \sigma_3, \dots, \sigma_i, \dots, \sigma_n)^T$$

$$\sigma_i = \begin{cases} 1 & \text{demand } i \text{ can be realized} \\ 0 & \text{demand } i \text{ cannot be realized} \end{cases}$$

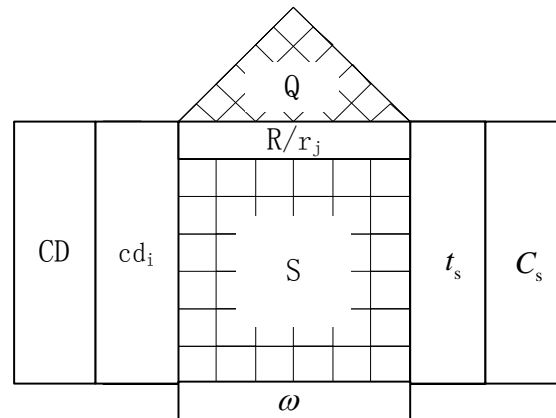
Note, if each  $\sigma_i$  was 0, it meant there is no demand. It doesn't make sense and this program should be removed.

### Relationship between customer demands and product development time & costs

Because that Quality function deployment (QFD) can turn customer demands, technical characteristics and correlation of each part into graphic showing, its intuitive and simple characteristics can help demonstrate decision problems (Vinodh and Kumar, 2011; Wu, Pan & Shao, 2013). As shown in Figure 1, the QFD matrix is defined like this: in the matrix,  $CD$  indicates the type of customer demands,  $cd_i$  indicates the weight to all customer demands for each one. Based on these customer demands, define  $R$  for the technical properties of design and production. The corresponding, define  $r_j$  for project category of each technical

characteristic, define  $Q$  for correlation degree of technical characteristics, and define  $S$  for the relationship degree between customer demand  $i$  and technical characteristic  $j$  (Hariri, 2013). The Parameters  $t_s$  and  $C_s$  represent the time and cost of the program  $\sigma_s$ .

Figure1. Relationship between customer demands and product development time and costs



For every customer demand requires at least one technical, so assume technical characteristics number was  $m$ , the technical characteristics  $R = (r_1, r_2, r_3, \dots, r_j, \dots, r_m)$ . Relating to the type of the technical characteristics, the technical characteristics of each weight should also be considered, therefore, it is necessary to define the technical characteristics weight matrix as  $\omega = (\omega_1, \omega_2, \omega_3, \dots, \omega_j, \dots, \omega_m)$ . In addition, there is a correlation constraint in technical characteristics, known as "technical characteristics of the autocorrelation matrix" (Geng, 2013; Zhai, 2000). We define it as  $Q_{ij}$ . According to the definition of technical characteristics, the relationship should exist between customer demands and technical characteristics, so, based on the QFD analysis of Miguel (2005) and Vinodh (2011), represent the correlation matrix as  $S$ .

$$Q_{ij} = \begin{bmatrix} q_{11} & q_{12} & \dots & q_{1i} & \dots & q_{1j} \\ q_{21} & q_{22} & \dots & q_{2i} & \dots & q_{2j} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ q_{i1} & q_{i2} & \dots & q_{ii} & \dots & q_{ij} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ q_{j1} & q_{j2} & \dots & q_{ji} & \dots & q_{jj} \end{bmatrix} \quad (3)$$

$$S_{ij} = \begin{bmatrix} S_{11} & S_{12} & \dots & S_{1j} & \dots & S_{1m} \\ S_{21} & S_{22} & \dots & S_{2j} & \dots & S_{2m} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ S_{i1} & S_{i2} & \dots & S_{ij} & \dots & S_{im} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ S_{n1} & S_{n2} & \dots & S_{nj} & \dots & S_{nm} \end{bmatrix} \quad (4)$$

According to the definitions above, for customer demands meeting programs  $\sigma_s$ , each customer demand is satisfied by costs and technical characteristics, it shows a positive correlation between development cost and technical characteristics, and also the technical characteristics weight and demands. Therefore, set technical characteristics weight matrix as cost elements for customer demands, and set the relationship of demands ( $\sigma_i$ ) and technical characteristics as development costs expenditure levels, then, build a development cost model for customer demand meeting program  $\sigma_s$ .

