ANALYSIS OF THE CPI INFLATION INDEX OF SELECTED WORLD ECONOMIES IN THE ASPECT OF SAFETY

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Abstract. *The article deals with the problem of analyzing and assessing the CPI inflation index of selected world economies and attempts to forecast the CPI inflation index - (Consumer Price Index) in China in terms of security. The other two indices, i.e. the GDP Deflator and PPI- (Production Price Index) will not be analyzed.*

The study began with the analysis and assessment of CPI inflation indices in selected global economies. Then, an analysis and assessment of the time series of the CPI inflation index in China were carried out. For research purposes, the series has been shortened by the last nine periods. The obtained results were used to select and apply various methods to forecast CPI inflation in China based on a shorter series called the learning one in the literature. The obtained forecasts were compared, and then subjected to analysis and assessment. The best forecasting method for 15 periods was chosen based on the CPI inflation time series in China in retrospective terms. The obtained research results are presented in the summary.

Keywords: forecasting, inflation, modelling, security

Introduction

According to the authors, inflation forecasting is still an important issue in the functioning of world economies in terms of security. Economic entities at the financial market and fiscal policy level make attempts to forecast inflation indices in order to stabilize specific macroeconomic problems.

The aim of the article is to analyze and evaluate CPI inflation indices in selected world economies, and to try to forecast the Chinese CPI inflation index for fifteen future periods in terms of safety.

The article uses **research methods** in the form of literature analysis concerning issues related to CPI inflation indices and its forecasting, analysis of source documents, computer simulation methods, and comparisons. Moreover, the following **research tools** were used: quartile chart, autocorrelation, partial autocorrelation, multiple regression, histogram, Shapiro-Wilk test, Grubbs's test.

The article consists of the introduction, four substantive points, summary and conclusions.

Literature analysis

A critical analysis of the literature allows the conclusion that inflation is a sustained increase in the price level in the entire economy over an extended period of time, combined with a large loss in value of money. On the other hand, the index of CPI inflation measures the increase in the prices of consumer goods (Begg, Vernasca, Fischer, Dornbusch, Macroeconomics, p. 414).

In world economies such as the USA, China, Japan and Canada, a low level of inflation has been observed in recent years, which, according to some authors, may change dramatically (https://www.weforum.org/agenda/2015/05/whats-causing-americas-low-inflation/). One of the world's largest economies is undoubtedly China. Therefore, forecasting the Chinese CPI inflation index becomes an extremely interesting issue by performing retrospective data observations in order to select methods for forecasting them for the future.

According to M. Cieślak (Cieślak, 2001, p. 18) and A. Zeliaś (Zeliaś, 1997, p. 16) is understood as a rational and scientific prediction of future events. Whereas J. Greń (Greń, 1978, p. 3-4) believes that "forecasting (i.e. prediction) is a practical activity (operation) aimed at formulating a scientifically justified assessment, i.e. estimating the probable state in the future on the basis of the possessed information from the past and knowledge about a given fragment of reality that is the subject of forecasting." According to P. Dittmann, forecasting is a rational, scientific prediction of future events (Dittmann, 2016, p. 15). However, the purpose of forecasting is to reduce the risk of making a mistake. It is important in decision-making processes related to the allocation of funds for investments in terms of security. According to R. Zięba, security is an existential need related to the existence of a given subject (Zięba, 2012, p. 8). One of the forms of ensuring safety is the correct obtainment of forecasting results.

In literature, economic security is considered to be the certainty of the survival and development of the state's economic system (Nurzyńska, 2016, p. 22). Maintaining CPI Indices at an appropriate level helps to maintain security.

The most frequently used classification of forecasts is the division according to the nature and structure in which **quantitative** and **qualitative methods** have been distinguished. From the point of view of the article, quantitative methods will be used including the Holt's and ARIMA exponential smoothing method.

