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METHODS OF FORECASTING BUDGET REVENUES

METODY PROGNOZOWANIA DOCHODÓW BUDŻETOWYCH

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Bartosz **Kozicki**[1], Tadeusz **Waściński**[2], Agnieszka **Lisowska**[3]

[1] Poland, Military University of Technology in Warsaw, Faculty of Logistics
ORCID: 0000-0001-6089-952x, e-mail: bartosz.kozicki@wat.edu.pl

[2] Poland, Warsaw University of Technology, Faculty of Management
ORCID: 0000-0002-4848-314x, e-mail: tadeusz.wascinski@pw.edu.pl

[3] Poland, Warsaw University of Technology, Faculty of Management
ORCID: 0000-0003-0143-1905, e-mail: agnieszka.lisowska@pw.edu.pl

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Abstract: In the article, the authors raises an issue related to the forecasting of budget revenue in Poland after previous analysis of primary data on a monthly basis from 2011-2018. The research data was obtained from the Central Statistical Office; and initiated with the analysis and evaluation of data concerning budget revenue in Poland dynamically. Then, on the basis of the results, prognostic methods were selected, which were then analyzed and evaluated. The best one was selected and applied in order to conduct the forecasting of the original series. The obtained budget revenue forecasts will allow for more accurate budgeting. Thus, the balance of planned needs, including revenues, with increased expenses will improve. The results obtained in the research were presented in the summary.
Keywords: forecasting, budget revenue

Streszczenie: W artykule poruszony został problem z zakresu prognozowania dochodów budżetowych w Polsce po uprzednio przeprowadzonej analizie danych pierwotnych w ujęciu miesięcznym w latach 2011-2018. Dane do badań pozyskano z Głównego Urzędu Statystycznego. Badania rozpoczęto od analizy i oceny danych dotyczących dochodów budżetowych w Polsce w ujęciu dynamicznym. Następnie na podstawie uzyskanych ocen wybrano metody prognostyczne. Metody zostały poddane analizie i ocenie. Wybrano najlepszą, którą wykonano prognozowanie szeregu pierwotnego. Uzyskane prognozy dochodów budżetowych pozwolą na precyzyjniejsze opracowanie budżetu. Tym samym nastąpi poprawa bilansowania się zaplanowanych potrzeb, w tym dochodów z podniesionymi wydatkami. Dalsze rezultaty badań przedstawiono w podsumowaniu.
Słowa kluczowe: prognozowanie, dochód budżetowy

Introduction

The purpose of this article is to analyse and evaluate the country's budget and to develop forecasting for fifteen future periods for a time series data based on monthly budget revenues. The use of budget revenue forecasting in Poland is made possible by introducing restrictions and assumptions for modeling. The assumptions and limitations are as follows: 1. Using the model for forecasting will be possible if the time series from the past budget revenues are available. 2. If tendencies in the form of seasonality are detected, the Holt-Winters exponential smoothing method will be used to forecast the time series of primary budget revenues.

This article makes recourse to research methods such as analysis of literature regarding issues related to budget revenue in Poland and its forecasting, analysis of source documents, computer simulation methods, and comparisons. In addition, a research technique in the form of the Statistica computer program was used. Moreover, the following research tools were used: quartile graph, autocorrelation, partial autocorrelation, multiple regression, histogram.

Literature review

The largest source of revenue for the country's budget, identified as a result of the critical analysis of literature carried out, are: taxes, profit earned by the National Bank of Poland, profit from entrepreneurs and the sole-shareholder companies of the State Treasury, and the contributions from budgetary units (Parlińska, 2010, p. 127).

Many authors accept that the basic division of budget revenue is the division into tax and non-tax revenues. It should be emphasised that since Poland's accession to the European Union, state budget revenues have been systematically growing on an annual basis by several percentage points. This has been caused by the economic growth resulting from the good economic situation (Parlińska, 2010, p. 128). The observed dependence, in the form of an increase in budget revenue in dynamic terms, allows for the use of retrospective data so as to build forecasting models and to make forecasts. The obtained forecasts may be valuable from the point of view of analysis and the assessment of future macroeconomic factors, which depend on the dependent variable being analysed, that is budget revenue.

