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FORECASTING THE RESERVE MONEY OF THE CENTRAL BANK OF POLAND IN THE ASPECTS OF ECONOMY SECURITY[1]

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Abstract. Forecasting of monetary policy tools, including reserve money of the Central Bank of Poland, in order to optimise economic decisions made by business entities operating on this market, becomes a basic canon of knowledge, in order to minimise a risk of undertaken economic operations – is currently the area of our investigation. The article raises a problem of forecasting the reserve money of the Central Bank of Poland on the basis of initial information received from the National Bank of Poland. The studies started with analysis and evaluation of time series of reserve money of the Central Bank in Poland. Then the analysed series were divided into two parts. Based on obtained results, the researchers performed forecasting of the first part of separated time series of reserve money of the Central Bank in Poland with the use of different methods. The above mentioned time series consists of 132 elements. Later on, the researches chose the best forecasting method and that was the basis for initial time series forecasting of reserve money of the Central Bank in Poland in mil PLN in retrospective terms during 2010-2021 for the next 2021-2022 years.

Keywords: value of reserve requirements; forecasting; COVID-19; Central Bank; economy security

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JEL Classifications: G18

Additional disciplines: political sciences and administration, law

1. Introduction

Reserve requirements are considered as funds that constitute a certain part of deposits paid to commercial banks, which cannot be used to finance lending activities. These funds are transferred to a central bank account, which is run for each commercial bank. The analysis of source literature and authors' own experience show that institutions dealing with business forecasting use different methods of forecasting, including those inappropriate. In view of the foregoing, the authors became inspired to undertake studies in the field of forecasting. The research problem revolves around the choice of methods for forecasting the reserve money of the Central Bank in Poland, in order to optimise the obtained forecast results in the aspect of economic security of Poland. Dynamic in the research covers the years 2010-2021, and the executed forecast involves the year on a monthly basis. The aim of the study is to forecast the amount of monetary reserves held by the Central Bank in Poland

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for the years 2021-2022 in the aspect of the maintenance of economic security. The authors formulated the following research question: To what extent does the use of analysis and evaluation of time series of reserve money of the Central Bank in Poland in a retrospective perception allow for choosing an optimal forecasting method, in order to minimise the risk of financial undertakings and evaluate monetary policy of the state in the aspect of economic security? Literature related to forecasting issue is very extensive and dispersed. There are no accurate descriptions of methods for analysing and evaluating time series in a retrospective perception, building forecasting models and the ways of conducting in order to calculate the result of forecast. In terms of the following study, the most useful literature positions describing forecasts, but according to authors, they are not sufficient to conduct a detailed analysis and evaluation of considered in the study series of reserve money of the Central Bank in Poland. Analysis and evaluation carried out in a proper way and forecasting model built on their basis require also intuition and experience in this type of research. The article uses research methods in the form of literature analysis that relates to issues connected with the central bank reserves, forecasting, analysis of source documents, computer simulation method and comparisons. Forecasting of the considered retrospective data was performed with the application of three methods: Holt's, Klein and the ARIMA model. The best method turned out to be Holt's exponential smoothing which was used to forecast data on the amount of the required cash reserves of Central Bank for the years 2021-2022.

2. Reserve requirement ratio and forecasting

Reserve requirement rate, called also minimum reserve rate, is determined by the Central Bank for trade banks to stem excessive expansion in lending or stimulate credit activity of banks, depending on the needs of economy. Minimum reserves might refer to current, term and monetary contribution or without diversifying types of deposits (Owsiak, 2010, p. 79).

Maintaining the appropriate level of Central Bank reserves is extremely important from the point of view of economic security. Economic security is a state of reality that allows for the development of the economy and ensuring a proper standard of living for citizens through continuous access to raw materials, assets, technology or information (Szubrycht, 2006, pp. 87-98). The infectious disease COVID-19 undoubtedly had an impact on Polish economic security. The first case of the disease was reported in December 2019 in China (Tia, and others, 2020; Zhu, Zhang, Wang, Li X, Yang, Song, et al., 2020; Zimon, Jurgilewicz, Kmiotek, 2020). The infectious disease showed a rapid growing trend in various countries of the world and on March 11, 2020 WHO declared it a pandemic (E. Satomi, and others, 2020).

A large number of infected people and a high number of deaths have led to the introduction of many restrictions on the functioning of people in various countries of the world: the use of face masks, disinfectants, various types of travel restrictions and a ban on group gatherings (Yan et al., 2020; Pike, Saini, 2020). The COVID-19 pandemic led to a slowdown in the growth of world economies (Luisetto, Fiazza, Latishhev. 2020). It resulted in high levels of indebtedness in large economies, unfavorable demographic conditions in developed markets, a lack of political will to implement major structural reforms, and increased geopolitical and trade risks (https://global.beyondbullsandbears.com/pl/2020/07/27/kryzys-wywolany-przez-pandemie-covid-19-przyspiesza-transformacje-cyfrowa/ ; as of 19.11.2020).