Data analysis of the cpi inflation index of selected state economies

The analysis in the first substantive point began with the compilation of the data on the monthly CPI inflation index between 2011-2018 in Canada, Japan, China, the USA, Russia and Poland on a line chart (Figure 1).
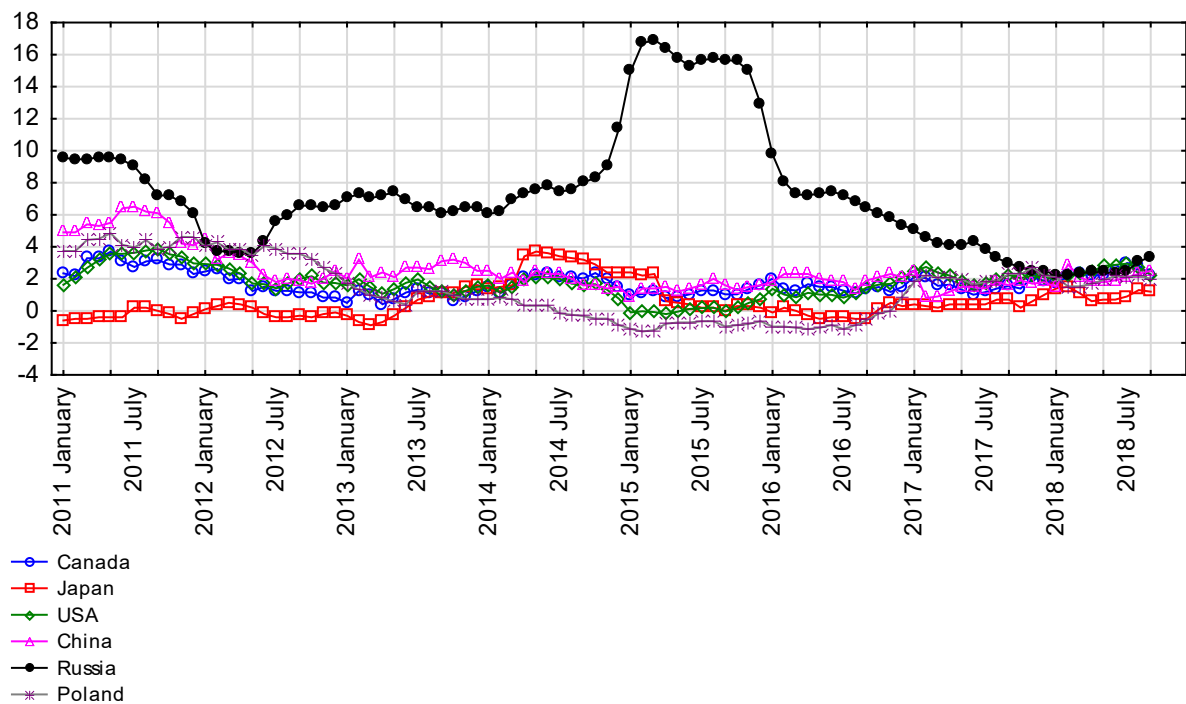

Fig. 1. Line chart of the CPI inflation index in China, the USA, Canada, Japan, Russia and Poland
Source: https://data.oecd.org/unemp/unemployment-rate.htm

Visual observation of the data presented in Figure 1 shows that the indices of CPI inflation in the USA, Canada, China, Japan and Poland are similar to each other. It should be emphasized that the indices of CPI inflation in Russia differ significantly from the others and they are irregular. The irregularity results from the sanctions imposed by the USA and the EU on Russia in 2014 in connection with its conflict with Ukraine in the Crimea. The sanctions increased the CPI inflation index between 2014-2015. Its stabilization has been visible since 2016.

The next stage of the study was the preparation of the correlation matrix for CPI indices in the analyzed economies. The results are summarized in Table 1.

Table 1. The correlation matrix of the inflation index in selected world economies

	Correlations of CPI inflation indices in selected world economies The marked correlation coefficients are significant with p < ,05000 N=93 (Missing data was removed at random)							
	Arithmetic mean	Standard deviation	**Canada**	**Japan**	**USA**	**China**	**Russia**	**Poland**
Canada	1,701816	0,715408	1,000000	0,072215	0,775012	0,638950	-0,220757	0,539458
Japan	0,605376	1,091207	0,072215	1,000000	-0,140117	-0,284677	0,060634	-0,367848
USA	1,770400	0,952552	0,775012	-0,140117	1,000000	0,646907	-0,629147	0,803272
China	2,486022	1,315757	0,638950	-0,284677	0,646907	1,000000	-0,052098	0,651725
Russia	7,266080	3,842073	-0,220757	0,060634	-0,629147	-0,052098	1,000000	-0,485850
Poland	1,396911	1,847469	0,539458	-0,367848	0,803272	0,651725	-0,485850	1,000000

Source: Own study based on the research, Warsaw 2018

The evaluation of the data presented in Table 1 is that Russia has the highest arithmetic mean and standard deviation of the CPI inflation index in the analyzed economies. The arithmetic mean was 7.26 and the standard deviation was 3.84. However, the lowest arithmetic mean and standard deviation of the CPI inflation index are in Japan. The arithmetic mean in Japan was 0.61 while the standard deviation was 1.09.