Critical analysis of the literature regarding the dates of forecasting reveals that they have been interpreted differently by the authors. P. Dittmann states that "the forecast is a judgment regarding the future of the forecast phenomenon – precise and uncertain" (Dittmann, 2016, p. 9). On the other hand, Z. Czerwiński believes that "by forecast, it is a court that a specific event has occurred within a specified time with accuracy to the moment or period of time belonging to the future" (Czerwiński, Guzik, 1980, p. 19). In turn, E. Nowak states that the forecast is a predicted court about the development of phenomena and processes in the future based on basic sciences (Nowak, 1998, p. 10). What's more, the forecast in various aspects is called M. Cieślak (Cieślak, 2001, pp. 18-20) and J.B. Gajda (Gajda, 2001, p. 135).

According to M. Cieślak (Cieślak, 2001, p. 18) and A. Zeliaś (Zeliaś, 1997, p. 16), the term forecasting is understood as rational and scientific prediction of future events. On the other hand, J. Greń (Greń, 1978, pp. 3-4) believes that "forecasting (i.e. prediction) is a practical activity (activity) aimed at formulating a scientifically justified assessment, i.e. an estimate of the probable future state based on the information from the past and substantive knowledge about a given fragment of reality being the subject of forecasting". According to P. Dittmann, forecasting is a rational, scientific prediction of future events (Dittmann, 2016, p. 15).

The assessment of the forecasting term is the statement that it is a prediction of future events based on an analysis; and evaluates data from the past and the use of other regularities observed during the research on the construction of the model for forecasting space.The data used for forecasting can be presented making recourse to both quantitative and qualitative variables. As a result of a critical literature analysis, the following types of forecasts were identified in the form of short, medium and long-term.

The short-term forecast is for a period of time in which only quantitative changes occur. According to M. Cieślak, "then it is legitimate to use variable inertia and determine the forecast by extrapolating existing trends or relationships" (Cieślak, 2001, p. 25). However, the medium-term forecast is built up over a period of time in which there are quantitative changes as well as trace qualitative changes (Dittmann, 2016, p. 18). Long--term forecasting refers to the time period during which quantitative changes and major qualitative changes may occur (Cieślak, 2001, p. 25). Some researchers believe that forecasting budget revenues is biased, and emphasize that it requires forecast error analysis (Boukari, Veiga, 2018) this doesn't belong here. Large discrepancies between the forecasted and observed values testify to the wrong model for future forecasting.

For the purposes of this work, quantitative methods will be applied, which include the method of Holt-Winters exponential smoothing and ARIMA. Detailed procedures for using Holt-Winters forecasting methods and the ARIMA model are available in the literature (Rabiej, 2012, pp.: 301-307; 326-332).

Methodology and theoretical basis

The first stage of the study involved summarising data on a line chart, which regarded budget revenues on a monthly basis between 2011-2018 in PLN million (Fig. 1).

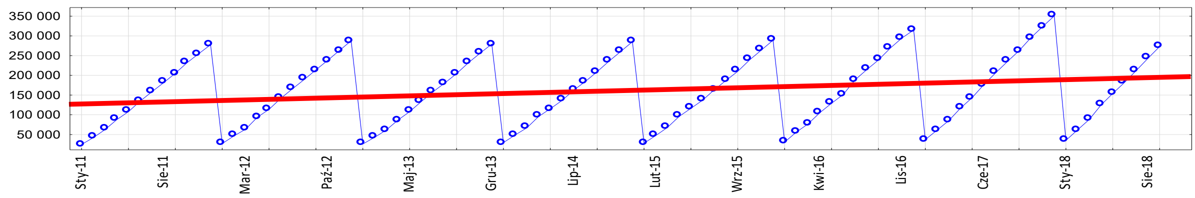

Figure 1. Line chart presenting budget revenues in Poland, monthly, 2011-2018
Source: own elaboration based on data obtained for the website: http://stat.gov.pl/wskazniki-makroekonomiczne/.

Visual observation of the Figure 1 allows to state that in the analysed line graph there is very pronounced seasonality and a slight growing trend.

The next stage of the study was the analysis of the original time series through the use of the following research tools: autocorrelation (Fig. 2), partial autocorrelation (Fig. 3), histogram (Fig. 4), and normality chart (Fig. 5).

The use of the research tool – autocorrelation indicates the existence of seasonality (Fig. 2). The use of partial autocorrelation confirms the existence of seasonality on a monthly basis (Fig. 3). The use of a test tool in the form of a histogram may indicate a normal distribution (Fig. 4).