The COVID-19 pandemic has had and continues to have an impact on the level of the required monetary reserves of the Central Bank of Poland. Therefore, it is extremely important to constantly analyze and evaluate the level of required reserves from the past in terms of their forecasting for the future.

The methodology used in the study may involve the planning of other types of variables in any entity in which the same regularities will be detected from the analysis and evaluation of data from the past and on the basis of which it will be possible, through a critical analysis of the literature, to choose the correct methods for the forecasting for the future. Examples of data analysis in terms of the detection of regularities such as trend or seasonality on not only financial data but, above all, on quantitative variables can be found in many literature items (Luszniewicz, 2003, pp. 143-160; Kozicki, Waściński, Brzeziński, Lisowska, 2018, pp. 1235-1241; Ko-

zicki, 2020; Rabej, 2018, pp. 43-278). However, the building of models itself for data forecasting is widely described in the literature by various researchers (Forlicz, 2012, pp. 333-349; Kuźniak, red. nauk. M. Podgrodzka, 2018, pp. 83-92; Skudlik, 2015, Puławska-Turyna, 2011; Chan Raymond H., Lee Spike Tsz Ho, 2014; Elliott, Timmermann, Economic forecasting; Franses, Dick van Dijk, Opschoor, 2014; Kot, Jakubowski, Sokołowski, 2011; Makridakis, Wheelwright, Hyndman, 1998).

The issue of forecasting the reserve money of the Central Bank in Poland that was taken up by the authors is important, because its growth or decrease effectively affects the size of money circulation in Poland and allows it to be limited. According to P. Dittmann, forecasting is a rational, scientific prediction of future events (Dittmann, 2016, p. 20), and its aim is to reduce the risk associated with making a mistake. This is very important while planning the reserve requirement ratio of the Central Bank. In market economies, the central bank plays an essential role. It performs three basic functions, such as: an issuing bank, a bank of the banks, a central bank of the state (Narodowy Bank Polski, 2021).

There are many different classifications of forecasting methods in the literature, but division of methods into quantitative and qualitative is one of the most commonly used. From the point of view of this study, the authors will use quantitative methods. The choice of appropriate methods will be preceded by an exact analysis and assessment of time series of ecology costs in the retrospective perception.

3. The analysis and evaluation of time series of the Central Bank reserve money in millions of PLN during the years 2010-2021

The research began with the outlining of the data obtained from the website of the National Bank of Poland concerning the amount of the required cash reserves held in Poland from January 2010 to August 2021. The data is outlined in Figure 1.

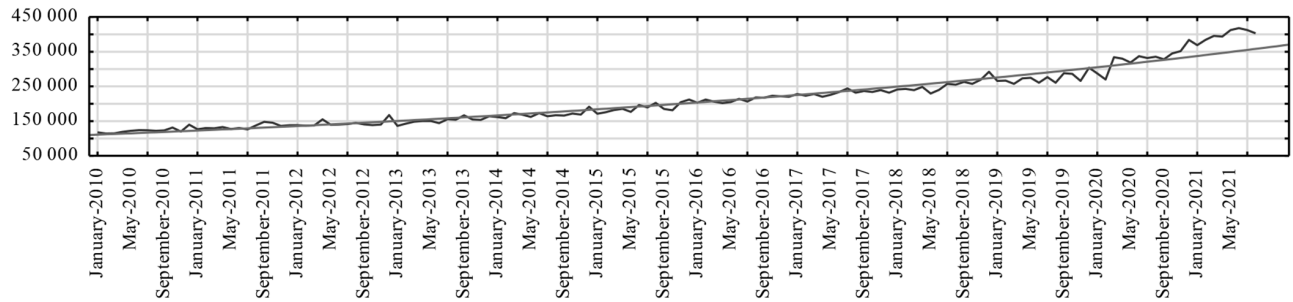

Figure 1. A linear graph of the number of required cash reserves of the Central Bank in Poland from January 2010 to August 2021 in million PLN

Source: https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/rezerwowy.html (Date of access: September 29, 2021.

The evaluation of the data presented in Figure 1 is the observation of regularities – an increasing trend. A function that takes an exponential shape was fitted to the outlined data. In total, 140 variables are presented in the chart. Their sum is PLN 29 698 992,59 million. The arithmetic mean of the analyzed data was PLN 212 135,66 and the median was PLN 202 373,79. Standard deviation was at the level of PLN 77 473,47 million. There was also a strong increase in the level of reserve requirements at the Central Bank in Poland caused by the COVID-19 infectious disease pandemic from March 2020.

