CHOICE OF THE OPTIMUM FORECASTING MODEL IN DIFFERENT VALUE OF INITIAL INFORMATION

Mirsalih Marupov
Associate Professor of the Department "Transport Logistics
Tashkent State Transport University
Republic of Uzbekistan, Tashkent

Zokirkhon Yusufkhonov
Assistant of the department "Transport logistics"
Tashkent State Transport University,
Republic of Uzbekistan, Tashkent
E-mail: zybuzrukov@mail.ru

ВЫБОР ОПТИМАЛЬНОЙ МОДЕЛИ ПРОГНОЗИРОВАНИЯ ПРИ НЕРАВНОЗНАЧНОСТИ ИСХОДНОЙ ИНФОРМАЦИИ

Марупов Мирсалих Мадиевич
доц. кафедры "Транспортная логистика
Ташкентский государственный транспортный университет,
Республика Узбекистан, г. Ташкент

Юсуфхонов Зокирхон Юсуфхон угли
ассистент кафедры "Транспортная логистика"
Ташкентский государственный транспортный университет,
Республика Узбекистан, г. Ташкент

ABSTRACT

The article deals with the issues of choosing the type of the best function when predicting the main indicators of the operation of road transport in the future in conditions of unequal initial information. When forecasting, three types of functions were used, namely, linear, quadratic, and exponential. The choice of the type of trend function, the parameters of which are determined by the least squares method, is made empirically in most cases, by constructing a number of functions and comparing them with each other according to the value of the following criteria: average absolute deviation; standard deviation; the coefficient of variation; correlation index. Experimental calculations have shown that the method of least squares is acceptable for the formation of long-term enlarged plans and the determination of general trends in the development of road transport enterprises.

АННОТАЦИЯ

В статье рассматриваются вопросы выбора вида наилучшей функции при прогнозировании основных показателей работы автомобильного транспорта на перспективу в условиях неравнозначности исходной информации. При прогнозировании использованы три вида функции, а именно линейная, квадратичная, показательная. Выбор вида функции тренда, параметры которой определяются методом наименьших квадратов, производится в большинстве случаев эмперически, путем построения ряда функций и сравнения их между собой по величине следующих критериев: среднее абсолютное отклонение; среднеквадратическое отклонение; коэффициент вариации; индекс корреляции. Экспериментальные расчеты показали, что метод наименьших квадратов приемлем для формирования долгосрочных укрупненных планов и определения общих тенденций развития предприятиях автомобильного транспорта.

Keywords: Interpolation, extrapolation, least squares method, function, criterion, trend, mean absolute deviation, standard deviation, coefficient of variation, correlation index, forecasting, economic indicator, forecast error.

Ключевые слова: интерполяция, экстраполяция, метод наименьших квадратов, функция, критерия, тренд, средне абсолютное отклонение, среднеквадратическое отклонение, коэффициент вариации, индекс корреляции, прогнозирование, экономический показатель, ошибка прогноза.

The development of the use of forecasts is one of the important directions for improving planning in modern conditions, raising its scientific level. In modern conditions, only such planning can be scientific, which is based on carefully developed forecasts - technical and economic, demographic and others, covering all possible changes in the productive forces in the environment.

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The following requirements are imposed on the developed forecasts. Forecasts must be, first of all, scientifically substantiated, timely and reliable, and also contain sufficient information necessary for the development of long-term plans.

The main functions of forecasting, as the most important stage of work on the scientific substantiation of long-term plans, are: identification and analysis of the existing patterns and trends of economic development; assessing the impact of these trends in the future and taking into account their positive and negative consequences; anticipation of new economic situations, new problems requiring their solution; identification of possible development alternatives in the future; accumulation of information for a comprehensive justification of the choice of direction in the development of an optimal planned solution that provides an active impact on the development of the economy [1].

Forecasting the development of motor transport enterprises (Automobile plants, automobile transport enterprises, car repair plants, service stations, etc.) at various levels of aggregation is devoted to a number of works. Therefore, it is expedient to analyze the advantages of various forecasting methods and choose the most effective ones for use in the problems of optimizing the management of enterprise work processes. Especially, it is necessary to carefully choose methods for the implementation of long-term forecasting as the most difficult.

Forecasting methods based on the analysis of one-dimensional time series most fully meet the following requirements: realism; simplicity, etc. Indeed, the methods for analyzing one-dimensional time series, unlike many other methods (multiple regression, econometric methods, expert estimates, complex methods), do not require extensive information, since they are based on information contained in individual time series. One-dimensional time series are a selection of economic indicators (a set of random numbers) taken in the dynamics of their development. The mathematical models used in these methods, as a rule, have a very clear meaning and simple formulations. At the same time, the forecast accuracy obtained by analyzing one-dimensional time series can be quite satisfactory in most cases [2].

The choice of the shape of the curve for smoothing depends to a certain extent on the goals of smoothing: interpolation or extrapolation. In the first case, it is the achievement of the greatest proximity to the actual levels of the time series, in the second, the identification of the main pattern of the development of the phenomenon, in relation to which it is possible to put forward a hypothesis that it will continue in the future.

In the analytical expression of the trend, when smoothing time series using the least squares method, time is considered as an independent variable, and the levels of the series act as functions of this independent variable. It is clear that the development of a phenomenon depends not only on how many years have passed since the starting point. It is also determined by what factors, in what direction and with what intensity influenced it. The development of the phenomenon in time acts as a result of the action of these factors.

To identify the main trend by the analytical method means to give uniformity to the development of the processes under study during the considered period of time. Correctly establishing the type of curve, the type of analytical dependence on time, is one of the most difficult tasks. Since smoothing allows you to express the pattern of development in time, since the choice of a smoothing method and determining the type of trend function must be approached with particular care [3].