The correlation matrix presented in Table 1 shows that the economies of the USA and China have the greatest impact on CPI indices in respective countries.

For research purposes, a multiple regression tool was used for the dependent variable of China (Table 2) and explanatory variables in the form of CPI inflation indices of five economies under examination. Only the significant predictors are listed in Table 2.

Table 2. Multiple regression of the index of CPI inflation for the dependent variable China

N=93	R= ,81733937 R^2= ,66804365 Correctness R2= ,65685411 Standard error of estimation: ,77075					
	b	**Standard error ***	**b**	**Standard error**	**t(89)**	**p**
Free element			-1,08688	0,376214	-2,88901	0,004853
USA	0,735961	0,115404	1,01658	0,159407	6,37727	0,000000
Poland	0,340595	0,102629	0,24257	0,073092	3,31871	0,001312
Russia	0,576408	0,078641	0,19740	0,026932	7,32958	0,000000

Source: Own study based on the research, Warsaw 2018

Table 2 shows that the model was poorly fitted as the multiple R^2 was 0.69. Significant predictors for the Chinese dependent CPI variable are indices of the USA, Poland, and Russia CPI inflation. The standard error in the estimation of the constructed multiple regression model was 0.77. The evaluation of the data presented in the constructed multiple regression model is that the indices of inflation in China, the USA, Poland and Russia are to some extent dependent on each other.

Data analysis of the cpi inflation index in china

The following stage of the study was an attempt to forecast the CPI inflation index for one of the world's largest economies - China. The forecast was preceded by an analysis and evaluation of the time series of data on the CPI inflation index in China between 2011-2018.

The visual observation of the analyzed primary series allowed for the conclusion that in 2011 there were values that differed from the others which were considered typically random. For research purposes, in order to obtain correct forecast results, the analyzed time series of the CPI inflation index in China was reduced by data from 2011 and it is presented in Figure 2.
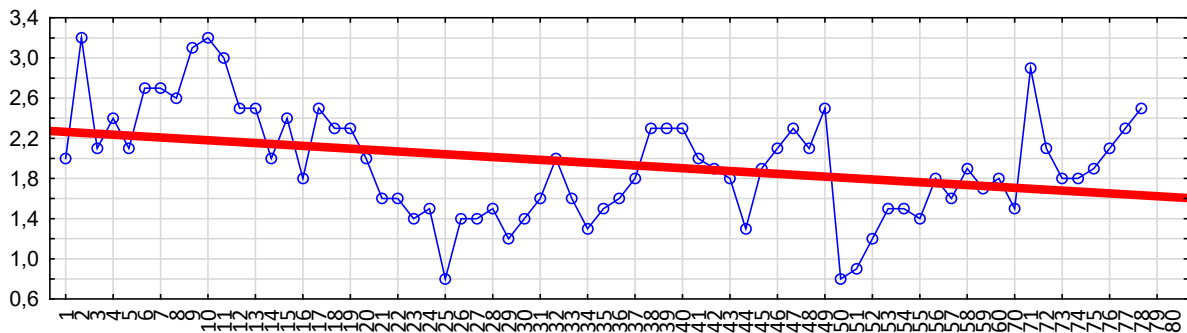

Fig. 1. A line chart of the CPI inflation index in China between 2012-2018
Source: Own study based on the research, Warsaw 2018

The visual observation of Figure 2 shows that there is a downward trend in the analyzed time series which is described with the function $Y = 2.2728-0.0083 \bullet X$.