The next stage of the research was the search for outliers and extreme values from the median of the analyzed data. To achieve this goal, a histogram was made (Fig. 2).

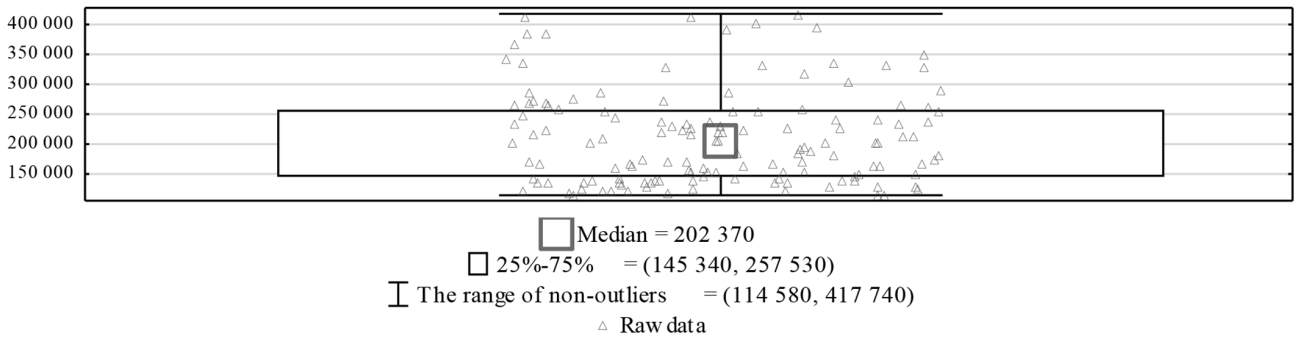

Figure 2. Histogram of the amount of the required cash reserves of the Central Bank in Poland

Source: https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/rezerwowy.html
(Date of access: September 29, 2021.

The evaluation of the data presented in Figure 2 is that they lack outliers and extreme values. The lower limit of the outliers was PLN 114 580 million and the upper one was PLN 417 740 million. Then, the distribution of the data under consideration was investigated. For this purpose, a normality graph was made with the Shapiro-Wilk test. The results are outlined in Figure 3.

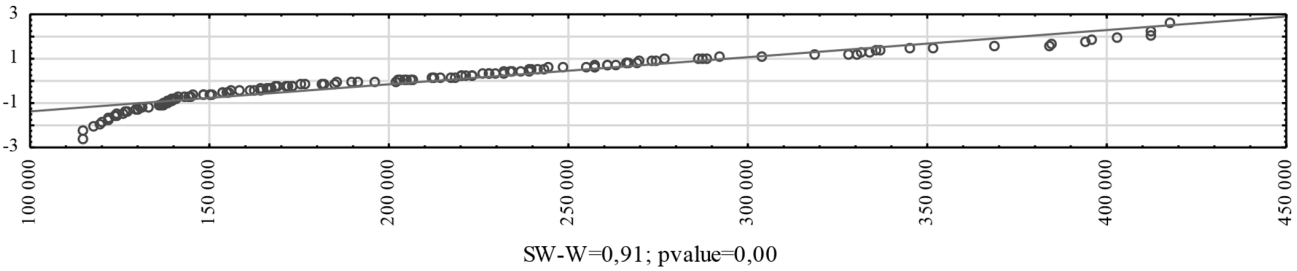

Figure 3. The normality graph with the Shapiro-Wilk test of the amount of the Central Bank's required cash reserves in Poland

Source: https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/rezerwowy.html
(Date of access: September 29, 2021.

The visual observation of Figure 3 shows that the distribution of the considered data is not normal. The lack of normality of the distribution is confirmed by the result of the obtained Shapiro-Wilk test where the p value is lower than the significance level. Then, the relationship in the delays of the primary time series under consideration was investigated. To achieve this goal, the following were used: autocorrelation (Fig. 4) and partial autocorrelation (Fig. 5).

