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The Use of Arima Model in Forecasting Accounts Payable

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ABSTRACT: The authors obtained a forecast of accounts payable of a public enterprise providing communication services and the Internet. In the work the authors performed evaluation of models ARIMA with the acceptable identification according to the methodology of Box-Jenkins. On a sample of 29 quarterly observations on accounts payable estimated model ARMA (1;0), ARMA (1;1), ARIMA (1;1;1), ARIMA (0;1;1). The authors focused on the method of selecting the most valid model according to the criteria RMSE and AIC used the method of selection of the designated circle of the most simple model with the fewest parameters. The forecast estimate confirmed the hypothesis of a decrease in the value of accounts payable. The reliability of the results is confirmed by the information criterion of Akaike, the mean square error of the forecast, the diagnosis of residues on the normal distribution using a special test and the absence of autocorrelation using the Ljung-Box test. The results of the empirical estimates confirmed the feasibility of practical use of this approach in forecasting the accounts payable of public companies with a stable financial position. The projected amount of accounts payable will allow the company to control the probability and signs of bankruptcy, to form a forecast balance sheet and to implement the mechanisms of debt management strategy. There is a possibility of comparative analysis of various options of contractual work in terms of providing additional payment in the form of interest for deferred payment, installment debt repayment and the use of other similar debt management tools.

Keywords: accounts payable, time series, stationarity, forecast, ARIMA model.

I. INTRODUCTION

Forecasting is one of the most popular business intelligence tasks. Purchases, deliveries and shipments are directly related to the occurrence of accounts payable, and given that all of this appears to be processes that are distributed over time, hence all of this is related to time series analysis. A time series is a sequence of observations of changes in the values of parameters of a certain process over time. Time values are represented by specific data that is captured at the appropriate time. One-dimensional time series contain observations of changes in only one parameter of the studied process, and multidimensional – for two or more. The basic prerequisite for forecasting a one-dimensional time series is its stationarity. The dynamics of accounts payable of a public enterprise of communication services and the Internet, which has financial stability and is independent of the season of the year type of activity, is most often stationary, or contains a stochastic trend. Financial stability of the enterprise is caused by the actual monopoly among consumers - the state customers. In addition, the company is the only one in the region that provides wired telephone coverage. Therefore, the forecast of accounts payable is convenient to obtain with the help of ARIMA model, which for short-term forecasts often shows good results [1- 4]. The purpose of the study is to select a short-term forecast model that most accurately describes the dynamics of accounts payable. The hypothesis of the study - the accounts payable of the enterprise "XXX" tends to decrease.

II. METHODS

The study used data on the accounts payable of the enterprise "XXX" from the 4th quarter of 2011 to the 4th quarter of 2018, obtained from the open financial statements. Estimation of ARIMA models performed with the software Gretl – GNU Regression, Econometrics and Time-series Library.

The highly flexible software products, a model of type ARIMA is a classic in the predictive estimates. To build ARIMA-type models, we used the Box-Jenkins approach [5-6], which consists of the following procedures:

1. Graphical analysis of the time series (is the time series stationary ?);
2. Construction of ACF and PACF diagrams for the initial time series (with a slow decrease in the ACF correlogram, there is reason to believe that the time series is not stationary);
3. Conducting the Dickey-Fuller test (ADF test, null hypothesis of unsteadiness [7]) for the initial time series (if the series is not stationary, then taking the first difference between the levels (d=1));
4. Conducting the Dickey-Fuller test (ADF test) for the first time series difference;
5. Charting ACF and PACF for the first difference of the time series to identify the order p (for PACF), and q (for ACF);
6. Evaluation of ARIMA model (p, d, q) or several models by the first time series difference;
7. Diagnostics of ARIMA model residues (p, d, q) for autocorrelation and normality (Ljung-Box test [8]);

8. The choice of the model ARIMA (p, d, q) according to the minimum AIC criterion.
9. Using ARIMA model (p, d, q) for prediction;
10. RMSE forecast error calculation.

III. RESULTS AND DISCUSSION

Dynamics of accounts payable of the enterprise "XXX" (Fig. 1) shows a decreasing stochastic trend, which indicates the unsteadiness of the time series.

