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Modified grey demand forecasting model based on marketing efforts

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ABSTRACT

Based on the adaptation of grey forecast models on the new product, this paper considers the influence of marketing on the demand, and establishes an improved grey model GMM(1,1) based on the definition of marketing efforts flexible of new product, which is compared with GM(1,1),GM(1,2), GM(0,2) and regression modelby theoretical analysis and calculation to verify its feasibility and superiority. It is improved that GMM(1,1)can be effectively applied in new productsdemand forecast when it is relative lack ofdata.

KEYWORDS

New product demand; Greyforecastmodels; Marketing efforts flexible; Modified grey demand forecasting model.

INTRODUCTION

Market share of new products always has a great growth potential, however it isinfluenced significantly by marketing in turn.In order to reduce risk, enterprises need to forecast new product demand before making production or ordering decisions, which is considered one of the challenges enterprises facing[1]. Various factors such as lack of historical sales data lead to a higher accuracy of forecasts, which further leads to inventory redundancy or out of stock. Therefore, enterprises urgently need appropriate new product demand forecasting methods. The traditional time-series methods and causal regression analysis require a large amount of historical data[2, 3], thus, these traditional forecasting methods are not suitable for new products.

Early scholars have noted the problem of data shortage in terms of new product demand forecasting and proposed appropriate solutions. Morrison proposed an expansion model for unlisted products, which uses three parameters: the long-term saturation level, turning point in the expansion curve and delay factor. As per the study, not all of the sales curves are incremented before the turning point, curve symmetrical features also needs further study[4]. Goldfisher and Chan proposed a forecasting method using sales target, however, the result is not accurate enough because of relying on only three periods'historical data[5]. Mclean and Wortham thought that prediction function could be replaced by Taylor sequence, thus prediction becomes a sum of historical data and weights multiply, and the more recent data the greater the weight, the smaller the contrary[6]. Since the new century, some scholarsuse heuristic algorithms to solve new product forecasting problem with the support of decision support systems. With the application of clustering and classification tools,Thomasseyproposeda decision support systembased on neural network to solve product sales forecasting problems with lack of historical data[7]. Chernetl proposed a sales forecasting system of new products, which includes model selection module, model solving module, prediction module, etc. The results show that the system is better than moving average method and involves in less subjective factors[8]. However, the model assumes thatproducts of same type have the same sales mode and are applicable for the same model. In practice, this assumption does not have the versatility.

Compared with other quantitative methods, grey prediction method can be effectively applied to the case of less data. Chu and Liu applied Grey Model GM (1,1) to predict transport volume in China[9]. Li etl used trends and tracking technology to analyze sample behavior and extract potential information, then applied the gray model to predict[10]. These methods are only suitable for monotonically increasing or decreasing data, data fluctuationsandother influence factors are rarely considered.

This paper first summarizes the characteristics of new product demand, and then analyzes the adaptability of grey prediction modelfor new product demand forecast. By defining marketing efforts flexibility, this paper establishes a modified grey prediction modelGMM(1,1)based on marketing efforts (GM based on Marketing Efforts, GMM), and compares the prediction results with regression prediction model (Regression based on the Marketing Efforts, RM), GM(1,1), GM(1,2) and GM(0,2). The results show that the proposed GMM(1,1) has a higher accuracy over other models and can effectively solvenew product forecasting problems in terms of marketing efforts.

MODIFIED GREY DEMAND FORECASTING MODEL BASED ON MARKETING EFFORTS

Seeking law trough processing and sorting out raw data, grey model is suitable for the analysis and prediction of scarce information. In addition,in the stage of introducing new products, demand generally appears trend of monotonically increasing, while grey model performances well for predicting monotonous sequence. Therefore, grey model is a feasible and effective methodto forecast demand of new products.

There are several grey prediction models based on difference of forecast mechanisms. GM (1,1) model is a widely used grey forecasting model, in which the two "1" respectively denotes a first-order equationand a variable (i.e., no independent variables); GM(1,N) model is also called analysis model or factor model, in which “1” denotes a first-order equation and “N” denotes N variables (i.e., including N-1 independent variables and one dependent variable); GM(0, N) model is a0-order grey model with N-1 independent variables denoted by $x_i^{(1)}$, which is similar to the linear regression model, however GM(0, N) model needs accumulated generating operation(AGO) for raw data so that the raw data transfers to a more regular increments curveto model, therefore, GM (0, N)overcomes the deficiency of a linear regression modelto some extent[11].