$$C_s = \sum_{i=1}^n \sigma_i \sum_{j=1}^m \omega_j S_{ij}^T \quad (5)$$

In addition, for a demand meeting program  $\sigma_s$ , due to the demands associate with the technical characteristics, the development time relate to the relationship intensity in technical characteristics. In other words, there is a positive correlation between development time and technical characteristics autocorrelation level, since the between the degrees. So, set the technical characteristics autocorrelation level as development time expenditure levels, and the development time of customer demand meeting program are as follows:

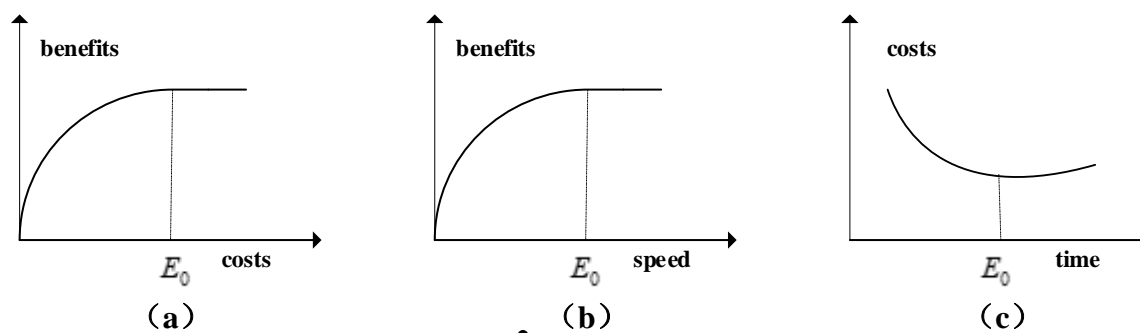
$$t_s = \sum_{i=1}^n \sigma_i \sum_{j=1}^m \varphi Q_j \cdot \bar{S}_{ij}^T \quad (6)$$

Note,  $\varphi Q_j$  means sum of  $Q$  in line or column,  $\bar{S}_{ij}$  denotes a matrix that each element which is not 0 is replaced by 1, it represents the distribution of required technical characteristics on program  $\sigma_s$ .

### Customer demand saturation

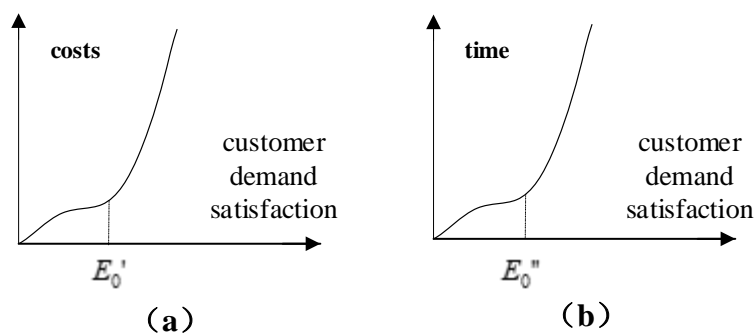
In the course of product development, focusing on demands can improve the adaptability and competitiveness of enterprises. However, excessive meet customer demand will increase development costs and time. Therefore, a balance between demands and development costs and time must be made to control the situation. For development costs, development speed and the benefit of meeting demands, Hou (1998) analyzes the three elements of the issue. He defined the problem as "The balanced in new product development features value and the benefit." The three elements of the development process are as shown in the figure 2.

Figure 2. Three elements and their relationship



As shown in Figure 2 (a), with the increase of investment, benefits and costs are positively correlated, due to the limited social technologies over a period time, when reached  $E_0$  point, benefits increase slowed. It also happened in development speed and the benefits, which is showed in figure 2 (b). In figure 2(c), it can be find, in a certain range, development costs decreased with time increasing, and it just goes to show impact on proficiency in the job product development. In point  $E_0$ , minimal development cost got. Meanwhile, elements of customer demand meeting program are similar to the above. According to HOU and levtushenko's study, we obtain graphs as follows for factors of customer demand satisfaction, development time and costs (HOU, 1998; levtushenko and Hodge, 2012).