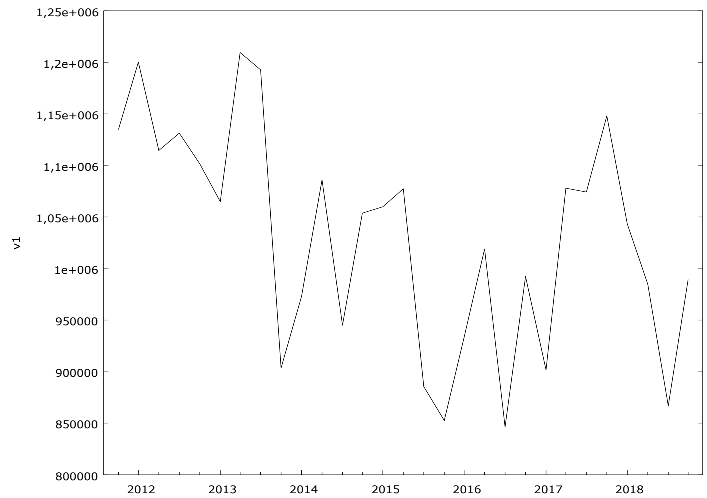

Fig. 1. Dynamics of accounts payable of the enterprise "XXX". from Q4 2011 to Q4 2018

The results of the extended Dickey-Fuller test with constant (p-value) was 0.02298) allow us to formulate two conclusions:
- the null hypothesis of the time series unsteadiness is rejected, since the p-value equal to 0.02298 is less than the significance level α=0.05. Thus, the time series of accounts payable of the enterprise "XXX" is stationary with reliability 95%;
- the null hypothesis of the time series unsteadiness is accepted, since the p-value equal to 0.02298 is greater than the significance level α = 0.01. The time series of accounts payable of the enterprise "XXX" is non-stationary with reliability of 99%.
Based on the first conclusion, we construct the ARMA model. The autocorrelation function and of the partial autocorrelation function (Fig. 2) contain significant correlation coefficients on the first lag, so we identify the order of p and q as an ARMA (1;1) model with a constant. As seen in Fig. 2 the autocorrelation function decreases smoothly, and the private autocorrelation function ends abruptly, so we also estimate the ARMA model (1;0) with a constant.

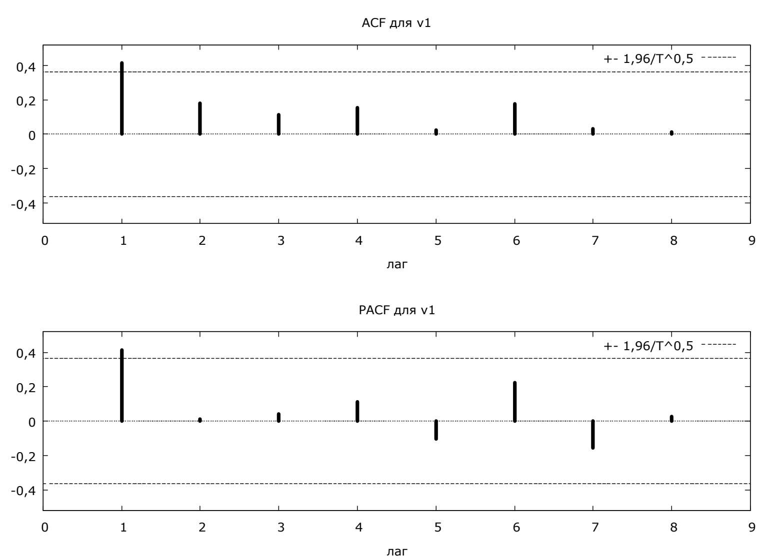

Fig. 2. Correlogram source time series accounts payable XXX.

It is difficult to determine whether there is an indication of the model the moving average, as it is impossible to say with certainty that the function PACF dies down after a delay, and a function of ACF has a sharp decline after the first lag, which is the order q.
Note that the time series of accounts payable of the enterprise "XXX" is non-stationary with a reliability of 99%. To determine the order p and q of the ARIMA model (p,1,q) according to the Box-Jenkins procedure, ACF and PACF correlograms were constructed for the first differences in payables of PJSC "Tattelecom", the results of which determined that the ACF has a significant autocorrelation coefficient on the first lag, PACF also has a significant autocorrelation coefficient on

the first lag. Therefore, it is advisable to build a model of ARIMA (1;1;1), since the first time series differences are stationary with a reliability of 99%. In addition, the ACF function has a fairly sharp reduction, and the PACF function decreases more slowly. Based on this, it is recommended to build an additional model – ARIMA (0,1,1).
Thus, ARMA (1;1), ARMA (1;0), ARIMA (1;1), ARIMA (0,1,1) models were estimated in the study for the purposes of accounts payable forecast.

