

TOWARDS FORECASTING RETAIL SALES USING MATHEMATICAL MODELS

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ДО ПИТАННЯ ПРОГНОЗУВАННЯ РОЗДРІБНИХ ПРОДАЖ З ВИКОРИСТАННЯМ МАТЕМАТИЧНИХ МОДЕЛЕЙ

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This paper addresses some practical issues on implementing statistical approximation methods to forecasting of sales volumes in retail trade. The forecasting procedure used in the article provided for formulation of the problem, definition of goals and objectives, determination of the period for which the forecast is made, collection of information required for analysis, the choice of the forecasting method, application of the chosen method to the collected information, evaluation of the obtained forecast. To identify the general trend in the development of sales for a certain period and make a forecast, regression analysis as well as the moving average method and the analytical alignment method were applied.

Key words: forecast, planning, management, sales volume, financial resources, regression analysis

У статті розглядаються деякі практичні аспекти застосування методів апроксимації для прогнозування обсягів продажів в роздрібній торгівлі. Методика прогнозування, використана в статті, передбачала постановку задачі, визначення цілей і завдань, визначення періоду, на який робиться прогноз, збір інформації, необхідної для аналізу, вибір методу прогнозування, застосування обраного методу збору інформації, оцінку отриманого прогнозу. Для виявлення загальної тенденції розвитку продажів за певний період і складання прогнозу застосовувалися регресійний аналіз, а також метод рухомого середнього і метод вирівнювання.

Ключові слова: прогноз, планування, управління, обсяг продажів, фінансові ресурси, регресійний аналіз

В статье рассматриваются некоторые практические аспекты применения методов аппроксимации для прогнозирования объемов продаж в розничной торговле. Методика прогнозирования, использованная в статье, предусматривала постановку задачи, определение целей и задач, определение периода, на который делается прогноз, сбор информации, необходимой для анализа, выбор метода прогнозирования, применения выбранного метода сбора информации, оценку полученного прогноза. Для выявления общей тенденции развития продаж за определенный период и составления прогноза применялись регрессионный анализ, а также метод подвижного среднего и метод выравнивания.

Ключевые слова: прогноз, планирование, управление, объем продаж, финансовые ресурсы, регрессионный анализ

INTRODUCTION

For the modern economy, the problem of improving the quality of financial resource management is especially relevant. The solution of the goals set by the company's management and aimed at increasing profits and rational use of financial resources presupposes the maintenance of stable growth in the economic activity of the organization, for which it is necessary to ensure a sustainable increase in the efficiency of financial resource management.

Financial forecasting is the foundation for financial planning and budgeting in a company. The starting point of financial forecasting is the forecast of sales and the corresponding costs. The goal (i.e., the end point) is to calculate external financing needs.

Compared to the improvements in the efficiency of industrial production modeling methods in these decades, the accuracy of systematic forecasting of sales volumes as well as demand is still quite low. At the same time, accurate forecasting of sales significantly determines organizational decisions, and plays an important role in profitable retail operations. In other words, an inaccurate forecast often leads to serious losses for the business, manifested both in the cost of returning goods and in lost opportunities (especially in industries related to the production of non-standard products).

Currently existing quantitative approaches to forecasting sales include mainly heuristic methods: time series decomposition and exponential smoothing, the use of regression models, autoregressive and integrated moving average. At the same time, approximation methods are widely used [1]. Since in the case of using traditional models, it is often impossible to take into account complex data interconnections in the forecast, modeling studies using neural networks are being conducted. For example, the predictive model based on the neural network [2] in predicting the electrical load, showed better performance than the regression model approach. However, there are also information on the weaknesses of the neural network approach in the context of the described problem. In particular, the authors of [3–5] report that the neural network does not outperform the regression model, even if the data is presented in dynamics. One of the reasons for this is that without a "training set" of sales data for a certain period (that is, in the "unsupervised" mode), the effectiveness of training the network is low. Thus, it can be argued that the predictive approach based on neural networks is far from always effective (especially for industries with a short life cycle or a wide variety of products). Under these conditions, despite the further development of forecasting methods based on "machine learning" and other "intelligent approaches" (see, for example, the use of clustering, fuzzy logic [6–7]), the regression approach to forecasting should be recognized as quite competitive.

This paper addresses some practical issues on implementing statistical approximation methods to forecasting of sales volumes in retail trade.