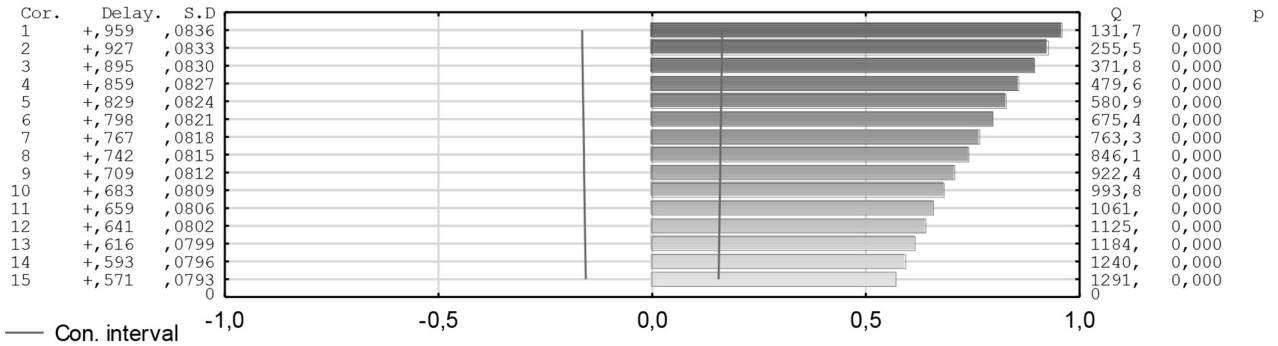

Figure 4. Autocorrelation of the amount of the required cash reserves of the Central Bank in Poland

Source: https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/rezerwowy.html
(Date of access: September 29, 2021.

The autocorrelation (Fig. 4) indicates the existence of dependencies as an increasing trend. The respective autocorrelation coefficients are higher than two standard deviation and the Q statistic increases strongly. P value is below the significance level.

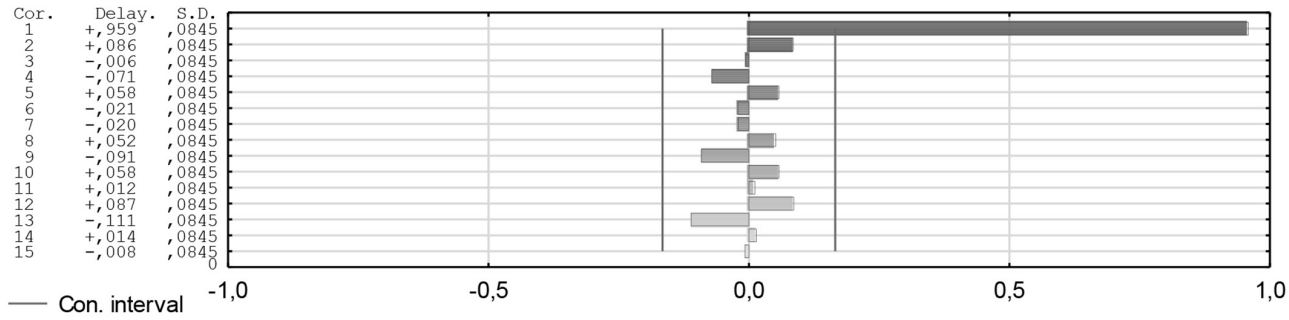

Figure 5. Partial autocorrelation of the amount of the required cash reserves of the Central Bank in Poland

Source: https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/rezerwowy.html
(Date of access: September 29, 2021.

The partial autocorrelation (Fig. 5) confirms the strong upward trend of the considered primary time series.

The next stage of the research was to confirm the existence of the trend in the considered time series. To confirm the correctness, a model consisting of three predictors was built. Significant predictors are summarized in Table 1.

Table 1. Multiple regression model

N=140	R= ,98441518 R^2= ,96907324 Correctness R2= ,96839103 Standard error of estimation : 13774					
	b*	**Standard error**	**b**	**Standard error**	**t(136)**	**p**
Absolute term			100361,8	8634,398	11,62348	0,000000
t	-0,551141	0,141934	-1052,8	271,118	-3,88307	0,000160
t^2	1,353830	0,101562	17,8	1,333	13,33008	0,000000
lnt	0,210600	0,055492	17316,5	4562,833	3,79512	0,000221

Source: https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/rezerwowy.html
(Date of access: September 29, 2021.

The multiple regression model, which was constructed, fits very well. The adjusted R2 was 0,97. The standard error of estimation was PLN 13774. Significant predictors confirm the existence of an exponential trend. The next stage of the research was the analysis and evaluation of the residuals of the constructed multiple regression model. Thus, a line graph of predicted and observed values was used (Fig. 6).