Figure 3. Relationship in customer demand satisfaction, development time and costs



As shown in Figure 3 (a), before reaching the point  $E_0'$ , with the increase of customer demand satisfaction, development costs rose slowly, when over point  $E_0'$ , costs are rising rapidly. As shown in Figure 3 (b), development time also has the same trends, when over point  $E_0''$ , the



time is rising rapidly. That is, to meet customer demands, it will lead to development costs and time rising. Therefore, it is necessary to find a balance between the three elements.

$$C_s = \sum_{i=1}^n \sigma_i \sum_{j=1}^m \omega_j S_{ij}^T$$

Based on the preceding analysis, we got the product development costs ( )

and development time (  $t_s = \sum_{i=1}^n \sigma_i \sum_{j=1}^m \varphi Q_j \cdot \bar{S}_{ij}^T$  ), through value engineering theory, make total

value of the program  $\sigma_s$  as sum of demands weights. The defined customer demand satisfaction is as  $\xi$  :

$$\xi = \frac{\sum_{i=1}^n \sigma_i \sum_{j=1}^m \omega_j S_{ij}^T}{|\sigma^T \cdot CD|} \tag{7}$$

In considering product development on the basis of cost, time, and customer satisfaction, define customer demand saturation as  $CDS$  (Customer Demand Saturation). And in the program  $\sigma_s$ , the saturation is  $cds_s$ .

$$cds_s = \frac{|\sigma^T \cdot CD|}{t_s + C_s} \tag{8}$$

After that, linking formula (5), (6), (8):

$$cds_s = \frac{|\sigma^T \times CD|}{\sum_{i=1}^n \sigma_i \sum_{j=1}^m \varphi Q_j \times \bar{S}_{ij}^T + \sum_{i=1}^n \sigma_i \sum_{j=1}^m \omega_j S_{ij}^T} \tag{9}$$

### DECISION OPTIMIZATION UNDER CONSIDERING CUSTOMER DEMAND SATURATION

As shown in figure 4, decision optimization is as follow:

**Step1.** Capture customer demand weights. Have a research on product demands, capture relevant data of customer demands, and then, evaluate the demands of weight ( $cd_i$ ) and weight matrix ( $CD$ ) by using variation coefficient method.

