MODELING AND FORECASTING OF DATAON PRODUCT BALANCE IN STOCK

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Introduction

In today's economy, mathematical modeling and computer analysis of data are used as methods of non-price competition. Using models of warehouse management with the ability to control or predict current liquidity allows to control an enterprise more efficiently.

The aim of this work - to construct a mathematical model describing the time series of residues of products in stock, with the ability to forecast values of the series.

Under the model of the time series equation, that relates the observation obtained at a given time, with observations obtained previously by the same and / or other characteristics of the variable of interest, will be understood. There are various models that are used to describe a time series. Among these models there are autoregressive models, moving average, as well as combinations based on them.

Autoregressive process AR (p) of order p is called a stochastic process X_t, which is defined by the following relationship [1, 2]

$$X_t = \alpha_0 + \alpha_1 X_{t-1} + a_2 X_{t-2} + ... + \alpha_p X_{t-p} + \varepsilon_t,$$

where ε_t – process of the "white noise" with zero expectation $\mu_\varepsilon = 0$. This model of time series based on the assumption that the behavior of the phenomenon under investigation in the future is determined only by its current and previous states.

Moving average process MA (q) of order q is called a stochastic process X_t, which is defined by:

$$X_t = \varepsilon_t - \beta_1 \varepsilon_{t-1} - \beta_2 \varepsilon_{t-2} - ... - \beta_q \varepsilon_{t-q}$$

where ε_t – process of the "white noise" with zero expectation $\mu_\varepsilon = 0$ and variance $\sigma_\varepsilon^2 = \sigma^2$. In models of the moving average MA (q) the average current value of a stationary stochastic process can be represented as a linear combination of current and past values of the error that has the properties of "white noise" [1, 2].

Combination processes AR (p) and MA (q) is called autoregressive moving average process, it is denoted as ARMA (p, q). Model ARMA (p, q) has the following form [1, 3]:

$$X_t = \alpha_0 + \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + ... + \alpha_p X_{t-p} + \varepsilon_t - \beta_1 \varepsilon_{t-1} - \beta_2 \varepsilon_{t-2} - ... - \beta_q \varepsilon_{t-q}.$$

Model ARIMA (p, d, q) - an integrated model of autoregressive - moving average. This model is an extension of ARMA models for non-stationary time series. The parameters p and q correspond to the number of components of the autoregressive model AR (p) and the moving average MA (q), respectively, and the parameter d - determines the order of integration.

In this paper, model ARIMA (p, d, q) is selected for the analysis of time series.

Construction of a mathematical model

In order to construct a mathematical model of the time series it is necessary to consistently determine the values of the model parameters - d, p and q.

The initial data for which you want to build a mathematical model and make a prediction, the remnants of products in stock in the period from 01.02.2008 to 21.05.2014, with the interval of 10 days (228 values).

To determine the value of the parameter d, the test series for stationarity (test the hypothesis that in the time series autoregression more than first order) was checked. Dickey-Fuller test and parametric tests - Student and Fisher criteria were selected. In all calculations, the significance level of 0.05 is chosen.

As a result, the investigated series turned out to be unsteady integrable of the first order next to, therefore, for the investigated time series model ARIMA (p, 1, q) is selected.

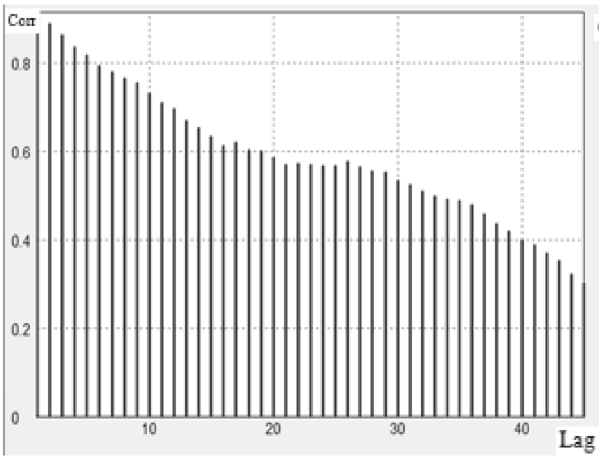

Fig. 1. Correlogram of the autocorrelation function

To determine the value of the parameter p, autocorrelation (ACF) and partial autocorrelation (PACF) of the time series and correlogram of these functions (see Fig. 1 and 2) were constructed.

ACF decreases exponentially, without changing the sign (see Fig. 1), PACF has significant emissions at lags 1 and 2, while the other values are not significant (see Fig. 2).