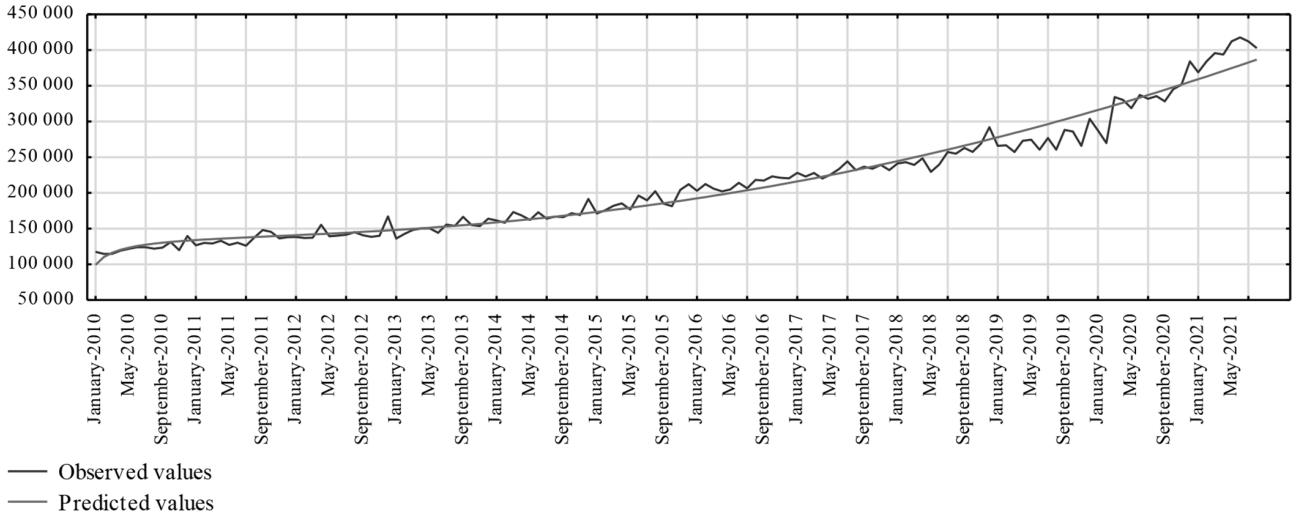

Figure 6. Line graph of predicted and observed values in million PLN

Source: https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/rezerwowy.html
(Date of access: September 29, 2021.

The evaluation of Figure 6 is a good match between predicted and observed values.

Then, in Figure 7, a line graph of the residuals of the constructed multiple regression model is outlined.

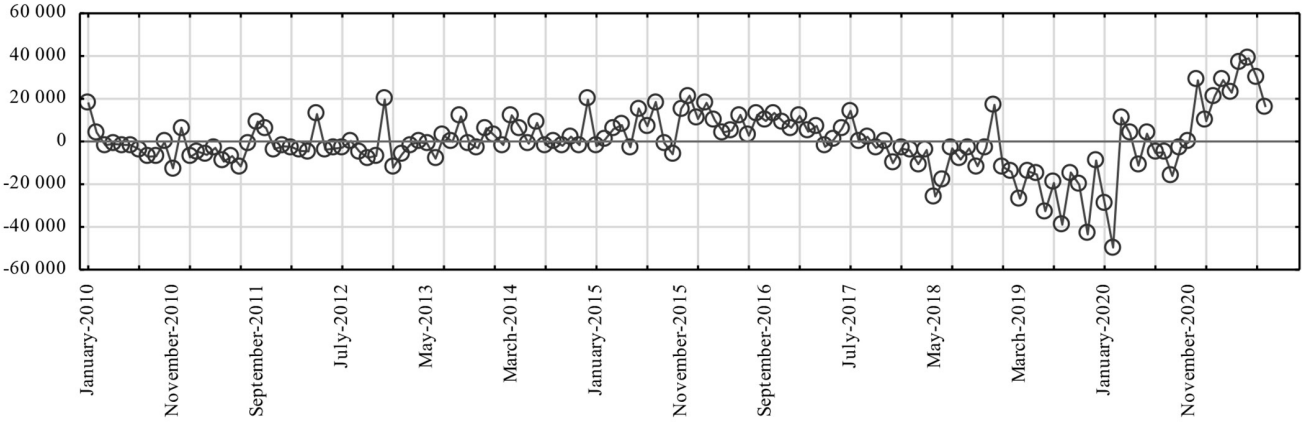

Figure 7. Line graph of the multiple regression model residuals in million PLN

Source: https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/rezerwowy.html
(Date of access: September 29, 2021.

The arrangement of the residuals of the constructed multiple regression model indicates the existence of a dependencies in their delays. This, in turn, is a premise for the use of autocorrelation (Fig. 8) and partial autocorrelation (Fig. 8).

