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Research Article

Research on a General Model for Spare Products Food Consumption Forecasting

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Abstract: This study establishes a general model of spares products food consumption forecasting based on various marketing strategies. Considering two marketing strategies of components called "non-replacement" and "condition based replacement" applied to inspection and three marketing strategies of components called "non-replacement", "certain replacement" and "condition based replacement" applied to regular marketing, on the basis of analyzing four factors which include components lives, remaining lives of components, the age of the product and next year's operation time, At last, an example is taken to illustrate the applicability of the general model. The general model provides a scientific basis for choosing spares storage amount reasonably.

Keywords: Food consumption, general model, marketing strategies

INTRODUCTION

With the application of high-tech and information technology, different kinds of product have become more and more complex in recent years. At the same time, different marketing strategies also tend to be applied for different components of product, making it difficult to grasp the law of product spare products food consumption and leading to heavier workload of spare products food consumption forecasting. To meet the needs of product marketing, an organization need to store a certain variety and quantity of spare products in advance. To ensure that spare products stored in the organization is of reasonable quantity and good quality and can timely and reliably guarantee the product marketing needs, a scientific and valid method of spare products food consumption forecasting must be given. If the storage capacity of spare products is too small, the product's successful completion of the training mission cannot be guaranteed; if the storage capacity of spare products is too much, it will cause overstock which affects economic benefit of the components.

Many scholars have conducted in-depth studies of methods of spare products food consumption forecasting. Xu *et al*. (2012) proposes the method of the cruise missile spare products food consumption forecasting based on rough sets and BP neural network, which gives full play to the advantage of rough set in handling of redundant data and improves the speed and effectiveness of forecasting. Yang *et al*. (2012) proposes a combination forecasting method of aviation material spare products based on least squares support vector machines and information entropy in order to achieve precision support of aviation product, which solves the problems of the existing methods in difficulty in accurately predicting the aviation material spare products under conditions of small samples. Cheng and Hausman (2003) analyzes the multiple failures of components, studies the component control model based on multi-tier technology and establishes spare products food consumption forecasting models as Mod-Metric, Vari-Metric, Dyna-Metric through improvement. Ni *et al*. (2009) uses the concept of the repair degree and improves the proportional hazards model based on the general renewal process. The parameter value is estimated by analyzing failure data and then the number rotables are calculated based on Monte Carlo simulation. An example is given and the results of various marketing policies with and without considering covariates are compared and analyzed. Results show that the model has a larger practical value (Ni *et al*., 2009). Others also have done scientific researches on spare products food consumption forecasting (Li and Liu, 2003). Through the analysis of the previous literature, it can be found there are few undertaken research works of the methods of spare products forecasting based on a variety of marketing strategies.

A certain type of product is maintained with a combination of inspection and regular marketing. Within 1 year, in the normal training phase of the product, the product can be inspected and after the end of the training, regular marketing of the product can be carried out. There may exist two marketing strategies called "non-replacement" and "condition based replacement" in the inspection of the product

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component; there may exist 3 marketing strategies called “non-replacement”, “certain replacement” and “condition based replacement” at the regular marketing of product. “Non-replacement” after inspection refers to the strategy not to replace components after failure or problem is found in inspection when the replacement condition is not available; “condition based replacement” after inspection refers to the strategy to replace components after failure or problem is found in inspection when the replacement condition is available; “non-replacement” after regular marketing refers to the strategy not to replace components after failure or problem is found in regular marketing when the replacement condition is not available; “certain replacement” after regular marketing refers to the strategy to replace components no matter the component is damaged nor not during regular marketing when the replacement condition is available; “condition based replacement” after regular marketing refers to the strategy to replace components if the service time of the component exceeds a predetermined value during the regular marketing when the replacement condition is available.

The determination of the storage capacity of spare products should be based on the food consumption law of the spare products. How to scientifically predict the spare products food consumption of the product under the circumstance of various marketing is a key issue in this text.

MATERIALS AND METHODS

Influence factors of spare products food consumption: The marketing strategy of product components determines how the component will be replaced in the next year, therefore it is closely associated with the spare products food consumption generated by the product in the next year. In addition, the four main factors including components lives, remaining lives of components, the age of the product and next year’s operation time have a direct impact on the spare products food consumption generated by product in the next year.