Then, the relationships in particular lags in the time series of the inflation index in China between 2012-2018 were examined. For this purpose, research tools were used in the form of: autocorrelation (Figure 3) and partial autocorrelation (Figure 4).
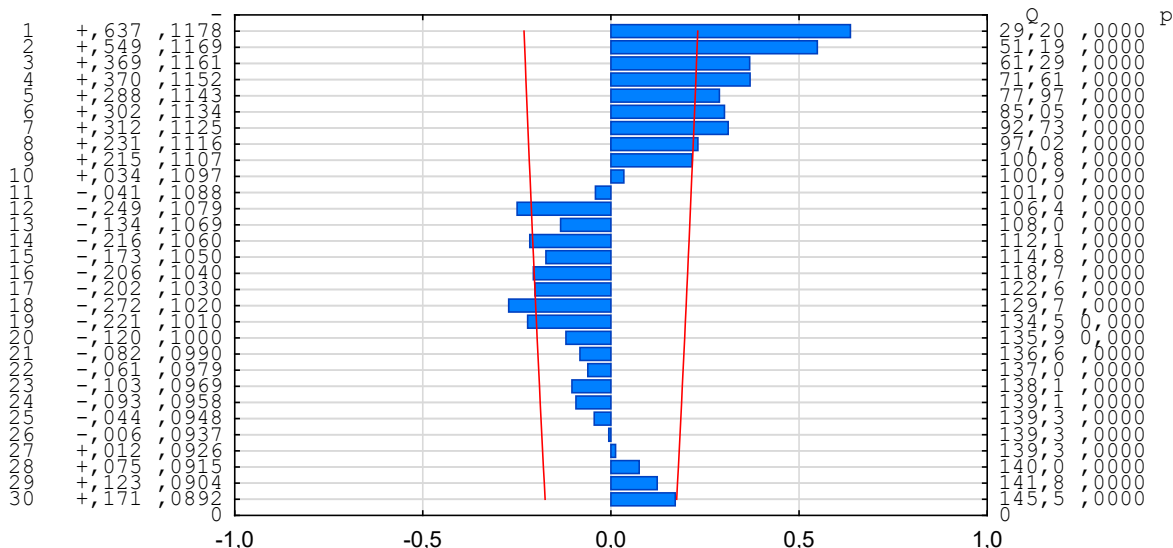

Fig. 3. Autocorrelation of the primary series of CPI inflation index in China between 2012-2018
Source: Own study based on the research, Warsaw 2018

The evaluation of the data presented in Figure 3 is the existence of a relationship in respective lags of the time series under consideration.
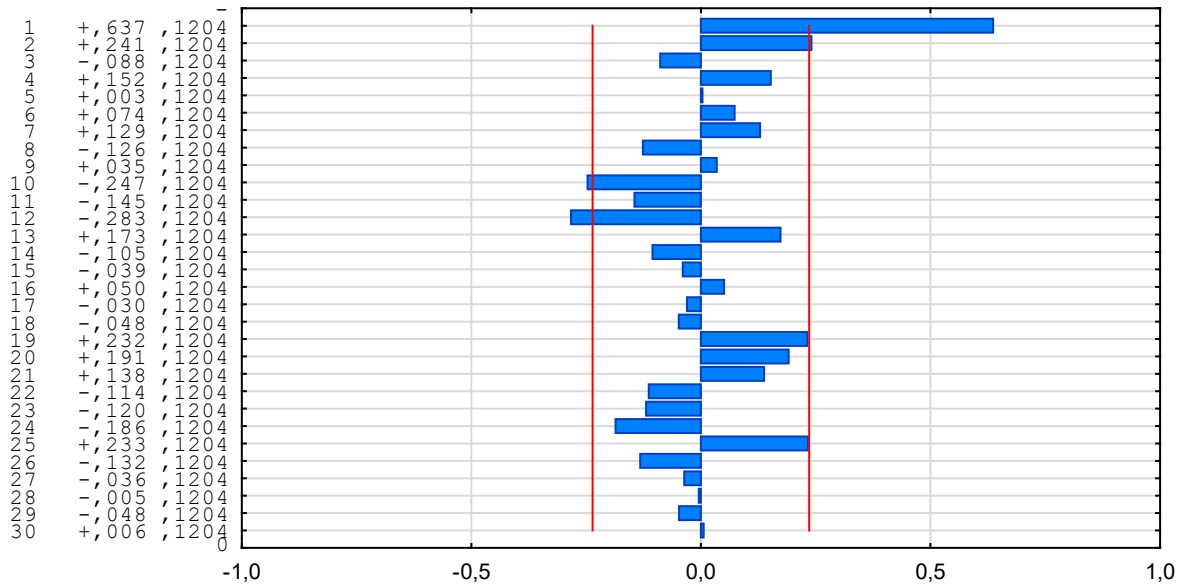
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 1  +,637 ,1204
 2  +,241 ,1204
 3  -,088 ,1204
 4  +,152 ,1204
 5  +,003 ,1204
 6  +,074 ,1204
 7  +,129 ,1204
 8  -,126 ,1204
 9  +,035 ,1204
10  -,247 ,1204
11  -,145 ,1204
12  -,283 ,1204
13  +,173 ,1204
14  -,105 ,1204
15  -,039 ,1204
16  +,050 ,1204
17  -,030 ,1204
18  -,048 ,1204
19  +,232 ,1204
20  +,191 ,1204
21  +,138 ,1204
22  -,114 ,1204
23  -,120 ,1204
24  -,186 ,1204
25  +,233 ,1204
26  -,132 ,1204
27  -,036 ,1204
28  -,005 ,1204
29  -,048 ,1204
30  +,006 ,1204
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Fig. 4. Partial autocorrelation of the primary series of the CPI inflation index in China between 2012-2018
Source: own study based on the research, Warsaw 2018