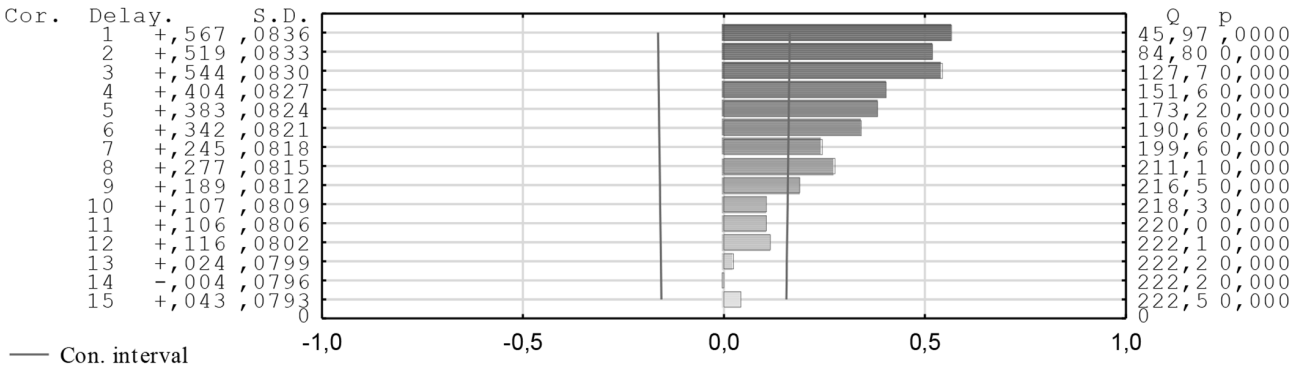

Figure 8. Autocorrelation of multiple regression model residuals

Source: https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/rezerwowy.html (Date of access: September 29, 2021.

The autocorrelation (Fig. 8) indicates the existence of dependencies in the residuals of the constructed model and, thus, the absence of the white noise phenomenon.

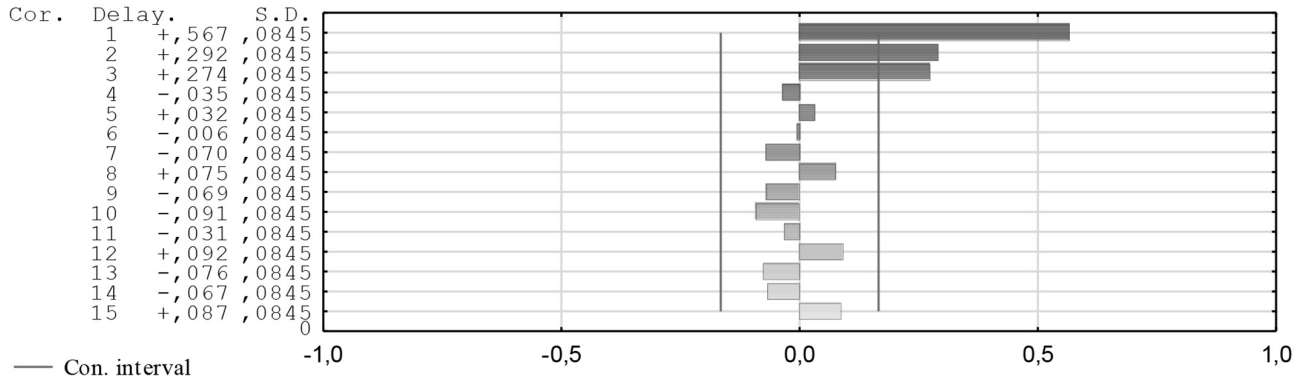

Figure 9. Partial autocorrelation of multiple regression model residuals

Source: https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/rezerwowy.html (Date of access: September 29, 2021.

The partial autocorrelation (Fig. 9) confirms the existence of dependencies in the residuals of the constructed model. The evaluation of the conducted analyzes of the time series of the amount of cash reserves held at the Central Bank in Poland is the observation of a regularity as an upward trend. The analysis of the literature on the subject of the research shows that the best method for the forecasting of the considered data with such regularities is actually three methods: Holt's, Klein and the ARIMA model. To evaluate the forecasts obtained, the primary time series was divided into two parts: teaching and testing (Fig. 10).