Components lives: Components lives refer to the interval time from usage of components as new products (0 time) to occurrence of malfunction. Components lives are random variables and hence the time when the component has malfunction is uncertain. However, under normal circumstances, the longer the average components lives are, the smaller the spare products food consumption quantity and amount generated by the product in the next year is.

Remaining lives of components: Remaining lives of components refer to the interval time from the counting date after the component has been working for some time to occurrence of malfunction. Remaining lives of components are also random variables. If the component is replaced at the previous year’s regular marketing, then when the product is trained in the next year, the component can be seen as a new product whose remaining life is equal to its life; if the component is replaced at the previous year’s regular marketing, then in determination of the remaining lives of components, the period that the component has been used should be fully considered.

The age of the product: The length of the age of the product decides the product marketing level in the next year. When different levels of marketing are undertaken for the product, the marketing strategy adopted by the same component may not be the same. Therefore, determination of the component marketing strategy for next year should be based on the age of the product.

Next year’s operation time: Under the condition that the other factors that influence spare products food consumption are unchanged, the length of product operation time determines the quantity and amount of spare products food consumption. The longer the next year’s operation time is, the larger the quantity and amount of spare products food consumption is; the shorter the next year’s operation time is, the smaller the quantity and amount of spare products food consumption is.

Spare products food consumption forecasting process: Replacement of product components may occurs during inspection or regular marketing. Possibly it will be replaced at both inspection and regular marketing, or not replaced at inspection and regular marketing. Therefore, in order to forecast spare products food consumption generated by any product component in the next year, the number of components replacement at inspection and regular marketing should be calculated first.

The forecasting process of spare products food consumption based on various marketing strategies is shown in Fig. 1.

If we respectively establish a model to forecast the spare products food consumption for each product component generated in the next year, the calculation amount is too large and the calculation process is cumbersome. Therefore, it is necessary for us to establish a general model for forecasting of spare products food consumption under various marketing strategies.

Generalized model of spare products food consumption.

Description of symbols:

θ : Unit lifespan

θ_0' : Unit residual lifespan before the first replacement in the next year

T_s : Product service time

T : Product usage time in the next year

x : Level of product repair; if the level of product repair is the minor repair, $x=1$ if the level of product repair is the medium repair, $x=2$; if the level of product repair is the major repair, $x=3$