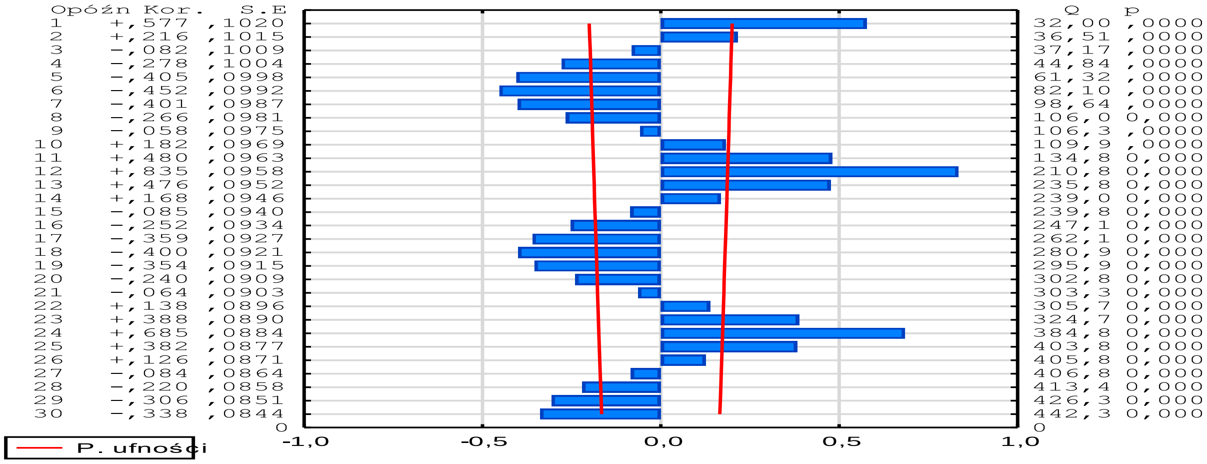

Figure 2. Autocorrelation
Source: own elaboration based on data obtained for the website: http://stat.gov.pl/wskazniki-makroekonomiczne/.

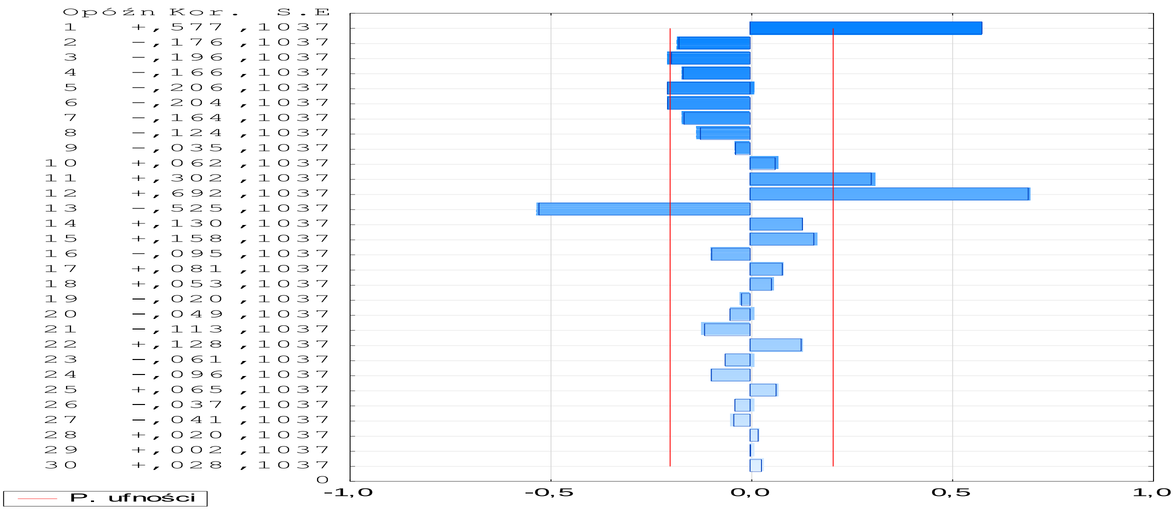

Figure 3. Partical autocorrelation
Source: own elaboration based on data obtained for the website: http://stat.gov.pl/wskazniki-makroekonomiczne/.