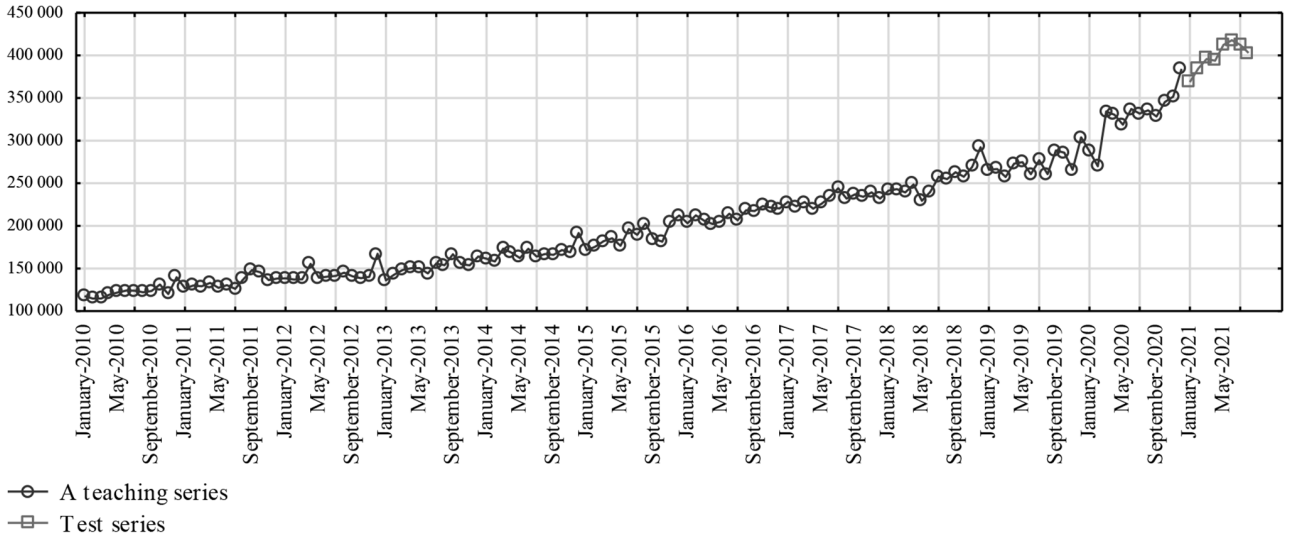

Figure 10. The division of the main time series into two parts: teaching and testing in million PLN

Source: https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/rezerwowy.html
(Date of access: September 29, 2021)

The teaching time series will be used to build forecasting models for the future and the testing one will be used to evaluate the obtained forecasts.

The forecasting results using three methods along with the testing time series are summarized in Figure 11.

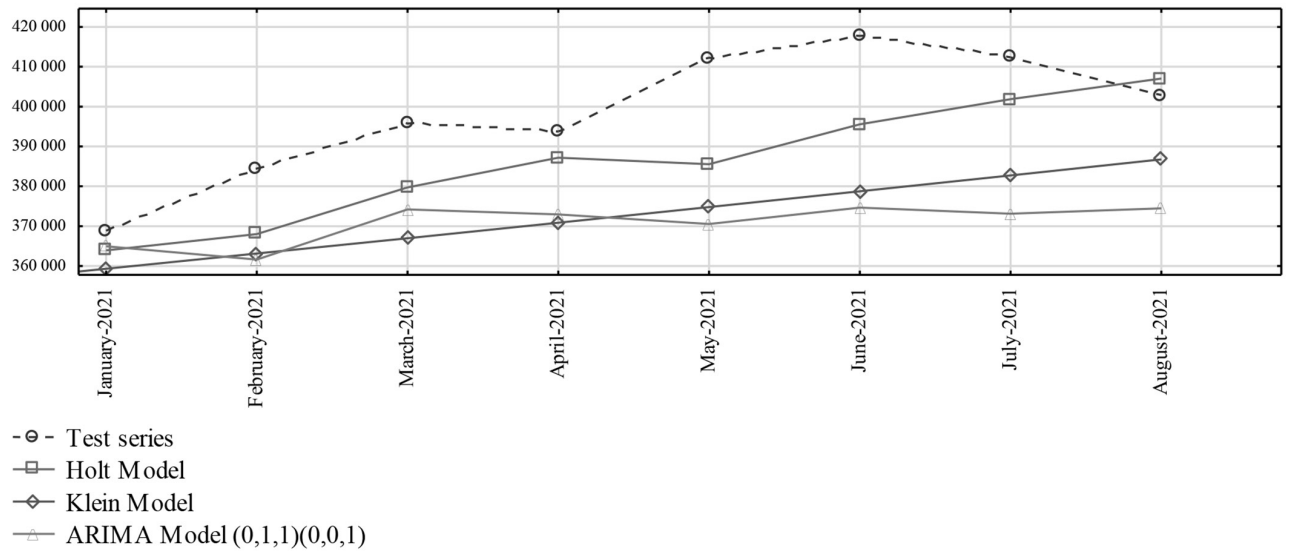

Figure 11. Comparative analysis of forecasts made with the following methods:
Holt's, Klein, ARIMA with a testing series in million PLN

Source: https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/rezerwowy.html
(Date of access: September 29, 2021.

Visual observation of the information outlined in Figure 11 allows for the conclusion that the best method for the forecasting of the considered data for the future is the Holt's exponential smoothing method.

In order to confirm the observed regularity, the analysis of the error residuals of the obtained forecasts was performed in Table 2.

Table 2. Forecasting errors analysis

	Holt's	Klein	ARIMA
MAPE	3,33%	6,36%	6,84%

Source: https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/rezerwowy.html
(Date of access: September 29, 2021.

The evaluation of the forecast error analysis conducted in Table 2 is that the best forecasting method is Holt's exponential smoothing. This became a premise for the forecasting of the considered time series of data on the amount of required cash reserves held by the Central Bank in Poland. The forecasting results for the years 2021-2020 are summarized in Figure 12.