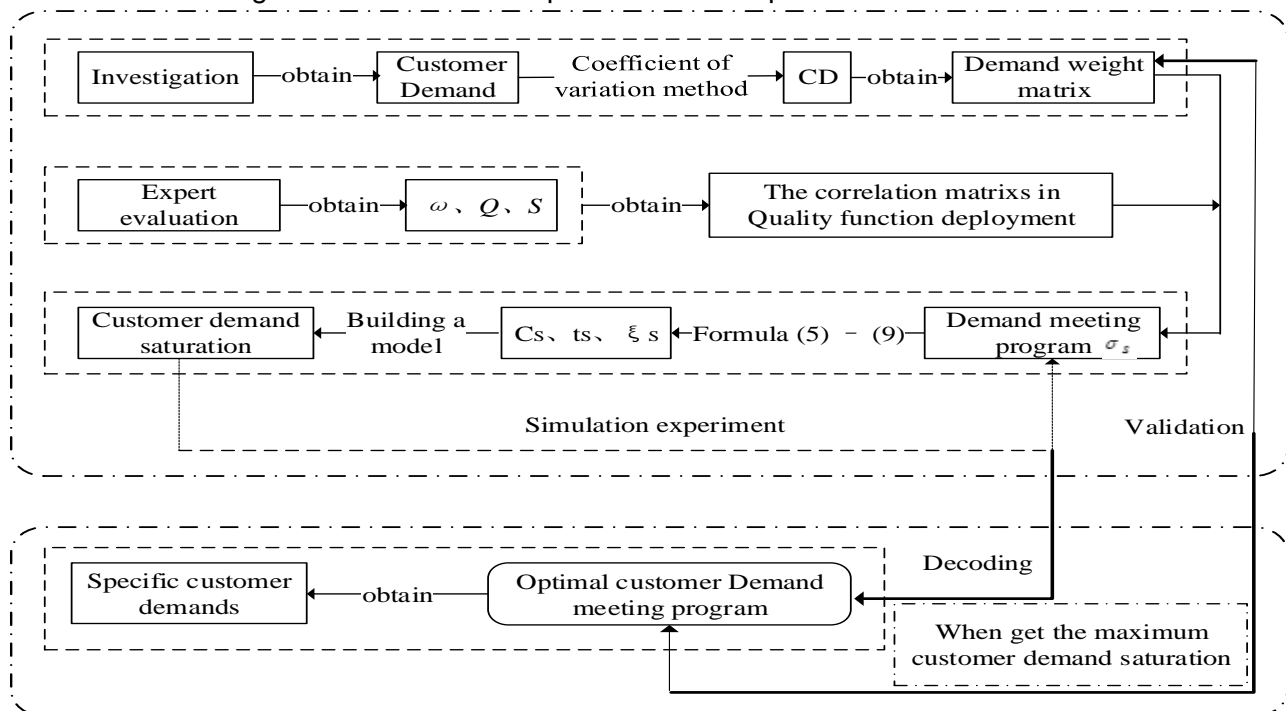
**Step2.** Calculate  $\omega$ ,  $Q$  &  $S$  in the quality function deployment matrix. Based on the Likert five-level rating scale and expert assessments, obtain technical characteristics matrix  $\omega$ , technical characteristics autocorrelation matrix  $Q$  and the matrix  $S$ .

**Step3.** Calculate customer demand saturation. According to the steps above, the customer demands of weight ( $cd_i$ ), technical characteristics autocorrelation matrix  $Q$ , matrix  $S$  and  $\bar{S}_{ij}$  can be obtained. With using formula (5) - (9), we can get the customer demand saturation of demand meeting program  $\sigma$ .

**Step4.** Simulation, propose product development program. First, based on the genetic algorithm, generate initial population of demand meeting program  $\sigma$ , through operations such as selection, copy, crossover, and mutation, Calculate the minimum value of  $\xi$  and maximum value of  $CDS$  in every generation; then, for the best individual in each generation, calculate the value  $t_s$  and  $C_s$  by using quality function deployment; finally, in the simulation process, when the variation of the value ( $\xi$ ,  $CDS$ ,  $t_s$  &  $C_s$ ) is mild, extract the ultimate best individual and decoded to customer demands on program  $\sigma$ .

**Step5.** Analysis the demands development time and costs on the obtained programs. After simulation, calculate development costs and the time for the getting satisfied demand meeting programs. In addition, compare the demands with demand table by weights, so as to testing the sequential consistency. Meanwhile, in order to determine validity and correctness of the model, change the set parameters of genetic algorithms and simulated again to test model stability.

Figure 4. Product development decision optimization flowchart



## APPLICATION CASE

In Chongqing Yonghui science and Technology Park, the H Company engages in developing notebook products. In order to ensure the adaptability of the product, Pacific Computers Website and BBS of ZOL digital online are commissioned to initiate discussion of the demand characteristics for new PCs.

According to forum feedback, merge customer demands based on the principle of similar demands, extreme demand excluding, the result is shown below:

Table 1. Customers demand characteristics

Number	Demand	Detail	Number	Demand	Detail
1	D1	Ultra-thin	9	D9	dual-camera
2	D2	Metal materials	10	D10	Advanced microphone
3	D3	well-cooled	11	D11	Advanced Audio decoder
4	D4	Engineering Plastics	12	D12	Retina screen
5	D5	Much electricity	13	D13	Genuine operating system
6	D6	A space streamlined	14	D14	Various colors.
7	D7	modular design	15	D15	high performance portable
8	D8	High camera pixels	16	D16	design advance

According to the data in Chongqing municipal industrial and commercial Bureau, as of 2012, in the Chongqing region, electronics store number is more than 1100, where dense in Nanan, Yuzhong, Jiangbei. Shapinba and Jiulongpo district. In the 5 boroughs above, there are more than 240 PC shops, 117 large-scale digital cities and more than 10 senior computer shops. For instance, in Cyber city, there are more than 90 Lenovo computer stores, 20 HP computer stores and 10 Acer stores. It registered an average of 6,000 passengers per day.