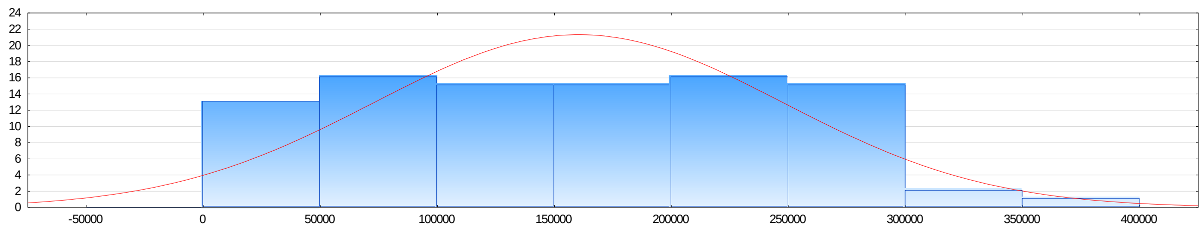

Figure 4. Histogram
Source: own elaboration based on data obtained for the website: http://stat.gov.pl/wskazniki-makroekonomiczne/.

The normality chart and the Shapiro-Wilk test confirm that the distribution of the analyzed primary time series is normal (Fig. 5). The next tool used to analyse the original time series was a box plot (Fig. 6).

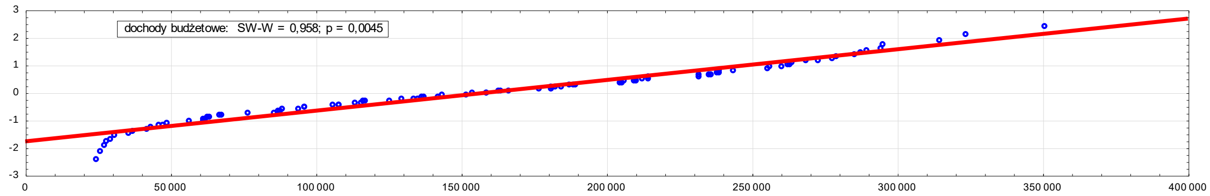

Figure 5. Normality chart and Shapiro-Wilk test
Source: own elaboration based on data obtained for the website: http://stat.gov.pl/wskazniki-makroekonomiczne/.

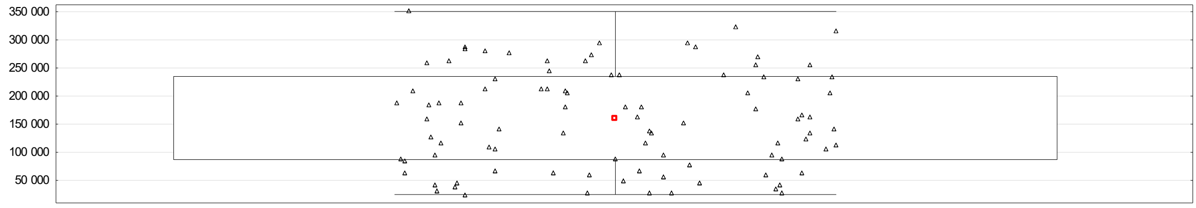

Figure 6. Box plot application
Source: own elaboration based on data obtained for the website: http://stat.gov.pl/wskazniki-makroekonomiczne/.

The use of a box-plot application indicates the absence of outliers and extreme values (Fig. 6).

The next stage of the study was the construction of a zero-one model of multiple regression to assess the existence of the trend and seasonality. For this purpose, fourteen predictors were used, including variables: t, t^2, Int, and eleven zero-one variables for eleven months. Table 1 shows only relevant predictors.

Table 1. Zero-one model of multiple regression

N=93	R= ,99562701 R^2= ,99127314 Correct R2= ,98983707 Std. error of estimation: 8767,2					
	b*	Std. err.	b	Std. err.	t(79)	p
W. free			291051	4361,341	66,7344	0,000000
t	-0,185236	0,042779	-597	137,838	-4,3301	0,000043
t^2	0,368738	0,042788	12	1,421	8,6177	0,000000
January	-0,867356	0,014747	-267567	4549,110	-58,8174	0,000000
February	-0,800679	0,014741	-246998	4547,372	-54,3166	0,000000
March	-0,734735	0,014737	-226655	4546,070	-49,8573	0,000000
April	-0,641284	0,014734	-197827	4545,193	-43,5244	0,000000
May	-0,570205	0,014732	-175900	4544,732	-38,7042	0,000000
June	-0,488367	0,014732	-150654	4544,685	-33,1495	0,000000
July	-0,400338	0,014733	-123499	4545,054	-27,1721	0,000000
August	-0,321009	0,014736	-99027	4545,847	-21,7839	0,000000
September	-0,242118	0,014740	-74690	4547,078	-16,4259	0,000000
October	-0,146441	0,014295	-48012	4686,783	-10,2442	0,000000
November	-0,071573	0,014294	-23466	4686,413	-5,0072	0,000003

Source: own elaboration.