RESEARCH METHODS

The system approach to forecasting and planning is a logical way of thinking, according to which the process of developing and justifying any decision is based on the determination of the overall goal of the system and subordination to the achievement of this goal of the activities of all subsystems, including development plans and all other parameters of this activity.

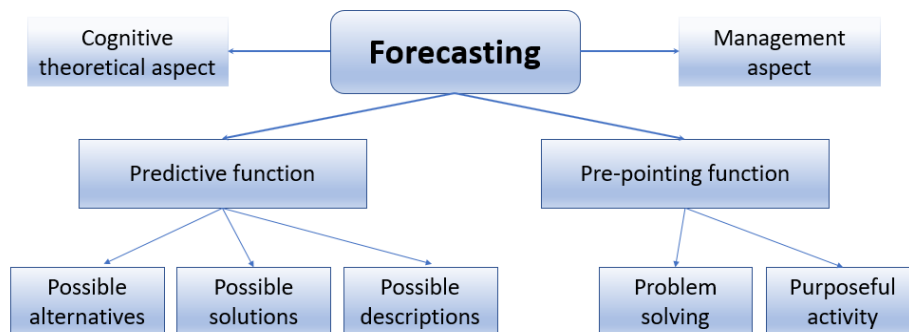


Figure 1. The structure and functions of the forecasting process

At the same time, the system is considered as part of a larger (global) system, and the general goal of its development is consistent with the development goals of the global system. An important element of the systematic approach is the use of mathematical apparatus and computers to define, develop, verify and implement the goals and decisions. We define forecasting and planning as prediction and pre-indication system (fig. 1).

The sales forecasting procedure used here included the following steps:

- 1) formulation of the problem, definition of goals and objectives;
- 2) determination of the period for which the forecast is made;
- 3) collection of information required for analysis;
- 4) the choice of the forecasting method;
- 5) application of the chosen method to the collected information;
- 6) evaluation of the obtained forecast.

To identify the general trend in the development of sales for a certain period and make a forecast: 1) the moving average method was used, and then 2) the analytical alignment method was applied.

The moving average method allows one to smooth out periodic and random fluctuations and thereby identify the existing trend in development. This effect is achieved by averaging empirical (initial) data and determining the calculated (theoretical) levels. In this case, a three-term moving average was used, i.e., the calculations take into account three levels in the series of dynamics.

The method of analytical alignment consists in replacing the actual levels of a number with theoretical ones, calculated according to a certain curve, reflecting the general trend of changes in indicators over time. Thus, the levels of the time series are considered as a function of time.

A preliminary analysis of the initial data (see the section "Results and discussion") suggested that the behavior of the sales volume in monetary and quantitative terms is described by a linear trend model, which looks like:

$$Y = a_i X_i + b, \quad i=1, \dots, n \quad (1)$$

where Y is theoretical level of the series (projected sales volume), dependent variable (function); X – advertising cost, independent variable (factor); a and b are the parameters of the model. The model (1) is used to predict sales of products based on advertising costs. Model parameters have specific values. With the help of forecasting and planning calculation models of different factor values, it is necessary to know the values of parameters in advance and determine them in advance.

RESULTS AND DISCUSSION

With the increase in sales of Shandong Buchang Pharmaceutical Co., Ltd [8], there was a need for deeper and more competent forecasting of future sales in order to determine the optimal production volume and effective placement of goods on the market.

The following (Table 1) is the data on operating income, sales expenses and R&D expenses of China Shandong Buchang Pharmaceutical Co., Ltd. from 2017 to 2020. Unit: ten thousand Renminbi (Yuan).

Table 1. Operating income, sales expenses and R&D expenses of case study

TIME	R&D expenses	Operating income	Sales expense
2017/9/30	23900	944600	556000
2017/12/31	48940	1386000	828700
2018/3/31	8942	243100	145300
2018/6/30	20430	574800	344300
2018/9/30	35020	928600	552400
2018/12/31	48020	1366000	803600
2019/3/31	5737	288300	170700
2019/6/30	11600	640500	383800
2019/9/30	18060	1024000	604900
2019/12/31	50540	1426000	808100
2020/3/31	4784	263900	139000
2020/6/30	17340	703500	368400
2020/9/30	25370	1124000	595900