After Network investigation, H Company grants questionnaires in big PC stores on the above 5 districts of Chongqing City, each district is distributed 200. The quantity of questionnaire amounts is 1000 copies, 873 recalled, and the recovery ratio is 87.3%. In the experiments:

(1) The calculated result according to the formula (1) – (2) is as follow:

Table 2. Questionnaire response results

num	Nanan district	Yuzhong district	Jiangbei district	Shapinba district	Jiulongpo district	standard deviation	coefficient of variation	Weight
1	123	120	130	145	135	8.913	0.068	0.033
2	71	106	109	127	147	25.203	0.225	0.111
3	139	154	165	140	140	10.327	0.070	0.035
4	128	111	138	110	147	14.607	0.115	0.057
5	133	145	150	134	130	7.710	0.056	0.028
6	125	91	110	107	111	10.852	0.100	0.049
7	100	88	99	104	112	7.788	0.077	0.038
8	148	120	117	155	133	14.975	0.111	0.055
9	170	134	145	142	159	12.853	0.086	0.042
10	168	106	159	106	112	27.426	0.211	0.104
11	172	136	160	64	137	37.504	0.280	0.139
12	170	154	166	94	117	29.721	0.212	0.105
13	156	121	149	132	136	12.416	0.089	0.044
14	170	131	143	164	154	14.094	0.092	0.046
15	159	111	118	117	138	17.716	0.138	0.068
16	154	118	151	137	146	12.952	0.092	0.045

(2) Based on LIU and ZHEN (2011, 2008), via e-mail and interviews, the technical characteristics come to shown in the table 3 by consulting product development engineer.

Table3. Technical characteristics

Number	Technical characteristics $R_i$	Detail
1	R1	appearance
2	R2	functions
3	R3	reliability
4	R4	package
5	R5	environmental protection
6	R6	machinable
7	R7	maintenance

(3) Through Likert five-level rating scale, obtain scores of technical characteristics, and the results are normalized as follows:

$$\omega = [R1, R2, R3, R4, R5, R6, R7] = [5, 2, 4, 2, 1, 5, 2]$$

After normalized

$$\omega = [0.238, 0.095, 0.190, 0.095, 0.048, 0.238, 0.095]$$

Matrix  $Q$  and  $S$  :

$$Q^T = \begin{bmatrix} 5 & 2 & 2 & 3 & 1 & 4 & 0 \\ 2 & 5 & 4 & 1 & 1 & 1 & 4 \\ 2 & 4 & 5 & 0 & 0 & 1 & 4 \\ 3 & 1 & 0 & 5 & 2 & 0 & 0 \\ 1 & 1 & 0 & 2 & 5 & 0 & 1 \\ 4 & 1 & 1 & 0 & 0 & 5 & 0 \\ 0 & 4 & 4 & 0 & 1 & 0 & 5 \end{bmatrix} \quad S^T = \begin{bmatrix} 5 & 4 & 1 & 2 & 2 & 4 & 1 & 2 & 2 & 0 & 0 & 2 & 0 & 5 & 1 & 5 \\ 1 & 2 & 3 & 0 & 4 & 0 & 4 & 4 & 4 & 3 & 5 & 5 & 3 & 2 & 0 & 3 \\ 2 & 3 & 2 & 3 & 3 & 1 & 5 & 3 & 2 & 3 & 5 & 4 & 4 & 0 & 2 & 3 \\ 2 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 2 & 1 & 2 \\ 1 & 2 & 0 & 3 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 2 \\ 5 & 4 & 1 & 3 & 0 & 3 & 4 & 3 & 3 & 3 & 4 & 4 & 0 & 2 & 3 & 4 \\ 1 & 1 & 0 & 1 & 2 & 0 & 5 & 3 & 4 & 3 & 4 & 4 & 4 & 0 & 3 & 2 \end{bmatrix}$$