F. Mills gives some practical recommendations for choosing the type of function that describes the trend [4].

1. If the values of t form an arithmetic progression, and the corresponding values of y form a geometric progression, then the trend equation is expressed by an exponential curve:

$$y(t) = a_0 a_1^t \quad (1)$$

2. If the relationship between the logarithms y and t is linear, then it is advisable to describe the trend using a power model:

$$y(t) = a_0 t^{a_1} \quad (2)$$

3. If the values of t are arranged in an arithmetic progression, and the first differences of the corresponding values of y are constant, then the trend can be described by a straight line:

$$y(t) = a_0 + a_1 t \quad (3)$$

4. If the values of t are arranged in an arithmetic progression, and the nth difference of the corresponding values of y is constant, then a polynomial of the nth degree can be taken as a function describing the trend:

$$y(t) = a_0 + a_1 t + a_2 t^2 + \ldots + a_n \quad (4)$$

The personal experience and knowledge of an economist can be of great help in choosing the type of function f(t). In other cases, when the type of functions is determined empirically, the resulting trend estimate $f(t)$ is considered as some interpolation formula that can help an economist to analyze time series.

In practice, the selection of the type of the trend function, the parameters of which are determined by the least squares method, is carried out empirically in most cases, by constructing a number of functions and comparing them with each other according to the value of the following criteria:

- mean absolute deviation:

$$|A| = (y_t - \hat{y}_t) \quad (5)$$

- standard deviation:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(y_t - \hat{y}_t)^2}{N-P-1}} \quad (6)$$

- the coefficient of variation:

$$v = \frac{\sigma}{\bar{y}} \cdot 100\% \quad (7)$$

- correlation index R, to assess the proximity of the theoretical process ŷ, to the original:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_t - \hat{y}_t)^2}{\sum_{i=1}^{n}(y_t - \bar{y}_t)^2} \quad (8)$$

At this $y_t, \hat{y}_t, \bar{y}_t$ - initial, theoretical and arithmetic mean levels of the time series; n is the number of parameters defined in the trend function.

As an example, to illustrate the application of the forecasting methodology under the condition of unequal initial data, let's take a time series of gross output of the ARZ for 2011-2021. (table 1. initial data to take conditionally).

Table 1.

Gross output of ARZ, in wholesale prices of enterprises, c.u.

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Gross output	702,2	808,0	871,9	924,1	1000,3	1028,0	1071,9	1126,4	1177,9	1192,8	1198,0

To highlight the general trend, three types of functions are used:

- straight

$$y = a_0 + a_1 t \quad (9)$$

- second degree polynomial

$$y = a_0 + a_1 t + a_2 t^2 \quad (10)$$

- power

$$y = a_0 * a_1^t \quad (11)$$

The calculation of the parameters of these functions is carried out by the least squares method, the main requirement of which is the minimum of the sum of squared deviations of the calculated values from the empirical ones. Having carried out the necessary calculations, we obtain the following equations:

$$\hat{y}_t = 1009{,}2227 + 49{,}204t; \quad (12)$$

$$\hat{y}_t = 1041{,}567 + 49{,}204t - 3{,}234t^2; \quad (13)$$

$$\hat{y}_t = 2{,}9982 + 0{,}022t; \quad (14)$$

The deviation is calculated for each of the functions (table 2).

According to the calculated data of Table 2, the following criteria are calculated using formulas (5-8): (A_t),σ, v, R^2 (table 3)

The analysis shows that parabolic (13) is better than others in all criteria, i.e. to predict the effective indicator (the relationship between y and t), you should take this form of communication [5]

Table 2.

Calculation of deviations for each function

Function types	Criteria			
	$\|A_t\|$	σ	v	R^2
$\hat{y}_t = 1009{,}2227 + 49{,}204t$	0,003	32,30	3,2	0,9623
$\hat{y}_t = 1041{,}567 + 49{,}204t - 3{,}234t^2$	0,003	12,06	1,195	0,9947
$\hat{y}_t = 2{,}9982 + 0{,}022t$	3,9	48,64	4,82	0,9145

After identifying the best nature of the trend, you can start forecasting this economic indicator by calculating its values:

As it was found out above, the trend of the analyzed series is quite well described by a parabola of the form [6].

$$\hat{y}_t = 1041{,}567 + 49{,}204t - 3{,}234t^2$$

To determine the value of the economic indicator for 2022, it is necessary to correctly set the value of t and t^2 Thus, for 2022: t=6.

$$y_{2022} = 1041{,}587 + 49{,}204 * 6 - 3{,}234 * 6^2 = 1220{,}387$$

Table 3 shows the results of the economic indicator forecast for 2022-2024 years and his mistake.

The average approximation error of this model is determined by the formula

$$\varepsilon = \frac{1}{n}\Sigma\frac{y_{fact} - y_{calc}}{y_{calc}}100\% \quad (15)$$

Table 3.

The results of the economic indicator forecast for 2022-2024 years and his mistake

Years	Forecast	Error forecast	Confidence interval	
			upper	lower
2006	1220,387	13,18	1233,567	1207,207
2007	1227,549	13,26	1240,809	214,289
2008	1228,243	13,27	1241,513	1214,973

The forecast error is thus 1.08.

The need for forecasts and their wide distribution contributed to the emergence of a variety of empirical, mathematical, logical and other methods and ways of developing economic and scientific and technical forecasts. The whole variety of methods can be conditionally combined into three groups; extrapolation, expert assessments and modeling, a significant role in forecasting is given to intuition based on the analysis of statistical data and the study of existing trends and patterns.

Some general conclusions can be drawn about the application of the above methods. Extrapolation by smoothing time series using the least squares method should be used with caution, and if the approximating function expressing the development trend is incorrectly selected, the forecast results may be erroneous.

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