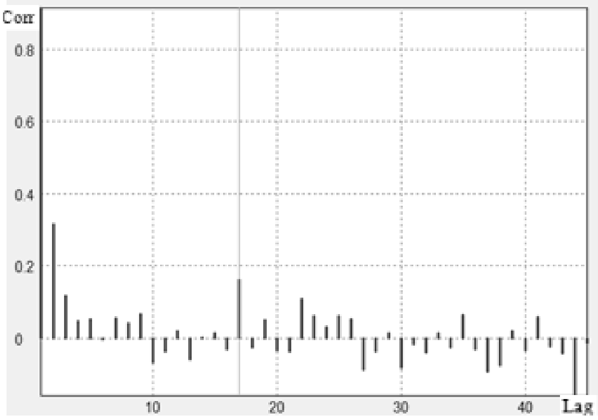

Fig. 2. Correlogram partial autocorrelation function

From the analysis of correlograms it can be concluded that the ARIMA model for the test series includes two parameter of the model AR, i.e. p = 2. At this stage, we assume that the model for a number of our model is ARIMA (2, 1, q).

To determine the optimal value of the parameter q following the models were built - ARIMA (2, 1, 0), ARIMA (2, 1, 1), ARIMA (2, 1, 2), respectively:

$$Y_t = 2154{,}4 + 0{,}61 Y_{t-1} + 0{,}38 Y_{t-2},$$

$$Y_t = 1{,}15 Y_{t-1} - 0{,}158 Y_{t-2} - 34{,}46 - 0{,}63 \varepsilon_{t-1},$$

$$Y_t = 1{,}825 Y_{t-1} - 0{,}825 Y_{t-2} - 14{,}94 - 1{,}32 \varepsilon_{t-1} + 0{,}36 \varepsilon_{t-2}$$

To find the coefficients of the models, the method of least squares was used.

The criteria for the optimal value of the parameter q were used (Table. 1): maximum value of the coefficient of determination (R2), the minimum value of the Akaike information criterion (AIC), the minimum value of the standard error (E).

Table 1: Performance of the constructed models

	ARIMA (2, 1, 0)	ARIMA (2, 1, 1)	**ARIMA (2, 1, 2)**
α_0	2154,5	-34,45	-14,94
α_1	0,60	1,15	1,82
α_2	0,38	-0,15	-0,82
β_1	–	-0,63	-1,31
β_2	–	–	0,36
R^2	86,45%	87,06%	**87,22%**
E	525 408,20	514 551,00	**512 561,00**
AIC	29,20	29,16	**29,16**

Comparison criteria showed that the best model for the investigated time series is model ARIMA (2, 1, 2). This model has the smallest error value E and the criterion AIC, the greatest value of the coefficient R2 (Table. 1 in bold).

All the coefficients α0, α1, α2, β1, β2 of constructed model ARIMA (2, 1, 2) are statistically significant. Original time series and the proposed model ARIMA (2, 1, 2) are shown in Fig. 3.

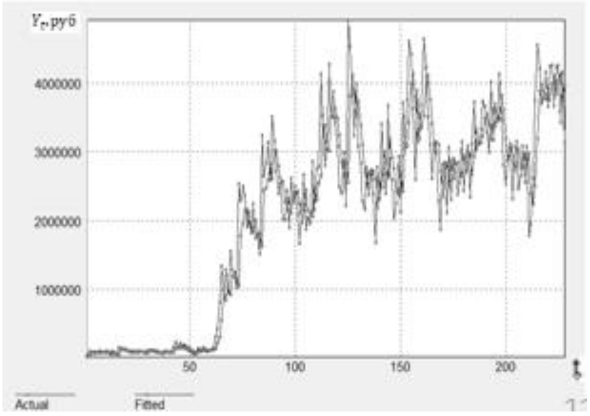

Fig. 3 Time series model and ARIMA (2, 1, 2)

Construction of the prognosis

On the basis of the model ARIMA (2, 1, 2), a forecast for three decades ahead -01.06.2014, 11.06.2014, 21.06.2014 was built. As a result, it is shown that on 1 April 2014 in stock there will be products to the amount of 3.54 million. rubles., On 11 April 2014 - 3570000. Rub., On 21 April 2014 - 3.59 million. rubles. Confidence interval is equal to 0,512,000. rub., the confidence limits of the interval chosen equal to ± 2E.

Conclusion

In this paper we made an analysis of the original data and built an integrated model of autoregressive - moving average ARIMA (2, 1, 2). On the basis of the proposed model, a forecast for three periods is made. The forecast showed that the remains of commercial products will double every 10 days by 0.02 million rubles.

Under the assumption that the random changes in the balances of goods in stock at each time interval are independent of each other, in the further research it is planned to use nonlinear models.

Literature

1 Econometrics: laboratory practice: a tutorial / NI Shanchenko. - Ulyanovsk Ulyanovsk State Technical University, 2011 - 117 p.

2 Tregub AV Tregub IV The method of constructing an ARIMA model to predict the dynamics of the time series // Bulletin of the Moscow State University of Forestry - Forestry Bulletin. - 2011. - № 5. - S. 179-183.

3 Grebennikov AV, Kryukov A., DV Chernyagin Modeling and forecasting of network traffic using the model ARIMA // Systems Analysis in Science and Education, 2011 - Vol. 1. - www.sanse.ru/download/79.