(4) Set the population size  $N = 100$ , most evolution generation  $T = 200$ , the objective function is customer demand saturation, crossover rate  $p_c = 0.80$  and mutation rates  $p_m = 0.01$ . Then have a simulation on customer demand saturation, development time and cost in MATLAB R2012a. Results were as follows:

Figure 5. Parameter simulation results

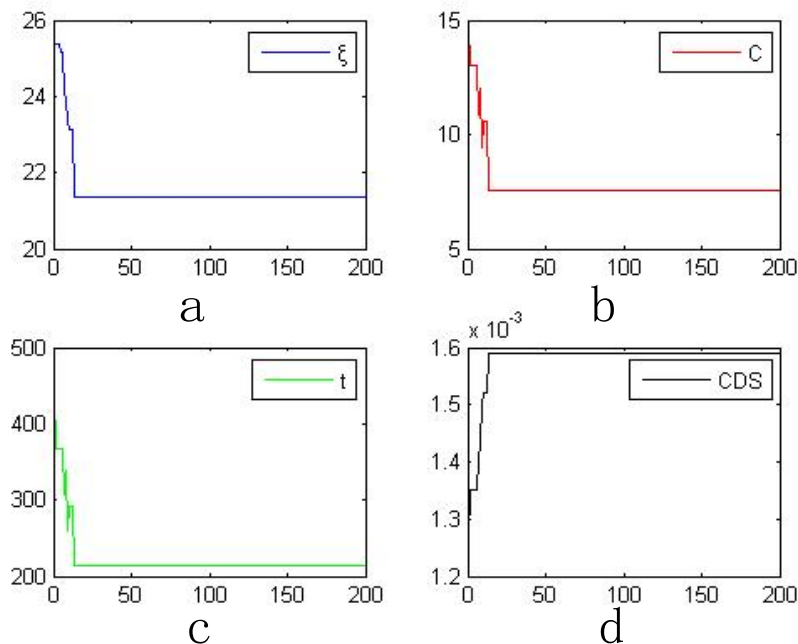
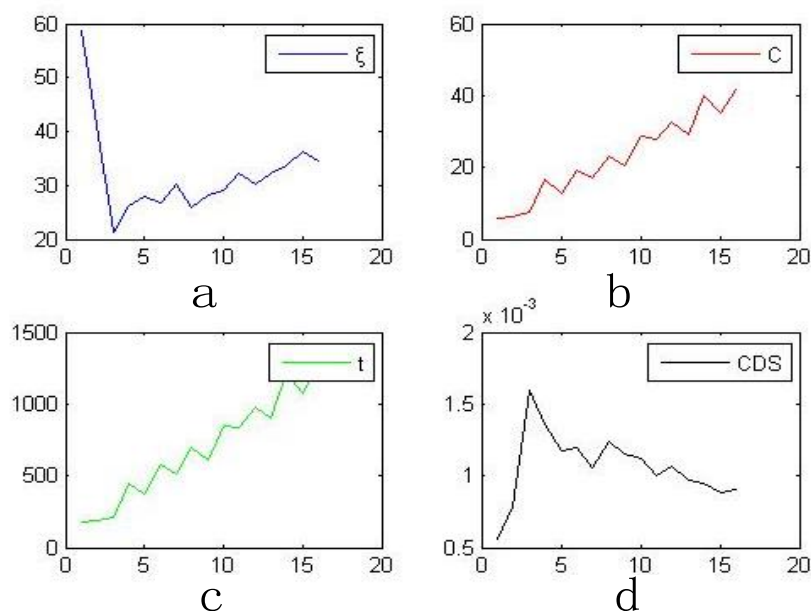


Figure 6. Relationship between quantity and parameters



The analyses Figure 5 and Figure 6 show that:

- (1) As shown in figure 5 (a, b, c & d) , before saturated, the value ( $\xi$ 、 $CDS$ 、 $t_s$  &  $C_s$ ) is undulation. With the numerical saturated, curve converged.
- (2) As shown in figure 6 (a, b, c & d), the lowest  $CDS$  appeared while the demand number is 3. When the quantity is less than 3, development cost and time is huge; when the quantity is more than 3, as before. Therefore, it can be concluded that best meeting customer demand number is 3.