The existence of relationships in the lags of the time series of the Chinese inflation index was also confirmed with the use of a research tool in the form of partial autocorrelation presented in Figure 4.

The next stage of the study is an attempt to confirm the existence of the relationships in the considered time series of the inflation index in China. For this purpose, a zero-one model of multiple regression was built with fourteen predictors to detect trend and seasonality. The predictors were t, t2, lnt, and eleven binary variables for eleven months. Significant predictions are summarized in Table 3.

Table 3. Zero-one model of multiple regression

N=69	R= ,58756405 R^2= ,34523151 Correctness R2= ,32539004 Standard error of estimation: ,44912					
	b*	Standard error	b	Standard error	t(66)	p
Free element			2,879711	0,167021	17,24157	0,000000
t	-2,22250	0,403987	-0,060575	0,011011	-5,50142	0,000001
t^2	1,94182	0,403987	0,000733	0,000152	4,80664	0,000009

Source: Own study based on the research, Warsaw 2018

Table 4 shows that the t and t^2 variables are significant predictors which proves the existence of a trend.

The evaluation of all analyzes carried out in the article is the unambiguous detection of the trend. It became a premise that the Holt's smoothing method and the ARIMA model can be used to forecast the analyzed series as a result of a critical analysis of the literature.

Forecasting the CPI inflation measure in China

The following step was to divide the analyzed time series into a learning and testing part. The results are presented in Figure 5.
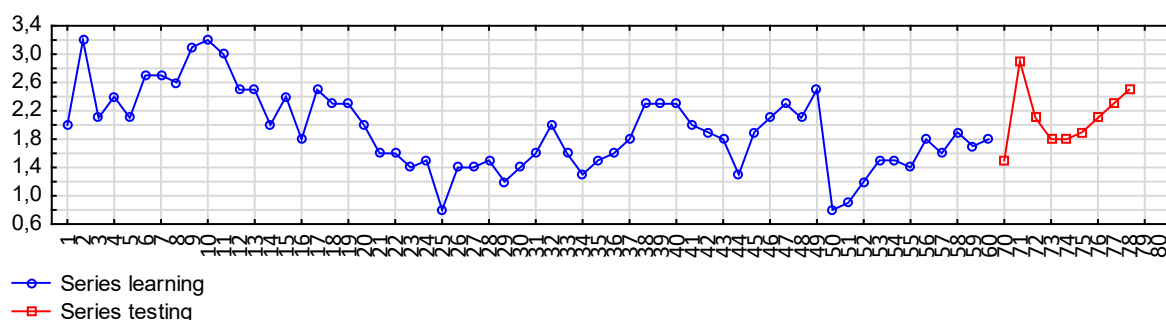

Fig. 5. Division of the primary series of the CPI inflation index in China into learning and testing parts
Source: Own study based on the research, Warsaw 2018