First, this section introduces the GM (1,1) modelbriefly, and then analyzes the limitations of GM (1,1) model for new product forecast. Next then, by defining marketing efforts factor, a modified GM (1,1) model considering marketing efforts-- GMM (1.1) model is proposed.

Applicability test of GM (1,1) for new product demand forecasting

Let's assume that sequence *y*is affected by factor *b*, and it conforms to $y = a + bx + \varepsilon$, in which ε is a randomfactorsubjecting to a(-0.5, 0.5)uniform distribution. And the value of x is generated according a TABLE of random numbers. Let a =8, b =3+μ , in which μ subjects to a(-0.5, 0.5)uniform distribution. Accordingly, we can generate values of y randomly and make the following analysis. Let the number of samples be 10, we can generate values of x and y as shown in TABLE 1.

TABLE 1 : Sample list

variables	1	2	3	4	5	6	7	8	9	10
x	3.9	6.5	7.5	4.5	4.5	1.9	9	6.4	6.1	2
y	21.1	28.3	31.8	22.8	20.1	13.7	35.9	26.8	27.6	13.8

If we apply GM(1,1) model to the original sequence, the predicted value and the original sequence curve can be obtained as shown in Figure 1.

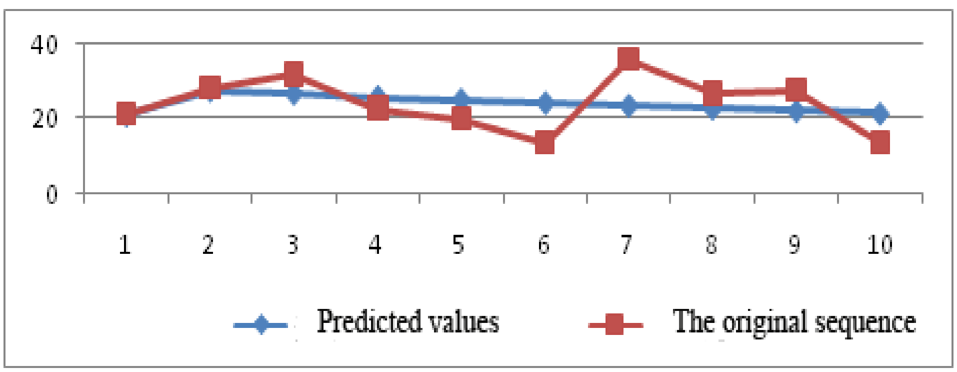

Figure 1 : Predicted value and the original sequence curve

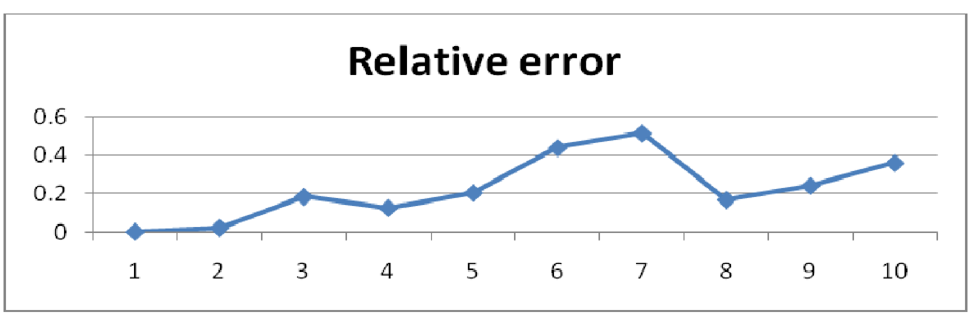

Figure 2 : Percentage of absolute error

The percentage value of absolute error can be shown in Figure 2, it can be seen that some errors are as high as 52%, thereforeGM (1,1) grey prediction model does not performance well here. It can be explained by two reasons: First, sequence*y* is a non-random sequence, and it can be known by the generation process that the sequence is affected by factor *x*;Second,GM (1,1) is only based on accumulated generating operation,and does not consider the impact of factors of sequence itself, and in this case, the information extraction of influence factors is not enough.

During the stage of putting on new products, typically companies pay great efforts on marketing to open the market,which has significant impact on sales of products. Thus, the error will be big if GM is applied directly to forecast the demand of new products. If the factor of promotion is removed effectively to get sequence of actual demand, the forecast results may be better. Consequently, this paper proposes a GMM model based on marketing efforts (namely, a GM model after removing promotion factor).