Table 1: Evaluation results Of ARIMA models.

<table>
<tr><th>Model</th><th>Level of reliability</th><th>Specification</th><th>AIC</th><th>RMSE</th><th>Forecast estimate for the Q1 of 2019.</th><th>The actual value for the Q1 of 2019.</th></tr>
<tr><td>ARIMA (1;0;1)</td><td>95%</td><td>Y_t=1031760$^{(***)}$+0,567012 $Y_{t-1}+\varepsilon_t$ – 0,179351ε_{t-1}</td><td>755,1238</td><td>94745,812</td><td>1 003 198,45</td><td rowspan="12">958 690</td></tr>
<tr><td colspan="6">Test for the normal distribution of residues – null hypothesis: the remains of the model have a normal distribution, the p-value was 0.18222</td></tr>
<tr><td colspan="6">Test Ljung-Box null hypothesis: autocorrelation in the residuals of the model are missing, the p-value was and 0.6950</td></tr>
<tr><td>ARIMA (1;0;0)</td><td>95%</td><td>Y_t=1031330$^{(***)}$+ 0,417766 $Y_{t-1}{}^{(**)}+\varepsilon_t$</td><td>753,2128</td><td>94914,767</td><td>1 013 644,60</td></tr>
<tr><td colspan="6">The test for the normal distribution of residuals is a null hypothesis: the residuals of the model have a normal distribution, the p-value was 0.19194</td></tr>
<tr><td colspan="6">Ljung-Boxtest is the null hypothesis: autocorrelation in the residuals of the model are missing, the p-value was 0,8384</td></tr>
<tr><td>ARIMA (1;1;1)</td><td>99%</td><td>Y_t=–6053,53$^{(**)}$ +0,291504 $Y_{t-1}+\varepsilon_t$ – 1$^{(***)}$$\varepsilon t_{-1}$</td><td>729,0631</td><td>89974,336</td><td>951 276,33</td></tr>
<tr><td colspan="6">The test for the normal distribution of residuals is a null hypothesis: the residuals of the model have a normal distribution, the p-value was 0.50445</td></tr>
<tr><td colspan="6">Ljung-Box test is the null hypothesis: autocorrelation in the residuals of the model are missing, the p-value was 0,7159</td></tr>
<tr><td>ARIMA (0;1;1)</td><td>99%</td><td>Y_t=–6356,34+ε_t–0,7577$^{(***)}$$\varepsilon_{t-1}$</td><td>728,9172</td><td>96283,772</td><td>960 905,57</td></tr>
<tr><td colspan="6">The test for the normal distribution of residues – null hypothesis: the remains of the model have a normal distribution, the p-value was 0.76811</td></tr>
<tr><td colspan="6">Ljung-Box test is a null hypothesis: there is no autocorrelation in the model residues, the p-value was 0.7600</td></tr>
</table>

Note: * * * parameter is significant with a reliability of 99%, * * parameter is significant with a reliability of 95%, * - significant with 90% reliability.

Diagnosis of the residues of the models pointed to the observance of the null hypothesis of normal distribution of residuals and absence of autocorrelation for all possible levels of significance (Table 1). Therefore, the choice of the most correct model from Table 1 for forecasting accounts payable is feasible by the least Akaike criterion (AIC), which contains a penalty for the complexity of the model, and the least mean square error (RMSE), which measures the accuracy of the model. These are the ARIMA (1;1;1) and ARIMA (0;1;1) models, respectively. According to the generally accepted practice of choosing between complexity and accuracy, the model with the least number of parameters should be chosen from these models, provided that its accuracy is not significantly different from another model (the deviation between the RMSE ratio of the models should not exceed 10%). Compare between average quadratic error of the models: 96283,772/89974,336 = of 1.07 (i.e. 7%). According to the results obtained, among the models ARIMA(1;1;1) and ARIMA (0;1;1) we prefer a simpler model with the least number of parameters - ARIMA(0;1;1). And indeed, this model received a forecast value (960 905.57 thousand rubles), which is closest to the actual (958 690 thousand rubles) – compared to other models, the deviation is minimal and is 2 215.57 thousand rubles. (Table 2).