The zero-one model of multiple regression model was very suitable. Multiple R^2 was 0.99. Significant predictors were the variables t, and zero ones for eleven months. This means that the existence of a trend and seasonality in the primary time series considered has been confirmed (Table 1).

The evaluation of the conducted analysis is the detection of several important regularities of the examined series. These include: seasonality and trend, as well as the way of bringing the non-stationary primary series to stationarity, which will facilitate the construction of forecasting models.

The above assessment became the premise for selecting forecasting models to make the prediction for the future. Through the critical analysis of the literature, two methods, that are considered the best in such relationships, were chosen. These include the Holt-Winters exponential smoothing method and the ARIMA class models.

Results and discussion

The construction of forecasting models was preceded by the division of the original time series of the budget revenues of Poland into two parts. The first part, called the teaching, was composed of 72 elements, the second part, called the tester, was composed of 21 elements. The division of the series is presented in Figure 7. In the figure the original series has been divided into two parts: teaching and testing. Forecasting will be performed based on the learner's time series. However, the test time series will be used to evaluate the forecast received.

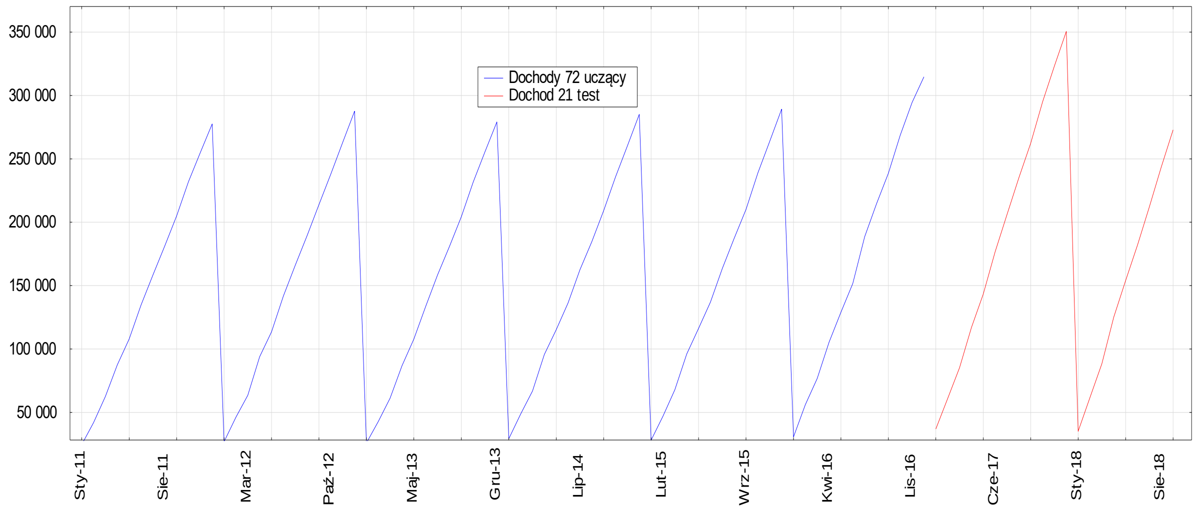

Figure 7. Division of the original time series of the budget revenue into the teacher part (72 - elements - blue line) and tester part (21 elements - red line)
Source: own elaboration.

The first forecast was made using the Holt-Winters exponential smoothing method. The forecast was made on the basis of a teaching series for twenty-one future periods. The results are summarised in Figure 8. Visual observation of Figure 8 allows us to state that in the teaching series prediction, the phenomenon of seasonality is visible.