GMM (1,1) model

Marketing efforts areefforts made by companies with the support of marketing mix for the purpose of reaching sales goals, including advertising strategies, promotion strategies, pricing strategies and so on.Fast moving consumer goods (FMCG) is sensitive to promotion and competition, which is an important factor that cannot be ignored when predicting. Different promotional resources lead to ranging sales, while promotional resources plan is not a random variable and has no specific laws of time, but in the forecasting process it has a character of data available. In addition,seasonal features and holidayscan also cause ranges in sales, so it is important to remove sales caused by difference of promotion degree before the grey forecast of FMCG sales.

Marketing effortselasticityput forward in this paper refers to impact change magnitude of marketing costs on sales changes, which is denoted by E_t ,

$$E_t = \frac{(Q_t - Q_{t-1})/Q_{t-1}}{(A_t - A_{t-1})/A_{t-1}}$$

In the equation, A_t denotes marketing costs of the ith period and Q_t denotes sales of the ith period.

Under normal circumstances, changes in marketing costs are non-random, which are dominated by corporate marketing plan. Sowe propose a new GMM (1,1) methodbefore the grey predictionin order to get better prediction results, namely removing marketing efforts factor before the grey forecast. The basic steps are:

(1) Calculate the gray correlation between sales sequence and marketing efforts, then proceed to step 2if the correlation is high, otherwise apply GM (1,1) model directly.

(2) Calculate the marketing efforts elasticity E_t .

(3) Remove the marketing efforts impacts of each period’s sales and generate correction sales of each period.

(4) Take the correction sales sequence as original data and then execute the GM model.

(5) Execute the grey forecast results a reverse process of step (3) to obtain the final predictive value.

When new demand data is generated, execute the forecast process after parameters correction.

CASE ANALYSIS

In order to validate GMM model, this section takes actual sales data (without loss of generality, the sales data are approximated as demand) of a new beverage productto do a case study, and makes a comparison between prediction results of GMM model and other models, including RM, GM(1,1),GM(1,2) and GM(0,2).

Prediction results of GMM (1,1)

Analyzing the sales data of the beverage product, we find that fluctuations in sales are caused mainly by different marketing efforts during holidays. Salespeak appears in the holiday period, while sales through appears in the following period. One of the reasons is that the presence of advance purchase during holidays and delayphenomenon of consumption. Holidays can be judged according to sales experience, historical statistics, folklore etc. of similar products. Through interviews with the company, the ability to promote salesfrom low to high can be divided into1,2,3 three categories,where 1 represents no sales activities. To describe the sales slump phenomenon in the next period of the post-holiday, the index 0.8 is introduced.

The processing steps of GMM are as follows:

Calculate the averagesales when the index equals 3, 2, 1, 0.8. Calculate the grey correlation between average sales and marketing capabilities, and the result is 0.7, proceed to step 2 for the grey correlation is high.

Calculate the rate of change in salesbetween adjacent indexes, assume a_1, a_2 is average sales of index 1,2 respectively, then the marketing efforts indictor when taking index 2 might as well denoted as follows,

$$E_2 = \frac{(a_2 - a_1)/a_1}{(2-1)/1}$$

Namely,

$$\frac{(8990.50 - 6954.41)/6954.41}{(2-1)/1} = 0.292777$$

Similarly, calculate the marketing efforts indictor when taking index 0.8 and 3, as shown in TABLE 2.

Remove the impact of marketing efforts from each period's sales and generate correction sales of each period. For instance, the forth period's sales are 6091 boxes, and the promotion ability is level 2, then the correction sales is

$$x = \frac{6091}{1 + (2-1) * 0.29} = 4711.53$$

The modified sequence is slower than the original sequence, as shown in Figure 2.

Taking correction sales of each period as the original sequence, execute GM parameter estimate and forecast with the support of Matlab. Then execute the forecast results a reverse process of step (3).

TABLE 2 : Average production and marketing efforts indictor of each promotion ability level

promotion ability level	0.8	1	2	3
Average production	3217.50	6954.41	8990.50	12552.33
marketing efforts indictor	-0.54		0.29	0.40

