DOI: 10.28934/ea.22.55.1.pp90-104

ORIGINAL SCIENTIFIC PAPER

Forecast of Belex15 and Belexline Movement Using ARIMA Model

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ABSTRACT
Financial markets are known to be volatile and often unpredictable. Movement of stock indices and stock prices over time can be labelled with big oscillations during time, so financial institutions and other investors are constantly working on forecasting these movements, in order to adjust their business decisions and increase their profit. Aim of this research is to determine whether the ARIMA model, which is often used for short-term forecast, is suitable for forecasting of movement of Belgrade Stock Exchange indices. Subject of this research is forecast of Belex15 and Belexline indices based on historical daily data from 5th January 2009 until 31st March 2022. ARIMA model was used to forecast index values for the following 11 trading days - from 1st April until 15th April 2022. Methodology of this research consists of presenting and analysing empirical data of Belex15 and Belexline movements, choosing suitable ARIMA models for forecast and forecasting index values, which were then compared with real index values. Obtained results point to high accuracy of forecasted values and lead to the conclusion that ARIMA model is corresponding econometric method for short-term forecast of Belgrade Stock Exchange indices.

Key words: *Belex15, Belexline, Belgrade Stock exchange, forecast, ARIMA*

JEL Classification: G17

INTRODUCTION

Financial markets are known for great uncertainty and volatility of stock indices and stock prices. Financial institutions and other participants in financial markets, which act as investors, are constantly trying to predict movements on financial markets, as well as values of stock indices and stock prices, in order to adapt their decisions which would lead to profit. Even though it is difficult to predict movement on financial markets because of their volatility, certain econometrics methods are used for forecasting, among which the ARIMA model stands out for short-term forecasts.

So far, the ARIMA model was often used for forecasting in economics practice, but also for testing accuracy of this model when forecasting certain stock indices and stock prices movements. However, this type of empirical research has not been empirically researched in detail in Serbia and on Belgrade Stock Exchange indices (BSE).

Subject of this research are stock indices of Belgrade Stock Exchange – Belex15 and Belexline, which are analysed from 5th January 2009 until 31st March 2022 (in total number of observations is 3,336 trading days per index). Empirical data has been taken from Belgrade Stock Exchange.

Aim of this research is to determine whether ARIMA model is suitable for short-term forecasting of movement of stock indices Belex15 and Belexline. ARIMA model was used to

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forecast values of Belex15 and Belexline for 11 trading days – from 1st April 2022 until 15th April 2022. After these values have been forecasted, they were compared with real values to determine if it is possible to make an accurate forecast of Belex15 and Belexline using the ARIMA model, which is based on historical data.

Methodology of this research contains of presenting empirical data of Belex15 and Belexline, basic descriptive statistics, checking of stationarity, choosing potential ARIMA models and selecting the corresponding one, based on which forecast of indices values has been conducted and forecasted values were compared to real values.

In this paper two hypotheses are defined:

Hypothesis H1: ARIMA model is suitable for accurate forecast of movement of stock index Belex15 in period 1st April 2022 - 15th April 2022.

Hypothesis H2: ARIMA model is suitable for accurate forecast of movement of stock index Belexline in period 1st April 2022 - 15th April 2022.

This paper is divided into 6 parts: the first part is Introduction, where subject, methodology and aim of this research are expressed and hypotheses are defined. The second part is literature review, which contains so far empirical research which has used the ARIMA model to forecast stock prices and indices movements, in both Serbian capital market and foreign markets. Third part is the methodology of this research, which presents the theoretical background of the ARIMA model, which was used as guideline for the ARIMA model analysis and forecast. In the fourth part is presented empirical data of Belex15 and Belexline values, which is followed by selection of corresponding ARIMA models for both indices, as well as forecast of Belex15 and Belexline indices respectively. In the fifth part of this paper are presented results of forecasts which are then compared to real values, in order to determine if it is accurate to use the ARIMA model for precise forecast of movement of analysed indices. Conclusion is the last part of this paper, where findings are expressed and recommendation for future research is given.

LITERATURE REVIEW

Financial institutions and individuals participating in financial markets are encouraged to continuously work on and promote econometrics methods for forecasting, due to their need to make decisions about investing, as well as to plan daily and future steps on financial markets. Due to the nature of financial markets, forecasting stock indices movement or stock prices is a difficult task. Among techniques that stand out for forecasting is the ARIMA model (Autoregressive Integrated Moving Average), which is known for its efficient forecast of financial time series, especially for short-term forecasts. In 1970 Box and Jenkins introduced the ARIMA model, which consists of 3 steps – identification, estimation and diagnosis of the ARIMA model (Adebiyi, Adewumi & Ayo, 2014).

Among so far research, which aimed to forecast values of stock indices or stock prices movements, ARIMA model was often used, especially for short-term forecasts. Mondal, Shit & Goswami (2014) analysed the efficiency of the ARIMA model to predict movement of values of 56 companies from 7 sectors from National Stock Exchange India (NSE India). Used historical data was from April 2012 until February 2014 and obtained results point to over 85% of correctly predicted values for all sectors. Khan & Alghulaiakh (2020) used the ARIMA model to predict stock values of Netflix, using empirical data for 5 years (from 7th April 2015 until 7th April 2020).