In Figure 2, the red line represents the testing series and the blue one - learning series. Based on the learning time series, forecasting for nine future periods was made. The Holt's exponential smoothing method was used to make the first forecast. The forecast results are presented in Figure 6.
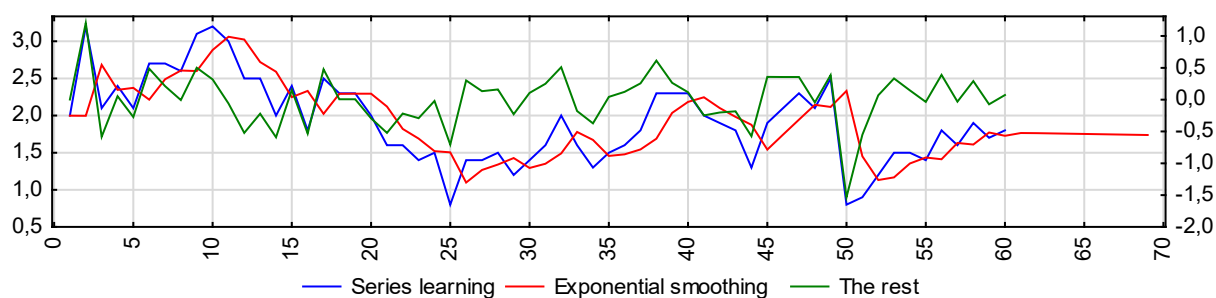

Figure 6. Forecast by Holt's exponential smoothing method of the learning series
Source: Own study based on the research, Warsaw 2018

The forecast obtained by the Holt's exponential smoothing method takes the shape of a straight line without a trend.

Then, the evaluation of the obtained forecast was carried out with the application of the mean absolute error of the forecast. The results are summarized in Table 4.

Table 4. Application of the mean absolute forecast error for the forecast made with the Holt's method

	HOLT'S MAPE
Mean	17,54

Source: Own study based on the research, Warsaw 2018

Table 4 shows that MAPE was 17.54% which proves the poor quality of the obtained forecast.

Another forecast was made by building the ARIMA model (1,1,0) (1,0,0) ln (x), D (1). The forecasting results of the ARIMA model are shown in Figure 7.
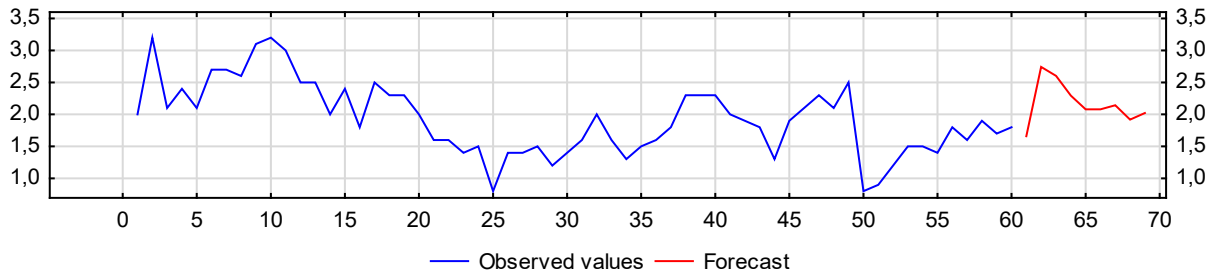
Fig. 7. Forecast of the learning series with the ARIMA model (1,1,0) (1,0,0) ln (x), D (1)
Source: Own study based on the research, Warsaw 2018

Visual observation of the data presented in Figure 7 allows to state that the obtained forecast takes the form of an upward trend in the first period and then a decreasing trend.

Then, the evaluation of the forecast obtained after the application of the ARIMA model (1,1,0) (1,0,0) ln (x), D (1) was performed with the use of the standard in the form of the mean absolute forecast error. The results are summarized in Table 5.

Table 5. Application of the mean absolute forecast error for the forecast made with the ARIMA model

	ARIMA MAPE
Mean	14,45

Source: Own study based on the research, Warsaw 2018

The evaluation of the data presented in Tables 4 and 5 is that the ARIMA model turned out to be the best forecasting method as the mean absolute forecast error was the lowest one here and amounted to 14.45%. This became the basis for forecasting of the primary time series of the CPI inflation index in China for fifteen future periods using the ARIMA model.