Table 2: Results of the forecast of accounts payable of the enterprise "XXX" in 2019, thousand rubles. model ARIMA (0;1;1).

Period	Forecast	Standard error	Lower limit	Upper limit
I.2019r.	960 905	96 284	712 895	1 208 916
II.2019r.	954 549	99 069	699 362	1 209 736
III.2019r.	948 193	101 780	686 026	1 210 360
IV.2019r.	941 837	104 419	672 870	1 210 803

Moreover, the lower limit of the forecast can be interpreted as an optimistic version of the forecast from the position of debt reduction, and the upper – as pessimistic from the position of increasing accounts payable.

IV. SUMMARY

In the process of forecasting the company's accounts payable, the most appropriate method of predicting values was chosen and four models of the accounts payable forecast were built, then after their evaluation, the ARIMA model (0;1;1) was chosen, which most accurately predicted the next forecast value of the company's accounts payable for the 1st quarter of 2019. Thus, the selected model is adequate and confirms the hypothesis of a decrease in accounts payable, it is recommended to apply such a model for forecasting with its further improvement as it is used. The obvious advantages of using the model include the fact that it is based on a very clear mathematical and statistical justification, which makes them one of the most scientifically based models of the entire set of models for predicting trends in time series.
Another advantage is the formalized and most detailed developed method, following which you can choose the model that is most suitable for each specific time series. The formal procedure for checking the adequacy of the model is quite simple, and the developed methods for the automatic selection of the best ARIMA allow you to choose the most suitable option for the problem under study.

V. CONCLUSIONS

We can point out a number of obvious advantages of ARIMA models. First, it is a clear mathematical and statistical justification, which makes them one of the most scientifically based models of the whole set of models for predicting trends in time series. Secondly, the presence of a formal and most detailed developed methodology, following which you can choose the model that is most suitable for each specific time series. The developed methods for automatic selection of the best ARIMA [1; 9] and does "greatly facilitate life" of the

forecaster. In addition, point and interval forecasts follow from the model itself and do not require separate estimation.
One of the obvious drawbacks of ARIMA models is the requirement for data series: to build an adequate ARIMA model requires at least 40 observations, and for SARIMA — about 6-10 seasons, which is not always possible in practice. The second serious drawback is the lack of adaptability of autoregression models: when receiving new data, the model should be periodically overestimated, and sometimes re-identified. The very same construction of the model is rather an "art", i.e. requires a lot of experience on the part of the forecaster. At the end of the last century, studies conducted by the International Institute of Forecasters have shown that ARIMA models have shown themselves to be no better than exponential smoothing models, and in each case you need to use your model [10]. Moreover, the use of models AR(1), AR(2) and ARMA(1, 1) bypassing the Boxing-Jenkins methodology (i.e. without studying correlograms and estimating residuals) gives no less accurate predictions than the ARIMA models built on the basis of the Boxing-Jenkins methodology [11]. The construction of ARIMA models is based on the assumption that the time series is generated infinitely in accordance with some function whose parameters need to be identified and evaluated. However, economic processes, as we already know, are essentially irreversible, and therefore such a "technical" attitude to them does not allow to take into account their features and, as a result, does not allow to give accurate forecasts. In evolutionary economic processes, there are constant changes in all the characteristics of the distribution, and therefore the "race" for the best (unbiased, efficient and well-founded) estimates without heteroskedasticity and autocorrelation in the residues is more like a search for what does not exist, where it does not exist in principle. For each case, it is necessary to refer to its forecast model: whether it is the simplest model, trend model, seasonal decomposition model, exponential smoothing or autoregressive models with moving average. It seems necessary to take into account both the positive and negative aspects of the models used, and to rely on those forecasts, on which (based on expert opinion and fundamental analysis of the industry) we can say that they will better describe the real situation in the future.

The perspective direction of development of this research can be obtaining forecast estimates of accounts payable on the basis of modeling of multidimensional time series through the elimination of false regression and analysis of co-integration. Polynomial trends described by discrete polynomials of low orders are also popular. Effective application in the construction of polynomial trends can find algorithms for their evaluation based on discrete transformations [9]. Also of practical interest is forecasting using fuzzy time series models [10].

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