As a result of calculations, the following linear trend equation was obtained (Fig. 1):

$$Y = 23,925 X + 252988 \quad (2)$$

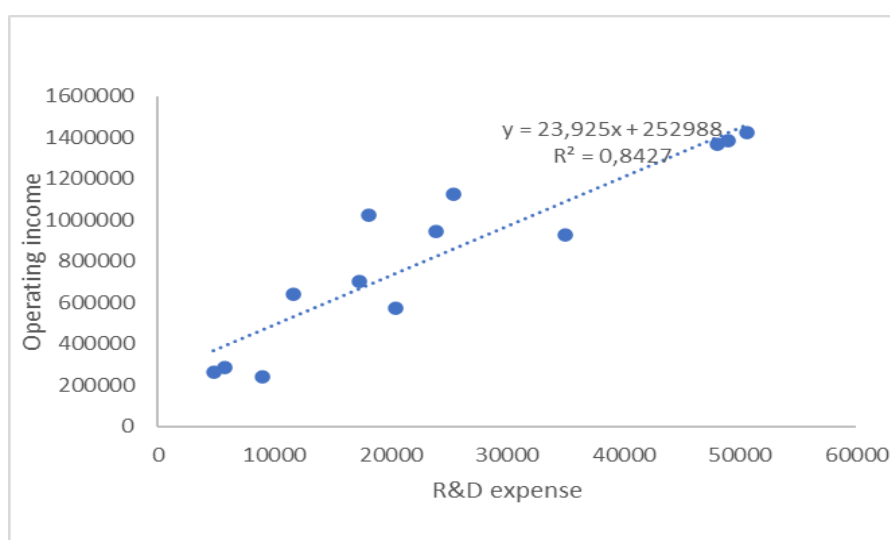


Figure 1. Scatter plot of Operating income and sales expenses

Since the obtained equation refers to regression equations, its statistical check was carried out (that is, the mean forecast error, determination coefficient, etc.) were determined.

КОМП'ЮТЕРНЕ МОДЕЛЮВАННЯ ТА ПРОГНОЗУВАННЯ РОЗВИТКУ СКЛАДНИХ СИСТЕМ РІЗНОЇ ПРИРОДИ

The calculation was performed using the Microsoft Excel analysis package. The regression analysis output is presented in Table 2, Table 3, and in Table 4.

Table 2. Operating income and R&D expenses: model summary

Regression statistics	Calculated value
Multiple R	0,917995056
R Square	0,842714923
Adjusted R Square	0,82841628
Standard error	176261,6311
Observations	13

Table 3. Analysis of Variance (ANOVA) of the model

	Number of the degrees of freedom	Sum of squares	Mean square	Fisher's statistic (calculated value)	Signif. F
Regression analysis	1	1,83E+12	1,83E+12	58,94	9,64E-06
Residual	11	3,42+11	31068162583		
Total	12	2,17E+12			

Table 4. Statistical estimating of the significance of the coefficients

Coeff.	Value	Least squares estimate of the standard error	t -statistic (calculated value)	t -statistic (tabular value)	Boundaries*	
					Lower	Upper
Intercept	252988,05	90698,73	2,789	0,0176	53361,49	452614,6
X Variable#1	23,9249	3,1164	7,677	9,62E-06	17,066	30,784

*Note: Boundaries for the confidence interval (at 95 % significance level)

In table 3 “Signif. F” is significance of F-statistic (i.e., the tabular value of Fisher’s statistic). Since the calculated value of the F-statistic is greater than the tabular value, the model is recognized as adequate. In Table 4 “t-Stat” is the t-test statistic (Students's statistic). According to the results of the calculation, the coefficients were recognized as significant.

From the equation, one can see that, on average, for each unit of ad spend, sales increase by 23,9 units. Substituting the corresponding value for advertising costs instead of x, it is possible to obtain the value of the sales volume corresponding to this value.

CONCLUSIONS

Forecasting sales and drawing up, on this basis, medium-term plans for the company's activities will help solve the problem of determining the most optimal order size for each of the types of products for the next planning periods.

Forecasting sales volumes is one of the methods to improve the efficiency of using cash, retail space, human resources, generally improving the economic efficiency of the enterprise.

The regression modeling method from dependent variable to multiple independent variables can fully reflect the integrity of the model. It can effectively solve the correlation problem between variables. When the sample size is less than the number of variables, it is suitable for regression modeling

The forecasting results can later be used for decision-making, as well as for analyzing the correspondence between the forecast and actual sales (solving the control problem).

Obviously, in conjunction with forecasting the volume of sales and drawing up purchase plans, it is also necessary to use marketing methods of sales management, such as smart pricing, advertising, merchandising, discounts, etc. This is a topic for further research.

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