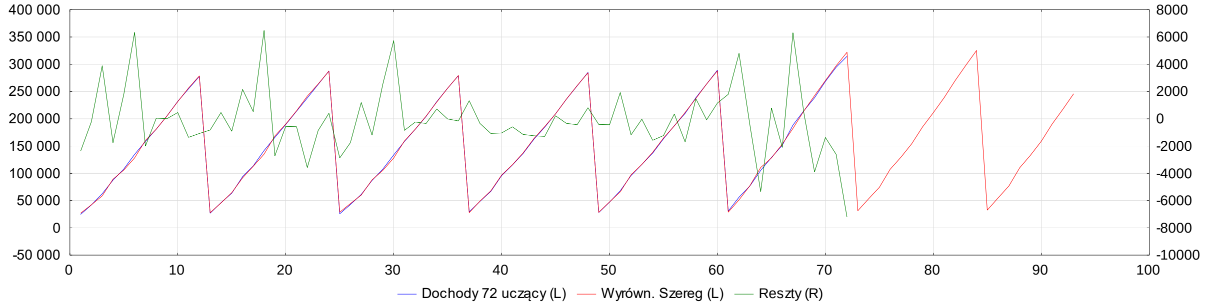

Figure 8. Forecast of the teaching time series for twenty-one periods performed with the Holt-Winters exponential smoothing method
Source: own elaboration.

The next stage of the analysis was to examine the average absolute error of the forecast. The results are shown in Table 2.

Table 2. Indicators of the average absolute forecast error for the Holt-Winters method

	MAPE HW
Average	10,68

Source: own elaboration.

The Holt-Winters method has an average absolute forecast error of 10,68.

The second forecasting method used was the SARIMA model. The first stage of building the SARIMA model was to verify the significance of the predictors used (Table 3).

Significant predictors according to Table 3 were variables q1 and Ps 1.

The forecast results are presented in Figure 9. Visual observation of Figure 9 allows us to state that in the teaching series prediction, the phenomenon of seasonality is visible.

Next, the average absolute error of the forecast was examined (Table 3). The analysis of two prognostic methods allowed us to choose the best one. The best method was the SARIMA model, which average absolute error in the forecast was the lowest and amounted to 3.93.

Table 3. Construction of the SARIMA model for teaching series

Parameter	Model:(0,2,1)(1,0,0) Seasonal delay: 12 Remainder MS= ,12778					
	Parameter	Asymptote	Asymptote	p	Bottom lim.	Top lim.
q(1)	0,814551	0,092043	8,84972	0,000000	0,630883	0,998219
Ps(1)	0,967727	0,067302	14,37877	0,000000	0,833427	1,102027

Source: own elaboration.

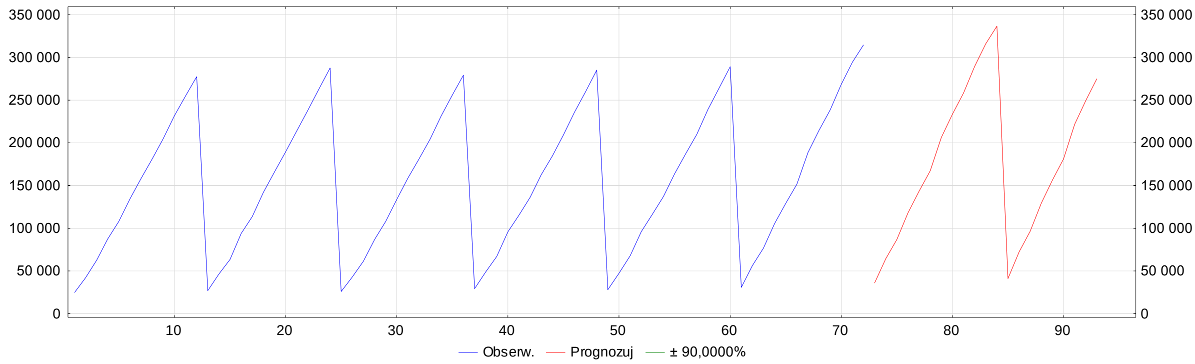

Figure 9. Forecast of the teaching time series for twenty-one periods made with the use of the SARIMA model
Source: own elaboration.

This became the reason for forecasting the original series of budget revenues by way the SARIMA model. The first stage of the study was to build an appropriate model and to check its predictors (Table 4). Significant predictors according to Table 4 were variables q1 and Ps 1.

Table 4. Indicators of the average absolute forecast error for the SARIMA model

	MAPE SARIMA
AVERAGE	3,93

Source: own elaboration.

Table 4. Construction of the SARIMA model for the primary series

Parameter	Model:(0,2,1)(1,0,0) Seasonal delay: 12 Remainder MS= ,09860					
	Parameter	Asymptote Std. error	Asymptote t(89)	p	Bottom lim. 95%l. of conf.	Top lim. 95%l. of conf.
q(1)	0,814349	0,079800	10,20492	0,000000	0,655789	0,972909
Ps(1)	0,980169	0,048941	20,02774	0,000000	0,882925	1,077413

Source: own elaboration.