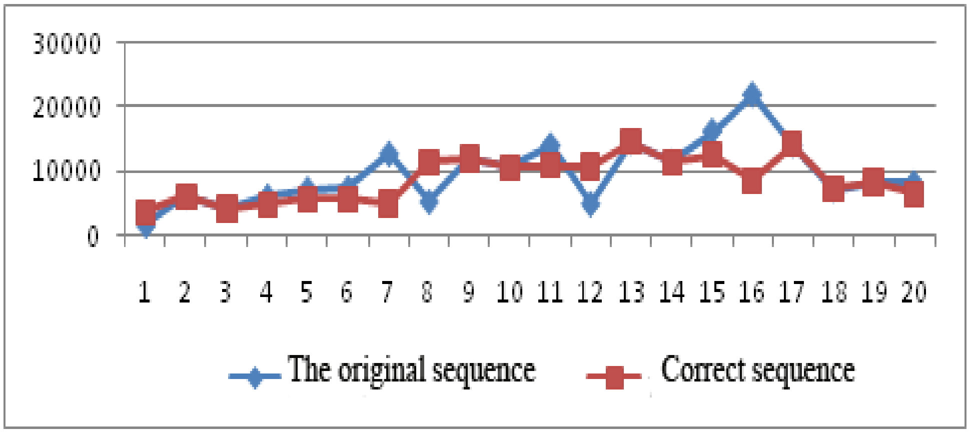

Figure 2 : Curves of the original sequence and the modified sequence

In the RM model, take marketing capability*x*as independent variables and demand*y* as dependent variables. Then the model can be expressed as follows,

$$y = \alpha_0 + \alpha_1 x + \varepsilon$$

In the equation, x denotes sales capacity, α_0, α_1 are parameters to be estimated and ε denote error.

Comparative analysis of different prediction models

Calculate the analog value of GMM, RM, GM(1,1), GM(1,2) and GM(0,2) respectively when the data scale ranges from 4-20, then calculate the mean absolute percentage error(MAPE) of each model, as shown in Figure 3.

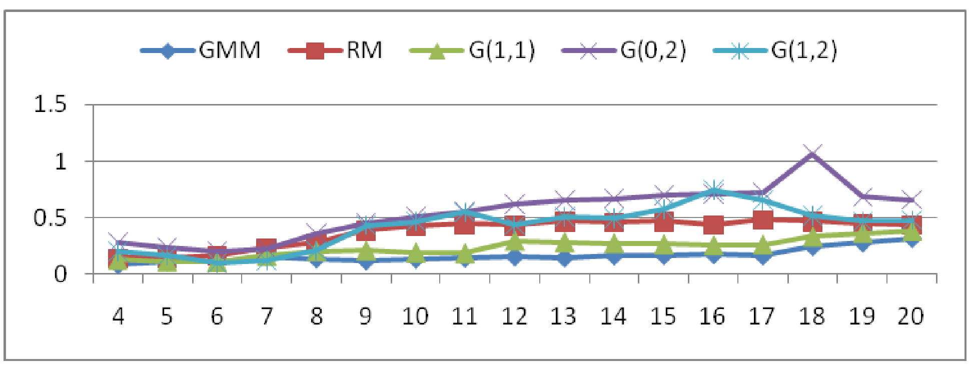

Figure 3 : The MAPE curves of GMM, RM and GM

The relative errors of GM (1,2) are almost all higher than that of GMM. And relative errors of GM (0,2) are almost always the biggest. Under circumstance of less data, although the relative error of RM is also small, it is still larger than that of the GMM and GM. And the gap increases along with the increasing of sample numbers. The relative error of GM has high fluctuations, which is higher than that of GMM. Especially under circumstance of data scale exceeds 7 periods, the relative errorincreases constantly while fluctuates. The relative error of GMM is almost the smallest of the five models except when the data scale equals 6. And it has smaller fluctuations, which ranges from 0.1-0.2 and begins to rise significantly after 17 periods.

It can be conclude that in the forecasting process of less data, the proposed modified grey prediction model GMM (1,1) has better accuracy over other models, and can effectively solve the new product forecasting problem considering marketing efforts. There are two reasons: first, the grey prediction method based on marketing effortsconsiders the randomness of the demand sequence, and has strong adaptability when the historical data is not enough; second, the GMM model considers the characteristics of FMCG itselfand takes fully advantage of marketing efforts and other information. Therefore, better prediction results can be obtained if the grey forecast is executed after marketing efforts factor removed.

CONCLUSIONS

Basing on analysis of demand characteristics of FMCG and review of new product forecast methods, this paper analyzes the suitability of grey prediction model; concerning FMCG new product prediction problem, this paper proposes the definition of marketing efforts and establishes a modified GMM grey forecast model based on the definition, the research makes up the shortcoming of requiring large amounts of historical data of the previous quantitative researches. And a case analysis shows that when the time-series sequence has less samples and is influenced more significantly by external factors, the forecast effect of GM is obviously not as good as RM, while the modified GMM model performances better than RM, at the same time, the modified GMM model also performances better thanGM (1,2) and GM (0,2) considering influence factors. In future studies, concerning the relationship between marketing costsand sales, the research of GMM model can be combined with corporate marketing decisionsthe perspective ofintegrated logistics management, which will improve the performance of marketing efforts in business operations.

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