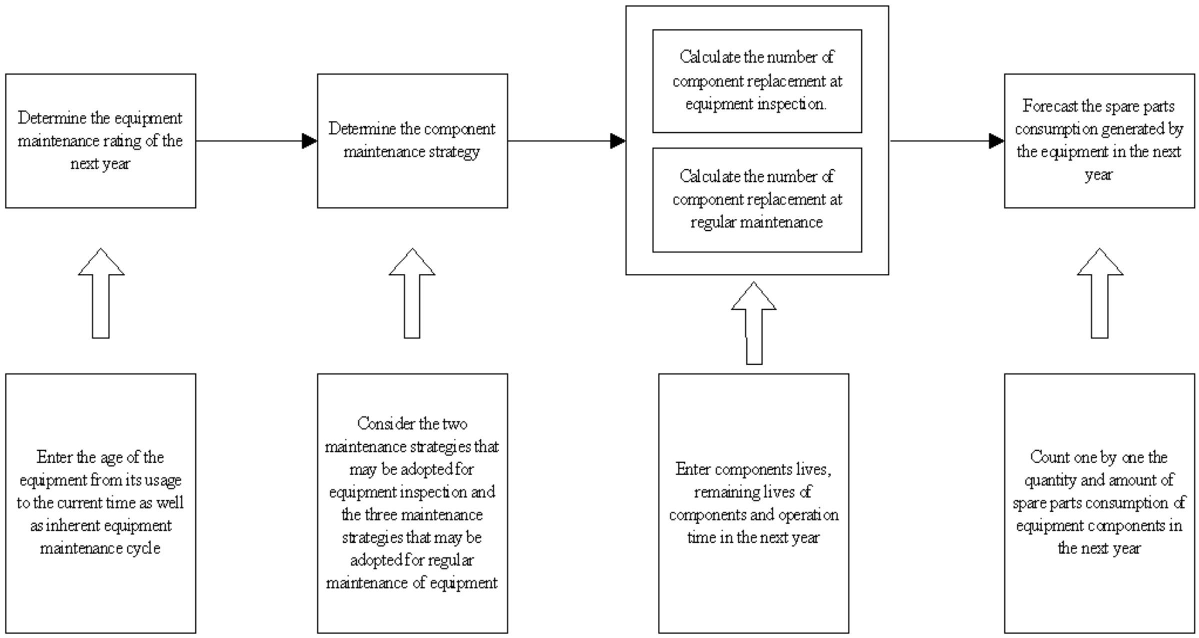

Fig. 1: The forecasting process of spare products food consumption based on various marketing strategies

L_0 : Unit marketing policy when product is under inspection; if non-replacement is upon unit marketing, $L_0 = 0$; if condition based replacement is upon unit marketing, $L_0 = 1/2$

L_x : Unit marketing policy when product is under the x level repair; if non-replacement is upon the x level product repair, $L_x = 0$; if certain replacement is upon the x level product repair, $L_x = 1$; if condition based replacement is upon the x level product repair, $L_x = 1/2$

Unit replacement number when the product is under inspection: Under inspection, the marketing strategy may be "non-replacement", or "condition based replacement". The unit replacement numbers are different when different policies are adopted.

Non-replacement: If non-replacement policy (L_0 = 0) is adopted, the unit replacement number under inspection is q_0 = 0.

Condition based replacement: If non-replacement policy L_0 = 1/2 is adopted, the unit replacement number under inspection after the first replacement is $y = \frac{T-\theta_0'}{\theta}$. The unit replacement number is an integer, so the unit replacement number under inspection is:

$$q_0 = [y] + 1 \tag{1}$$

The model of unit replacement number: We could use δ (y) to express $y = \frac{T-\theta_0'}{\theta}$ is an integer or not. When y is an integer, δ (y) = 1; when y is not an integer, δ (y) = 0:

$$\delta(y) = \begin{cases} 1 & y = \lfloor y \rfloor \\ 0 & y \neq \lfloor y \rfloor \end{cases} \tag{2}$$

The unit replacement number under inspection is:

$$q_0 = 2L_0\left[\lfloor y \rfloor + 1 - \delta(y)\right] \tag{3}$$

The unit residual lifespan is:

$$\theta' = (1-2L_0)\max\{\theta_0' - T, 0\} + 2L_0(\theta_0' + q_0\theta - T) \tag{4}$$

In Eq. (3) and (4), when $L_0 = 0$, the unit replacement number $q_0 = 0$, which implies non-replacement under inspection, so the unit replacement number is 0 and the unit residual lifespan θ' = max $\{\theta_0' - T, 0\}$; when $L_0 = 1/2$, the unit replacement number $q_0 = \lfloor y \rfloor + 1 - \delta(y)$, which implies condition based replacement under inspection, so the unit replacement number is $\lfloor y \rfloor + 1 - \delta(y)$ and the unit residual lifespan is $\theta' = \theta_0' + q_0\theta - T$.

Unit replacement number when the product is under various levels of repair: Various levels of repair are given to the product at T moment. The marketing strategy may be "non-replacement", "certain replacement" or "condition based replacement" under various levels of repair. The unit replacement numbers are different when different policies are adopted.

Non-replacement: If non-replacement policy ($L_x = 0$) is adopted, the unit replacement number upon various levels of product repair is $q_x = 0$.

Certain replacement: If the policy of certain replacement $(L_x = 1)$ is adopt, the unit replacement number upon various levels of product repair is $q_x = 1$.

Condition based replacement: If the policy of condition based replacement $(L_x = 1/2)$ is adopt and δ $(y) = 0$, the unit replacement number $q_x = 0$ if the policy of condition based replacement $(L_x = 1/2)$ is adopt and δ $(y) = 0$, the unit replacement number $q_x = 0$.