This became the basis for forecasting for the fifteen future periods. The results are shown in Figure 10. Visual observation of the forecast presented in Figure 10 allows us to conclude the existence of a seasonality phenomenon as well as of a trend of a growing nature.

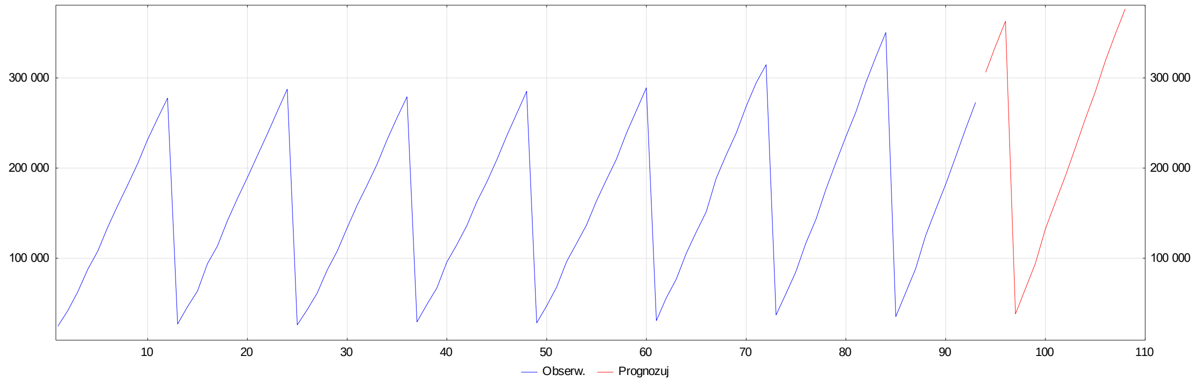

Figure 10. Forecast of the time series with the use of SARIMA model (0,2,1) (1,0,0) ln (x) for the primary series for fifteen future periods
Source: own elaboration.

Detailed forecast results are presented in Table 5. This table shows that budget revenue in 2019 would be higher than in the previous year. Moreover, it is possible to observe in the forecast the seasonality and trend factors that result from the economic and political specificity of Poland.

Table 5. The results of forecast with the use of SARIMA model (0,2,1)(1,0,0) lnx of data on budget revenues in Poland between 2011-2018 for fifteen future periods

No.	Month	Forecast of country budget revenues for 15 future periods from September 2018 to December 2019
1	October 18	287 838,24
2	November 18	297 971,79
3	December 18	309 503,33
4	January 19	97 853,19
5	February 19	135 250,13
6	March 19	157 122,13
7	April 19	189 408,72
8	May 19	212 833,06
9	June 19	228 924,52
10	July 19	258 271,98
11	August 19	283 061,75
12	September 19	307 939,08
13	October 19	317 871,63
14	November 19	328 124,54
15	December 19	338 708,16

Source: own elaboration.

Conclusions

The goal of this article has been achieved. Analysis and assessment of time series of budget revenues in Poland between 2011-2018 were carried out and forecast for fifteen future periods (months – 2019).

In order to select the correct forecasting model, it was necessary to thoroughly analyse and evaluate historical data on the time series regarding budget revenues between 2011-2018. The assessment became the premise for choosing two methods for forecasting. Forecasting methods were selected by way of the performing of critical analysis and the evaluation of literature. The literature shows that with the detected dependencies in the analysed time series, the best methods would be: the Holt-Winters method and the SARIMA model. Following the analysis and evaluation of both methods, it was deemed that the SARIMA model would prove to be the best. The model was used to forecast the primary time series on a monthly basis between 2011-2018 for fifteen future periods.

Total budget revenues should amount to PLN 2 855 368,89 in 2019. The arithmetic average for the twelve months in 2019 was at PLN 237 947,40. However, the median was higher and amounted to PLN 243 598,25. The distribution of the forecast is left-skewed (skewness index -0,37), more flattened than normal (asymmetry index -1,14).

The information obtained regarding the analysis and evaluation of budget revenue data is extremely important from the point of view of the main macroeconomic problems, as it facilitates the making of many planning decisions related to the planning of the spending of these funds.

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