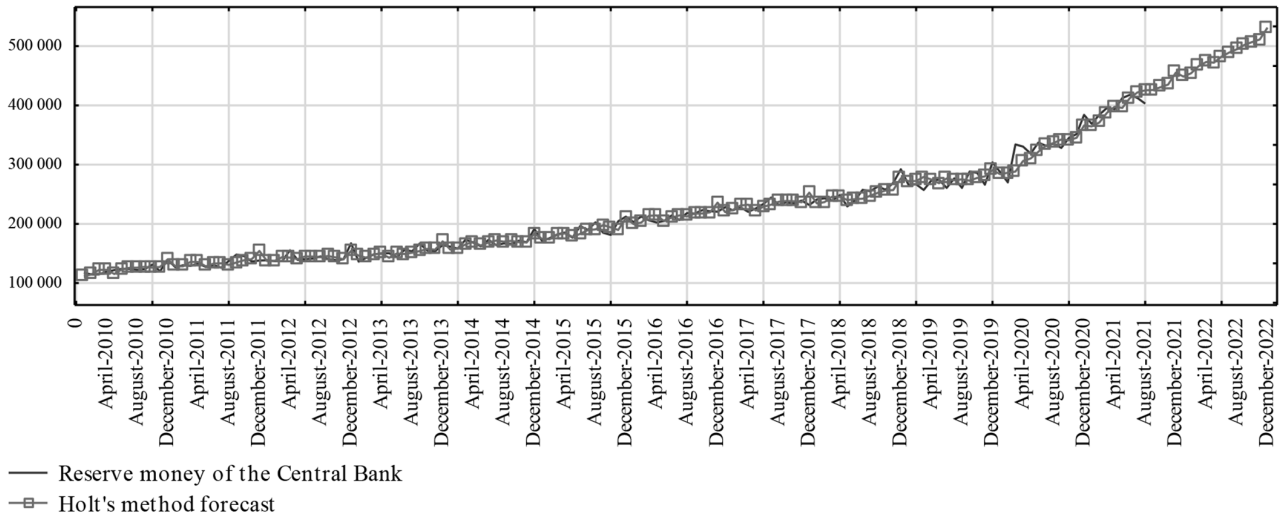

Figure 12. Forecasting of the time series of the required cash reserves in the Central Bank in Poland for the years 2021-2022 in million PLN

Source: https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/rezerwowy.html
(Date of access: September 29, 2021.

The evaluation of the forecasts obtained is the confirmation that a strong upward trend is maintained. The following table presents detailed forecasting results of the time series of statutory reserve of the central bank in mil PLN on a monthly basis during the years 2010- 2021. The above-mentioned time series consisted of 140 out of 16 future periods and its analysis was conducted with the use of the Holt's method.

Table 3. Results of the forecast made by the Holt method and based on data concerning time series of reserve money of the central bank in mil PLN on a monthly basis during the years 2010-2021, consisting of 140 periods.

Month-Year	Observation number	Holt's method forecast
September-2021	141	426087,834
October-2021	142	430805,1
November-2021	143	435210,749
December-2021	144	455208,727
January-2022	145	448740,021
February-2022	146	454221,581
March-2022	147	466341,631
April-2022	148	473283,139
May-2022	149	472100,912
June-2022	150	482544,615

July-2022	151	489284,952
August-2022	152	494812,709
September-2022	153	502234,102
October-2022	154	506951,367
November-2022	155	511357,016
December-2022	156	531354,995

Source: https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/rezerwowy.html
(Date of access: September 29, 2021.

The estimated amount of the required reserves at the Central Bank in Poland for 2021 is PLN 4 923 814 million while in 2022 it will increase to the level of approximately PLN 5 833 227 million. The monthly arithmetic average of the required reserves held at the Central Bank in Poland in 2021 will amount to PLN 410 317,8 million and in 2022 it will increase to PLN 486 102,3 million. The MAPE of the obtained forecast was at the level of 3,24%. Thus, it should be assumed that the obtained forecast is very good.

4. Conclusions

The analysis and assessment of the time series of statutory reserves of the Polish central bank in mil of PLN indicates the existence of upward trend. This is a result of economic growth of Poland (which is measured using growth rate of real production or real national income) and protection against financial crises emerging around the world. As a result of conducted studies, the answer to the research question supports the need for analysing and assessment of series of statutory reserves of the central bank in Poland in millions of PLN during the years 2010-2021, in order to choose appropriate forecasting method and conduct a forecast. Applying the Holt method with the maintained upward trend of reserve money of the Polish central bank in mil PLN may improve forecasting for institutions dealing with analysis, assessment and forecasting of retrospective data concerning national economy. The forecast of required reserves at the Central Bank in Poland for 2021 is PLN 4 923 814 million while in 2022 it will increase to the level of approximately PLN 5 833 227 million. The MAPE of the obtained forecast was at the level of 3,24%. Thus, it should be assumed that the obtained forecast is very good.

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