The model of unit replacement number: Therefore, the generalized formula of unit replacement number upon various levels of product repair can be expressed as:

$$q_x = 2L_x(2-2L_x)\delta(y) + L_x(2L_x - 1) \quad (5)$$

In Eq. (5), when $L_x = 0$, the unit replacement number $q_x = 0$, which implies non-replacement upon various levels of product repair, so the unit replacement number is 0; when $L_x = 1/2$, the unit replacement number q_x = δ (y), which implies condition based replacement upon various levels of product repair, so the unit replacement number is δ (y); when L_x = 1, the unit replacement number $q_x = 1$, which implies certain replacement upon various levels of product repair, so the unit replacement number is 1.

General model for spare products food consumption forecasting: The level of product repair in the next year is:

$$x = f(T) \quad (6)$$

By adding the generalized formula for unit replacement number q_0 upon product inspection and the generalized formula of unit replacement number q_x upon various levels of product repair in the next year, the predicted value of product spare products food consumption next year can be obtained as follow:

$$\begin{aligned} q &= q_0 + q_x \\ &= 2L_0[\lfloor y \rfloor + 1 - \delta(y)] + 2L_x(2-2L_x)\delta(y) + L_x(2L_x - 1) \end{aligned} \quad (7)$$

wherein: x = 1,2,3, the specific value of x is determined according to the product service time T_s.

Suppose the unit purchasing price is p, the cost of spare products in the next year is:

$$J = pq \quad (8)$$

The computer programming is conducted to the Eq. (7) and (8) and it is only needed to input the parameters of random unit, which will lead to an effective forecast for spare products food consumption of the unit in the year. Beside the easy operation and simple computing process, this method also greatly shortens the time cost in predicting the spare products food consumption by organizations.

RESULTS AND DISCUSSION

Example of spare products food consumption forecastıng: There is a certain type of product in a certain organization with the marketing cycle of 1-3-6, which has been in service for 2 years. The number of each type of unit in this product is 1 and the basic information including unit price, lifespan, service time already spent and marketing policy are shown in Table 1. Under inspection, the marketing strategy may be “non-replacement”, or “condition based replacement”. Under various levels of repair, the marketing strategy may be “non-replacement”, “certain replacement” or “condition based replacement”. In the next year the planned training time for this product is 0.6 year. After training, the product will be under various levels of repair, now a trial of forecasting spare products food consumption and relevant cost of 5 types of units is conducted.

Forecast the spare products food consumption of 5 types of units.

According to the marketing cycle of 1-3-6, it can be known that the level distribution for product repair is minor repair, minor repair, medium repair, minor repair, minor repair, major repair. Since the already spent service time $T_s = 2$ years, in the next the product should receive medium repair after finishing training task. The planned training time for the next year is $T = 0.6$ year. Hereby we firstly forecast spare products food consumption of the first unit.

According to the known conditions in Table 1 and relevant statistical theorems (Xu, 2013), it can be seen that the already spent time for the first unit is 0, in this case, the remaining service time of the first unit equals its entire service time. The marketing polices for the first unit when the product is under inspection or under medium repair are both condition based replacement, so $L_0 = 1/2$, $L_2 = 1/2$. In the case of medium repair and condition based replacement, we can compute the predicted value of spare products food consumption of the first unit in the next year. The predicted value is q = 2 with MATLAB program software. In addition, according to the price of the first unit, we can obtain the predicted value of spare part cost of the first unit in the next year. The predicted value is J = 4000.

Based on the prediction method of spare products food consumption of the first unit, we can calculate the predicted values of spare products food consumption amount next year for the second unit, the third unit, the fourth unit and the fifth unit respectively. The predicted values of spare products food consumption amount next year are shown in Fig. 2.

Meanwhile, the predicted values of spare products food consumption cost next year for the 4 units can also be computed respectively. The predicted values of spare products food consumption cost next year are shown in Fig. 3.