Increase or decrease the meeting demands, according to the obtained relevant formulas, parameters changing as follows.

Table 4. Variable changing according to demand meeting number

Demand number	$C$	$t$	$\xi$	$CDS$
1	5.898	173	59.780	0.0006
2	6.423	194	41.012	0.0008
3	7.561	215	21.360	0.0016
4	16.549	447	26.221	0.0014
5	12.602	370	28.042	0.0012
6	19.119	576	26.812	0.0012
...	...	...	...	...

Based the figure 6 and table 4, when the quantity is less than 3, the demand meeting program cannot be reasonably catered for customers. And when the quantity is more than 3, the increased customer satisfaction cannot offset the product development cost and time increasing. After decoding the meeting program when curve converged, the result is as follow:

$$\sigma = [0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0]$$

The three customer demands are Metal materials, Advanced Audio decoder and Retina screen.

In order to validate the robustness of the model, we change the parameter values of  $N$ 、 $P_c$  and  $P_m$ . After the simulation, decoding the obtained chromosome and the results are as follows.

Table 5. Simulation results of change the parameter values

number	Invariant parameter	Changing parameter	Program $\sigma$
1	$N$ , $P_c$	$p_m = 0.02$	$\sigma = [0000000001110000]$
	$N$ , $P_c$	$p_m = 0.15$	$\sigma = [0100000001100000]$
2	$N$ , $P_m$	$p_c = 0.70$	$\sigma = [0100000000100010]$
	$N$ , $P_m$	$p_c = 0.85$	$\sigma = [0100000001000010]$
3	$P_c$ , $P_m$	$N = 150$	$\sigma = [0100000001100000]$
	$P_c$ , $P_m$	$N = 300$	$\sigma = [0100000001100000]$

As shown above, the demands meeting program is Advanced microphone, Advanced Audio decoder and Retina screen or Metal materials, Advanced microphone and Advanced Audio decoder, while  $p_m = 0.02$  or  $p_m = 0.15$ , parameter  $N$  and  $P_c$  are invariant. The demands meeting program is Metal materials, Advanced Audio decoder and high performance portable or Metal materials, Advanced microphone and high performance portable, while  $p_c = 0.70$  or  $p_c = 0.85$ , parameter  $N$  and  $P_m$  are invariant. And the demands meeting program is Metal materials, Advanced microphone and Advanced Audio decoder, while  $N = 150$  or  $N = 300$ , parameter  $P_c$  and  $P_m$  are invariant.

On the analysis above, the top 3 ranked demands are Metal materials, Advanced Audio decoder and Retina screen. But the results of simulation are not fully consistent with that, this may be caused by the defects of genetic algorithms and the methods of weighting, and in the subsequent study, we will optimize the stability of the algorithm.

## CONCLUSIONS

In order to obtain the best demand meeting program with maximize customer satisfaction and considering product development cost and time, based on quality function deployment and genetic annealing algorithm, we get the preferable result. The main contributions are as follows.

- (1) Put a customer demand weight calculation method based on variation coefficient, so that enterprises can draw attention to the high degree customer demands.
- (2) With using quality function deployment model, customer demand saturation is constructed. Quantify development costs, development time and the degree of satisfaction of customer requirements and make the calculation of the balance of the three possible.
- (3) Use genetic algorithm to simulate the model, and also discussed the robustness of the model.

The established model can guide the enterprises to fully meet customer demands with concerning about development costs and time rising, it also can assist corporate production decisions. In the simulation process, there are some sequence deviations of demands ranking, but the model still has some constructive significance.

In addition, according to the unsatisfactory simulation results above, we will modified algorithm and make research on customer demands again in the next work, aim to ensure that the simulation data model can be robustness and accuracy.

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