The forecast of the primary time series made with the ARIMA model (1,1,0) (1,0,0) ln (x) D (1) is presented in Figure 12 and Table 6.
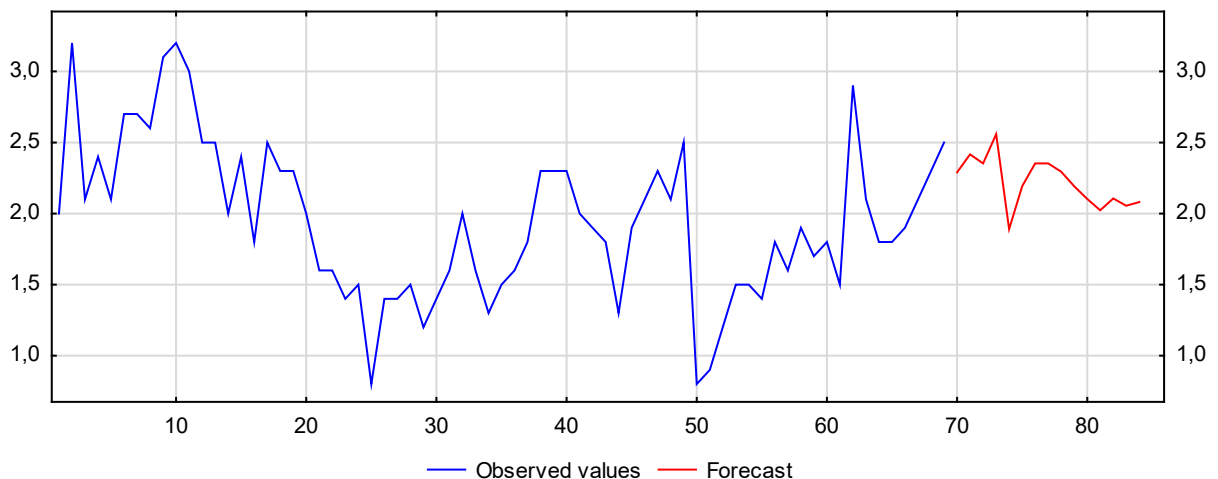

Fig. 8. Primary series forecast with ARIMA model (1,1,0) (1,0,0) ln (x), D (1)
Source: Own study based on the research, Warsaw 2018

The forecast shown in Figure 8 has been made for fifteen future periods. It hovers around the value of 2.2 of the CPI inflation index. The detailed results of the forecasting conducted with the ARIMA model are presented in Table 6.

Table 6. The results of the forecast made with the ARIMA model (1,1,0) (1,0,0) ln (x), D (1) based on the data on the CPI inflation index in China between 2012-2018

No.	Forecast of China CPI inflation index for 15 future periods
18-October	2,29
18-November	2,42
18-December	2,35
19-January	2,56
19-February	1,89
19-March	2,19
19-April	2,35
19-May	2,35
19-June	2,30
19-July	2,19
19-August	2,10
19-September	2,02
19-October	2,11
19-November	2,06
19-December	2,08

Source: Own study based on the research, Warsaw 2018

Table 6 shows that China CPI indices will follow a downward trend. The distribution of the forecast obtained is asymmetric on the right, more flattened than normal. The lowest forecast value is 1.89 - February 2019, and the highest one is 2.56 - January 2019.

Conclusions

The aim of the article has been achieved. The analysis and evaluation of the time series of CPI inflation indices of selected world economies in terms of security were conducted, as well as forecasting of the largest economy - China.

The evaluation of the visual observation of the CPI indices of selected world economies is that in Russia they differ significantly from the others and they are irregular. The irregularity results from the sanctions imposed by the USA and the EU on Russia in 2014 in connection with its conflict with Ukraine in the Crimea. Moreover, in economies such as: China, USA, Poland and Russia there is a linear relationship which was demonstrated using the research tool in the form of multiple regression.

One of the world's largest economies is China. This has become a reason to attempt to forecast China CPI inflation indices for the future. In order to select an appropriate forecasting model, it was necessary to carefully analyze and evaluate the information provided by the historical time series of the Chinese CPI inflation indices. Therefore, for the forecast based on the time series of CPI inflation indices in China, the most effective and accurate ARIMA models were selected and this was preceded by the analysis and evaluation of two forecasting methods.

The obtained forecast of the CPI inflation index in China takes the form of a downward trend. The arithmetic mean of the obtained forecast is 2.22. However, the median was lower and amounted to 2.19. The standard deviation was at the level of 0.18 and it proves that the obtained forecasts oscillate slightly around the level of the arithmetic mean - 2.22.

The information obtained on the analysis, evaluation of CPI inflation indices in selected state economies and forecasts of CPI inflation indices in China are extremely important from the point of view of the main macroeconomic problems as they allow for proper management of the production potential of the economy.

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