Table 1: Basic information of five kinds of components

				Marketing policy			
Unit	Unit price (Yuan)	Life span (year)	Service time (year)	Inspection	Minor repair	Medium repair	Major repair
1	2000	0.3	0.0	Condition based replacement	Condition based replacement	Condition based replacement	Certain replacement
2	2000	0.8	0.7	Non-replacement	Non-replacement	Certain replacement	Certain replacement
3	2500	1.2	0.7	Non-replacement	Non-replacement	Non-replacement	Certain replacement
4	3000	1.5	1.2	Condition based replacement	Non-replacement	Non-replacement	Certain replacement
5	4000	2.0	0.1	Non-replacement	Condition based replacement	Certain replacement	Certain replacement

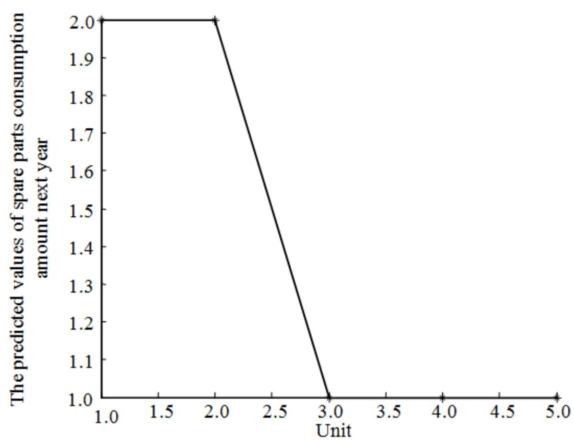

Fig. 2: The predicted values of spare products food consumption amount next year

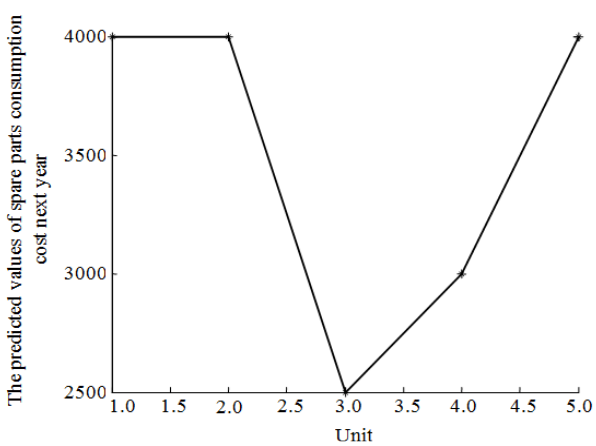

Fig. 3: The predicted values of spare products food consumption cost next year

Therefore, the predicted total cost of spare products food consumption for all types of units is 17500.

Based on the spare products food consumption amount and cost of the 5 types of units and with comprehensive consideration of product marketing levels and marketing cost, the marketing personnel can formulate a further plan to store the spare products for the 5 types of units.

CONCLUSION

Through analysis on various unit marketing polices when the product is under inspection or under different levels of repair, the multi-marketing policies based food consumption rule of spare products is studied. In addition, the spare products food consumption for the next year is predicted, which solves practical problems. Through improving the generalized model established in this study, spare products food consumption of products group can be further analyzed based on the multi-marketing policies, resulting in solution to problems including prediction of spare products food consumption of products group and the strategy optimization of spare products stock amount. On this basis, the military efficiency and economic efficiency of spare products support of product group can be enhanced.

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REFERENCES

Cheng, K.L. and W.H. Hausman, 2003. Multiple failure in a multi-item spares inventory model. Nav. Res. Log., 4: 13-14.

Li, S. and K. Liu, 2003. Optimized dynamic exponential smoothing model and its applications. J. Syst. Eng., 18: 163-167.

Ni, X., H. Zuo, F.T. Chen and X. Rong, 2009. Civil aircraft rotable spare products forecasting. J. Nanjing Univ., Aeronaut. Astronaut., 41: 253-256.

Xu, D., 2013. A further study on the exponential smoothing estimation method for parameters of forecasting model and its application. Syst. Eng. Theor. Pract., 2: 25-30.

Xu, T., A. Du and H. Cheng, 2012. Food consumption law forecast of missile spare products based on rough set theory and BPNN. J. Naval Aeronaut. Astronaut. Univ., 27: 570-574.

Yang, S., J. Guo, X. Dong and Z. Li, 2012. Combination prediction method for aerial spare parts based on LSSVM and entropy. Fire Control Command Control, 37: 154-157.