Rotela, Salomon & de Oliveira Pamplona (2014) confirmed the efficiency of ARIMA model for short-term forecast of Bovespa stock index (index of Sao Paulo Stock Exchange), by using monthly historical data of closing price from January 2000 until December 2012. Wadi, Almasarweh & Alsaraireh (2018) conducted a short-term forecast of closing prices of index Amman Stock Exchange (ASE) using daily historical data from January 2010 until January 2018 and they empirically confirmed efficiency of ARIMA model for short-term forecast. Li, Yang & Li (2017) used Shanghai Composite Index monthly closing price from January 2005 until October 2016 to forecast the Index movement for the period July 2016 until October 2016. Average error of predicted values is 2,4% which confirmed efficiency of ARIMA model for short-term forecast.

Meher, Hawaldar, Spulbar & Birau (2021) used ARIMA model to predict stock prices of selected pharmaceutical companies in India (quoted on NIFTY100). Analysis contained historical data from 1st January 2017 until 31st December 2019 and it has confirmed that there are no significant deviations between predicted and real values.

ARIMA model has been used to predict future values of stock indices in our region and domestic indices as well. Among authors which have researched forecast of index values of Belgrade Stock Exchange, Stanković, Marković & Radović (2015) stand out, which have conducted a research in order to determine precision of forecast of Belex15 index values and its most important components (at the time of writing their paper, the most important components were: "Alfa Plam" a.d. Vranje, "Energoprojekt Holding" a.d. Beograd, "Metalac" a.d. Gornji Milanovac, "Sojaprotein" a.d. Bečej, AIK Banka a.d. Niš, Komercijalna banka a.d. Beograd). Method used for the forecast was The Least Square Support Vector Machine – LS-SVMs). Obtained results point to higher precision in the forecast of values of Belex15 index components than the forecast of the index itself. Marković et al. (2014) have confirmed accuracy of Belex15 index prediction using method LS-SVM – subject of the analysis has been data of Belex15 movement from 4th April 2005 until 30th March 2013. Petrović (2020) used ARIMA model to predict Belex15 values for coming 10 trading days and it has been empirically confirmed that ARIMA model was corresponding model for short-term forecast of index values. Used historical data contained from index opening price from 10th January 2014 until 21st December 2018. Jakšić, Milanović & Stojković (2020) conducted a short-term forecast of Belex15 and Belexline movement (used methods were Winter's additive and Winter's multiplicative method). Analysis was based on monthly data from January 2009 until February 2019.

METHODOLOGY

In the ARIMA model, future values of variables are predicted based on the linear combination of historical values and residuals (Pai & Lin, 2005).

ARIMA model is defined as ARIMA (*p,d,q*), where *p* represents autoregressive parameter of analysed data set (number of lags of AR model), *d* refers to integrated parts of data set, and *q* represents number of moving averages (number of lags of MA model) (Mondal, Shit & Goswami, 2014).

ARIMA model is an upgrade of ARMA model (Autoregressive Moving Average), which expresses the conditional mean of Y_t as a function of previous values $Y_{t-1}, Y_{t-2}...Y_{t-p}$ and previous residuals ε_{t-1}, $\varepsilon_{t-2}...\varepsilon_{t-p}$. Number of previous values (observations) on which Y_t depends (*p*) is AR degree, whereas number of previous residuals (*q*) is MA degree. To determine the range of AR and MA degree, significant deviations are examined and compared on the correlogram ACF and PACF (Meher, Hawaldar, Spulbar & Birau, 2021).

ARMA (*p, q*) model can be presented as:

$$Y_t = \emptyset_1 Y_{t-1} + ... + \emptyset_p Y_{t-p} + \varepsilon_t - \theta_1 \epsilon_{t-1} - \cdots - \theta_q \epsilon_{t-q} \quad (1)$$

Where Y_t is observed variable, ε_t is random error in time *t*, $\emptyset_i$ i θ_i are AR and MA coefficients, *p* and *q* are number of lags in AR and MA model. ARIMA model has an additional letter "I" in acronym of this model, which represents Integrated. ARMA (*p,q*) model which is differentiated *d* times is ARIMA (*p, d, q*) model (Mustapa, Hayati & Mohd, 2019).

To determine an appropriate model for forecasting, the first step is to define the degree of differentiation *d*, which is required in order to make the data stationary. Method which is frequently used for this is Augmented Dickey-Fuller test (ADF test). After parameter *d* is defined, parameters *p* (autoregressive parameters defined by Partial Autocorrelation function (PACF)) and q (moving-average parameters defined by Autocorrelation function (ACF)) need to be determined (Jarrett & Kyper, 2011). ACF provides information about the potential number of lags of MA model, whereas PACF provides information about the potential number of lags of AR model (Prorok & Paunović, 2015).

In order to begin with defining the ARIMA model, it is necessary to define is analysed data stationary – a graphic overview of the variable movement can point to this conclusion. Stationary data implies that mean and variance are constant over time. Beside from the graphic overview, autocorrelation function, ACF plot and Augmented Dickey-Fuller test are used to check stationarity. ACF plots autocorrelation of time series among lags, which point to differences between one observation and observation which precedes. If data is not stationary, it should be differentiated and in most of the cases it is enough to differentiate the data set only once (d=1) (Mustapa, Hayati & Mohd, 2019).

Belex15 and Belexline – empirical data and forecast of index values by using ARIMA model

Serbian stock market is considered to be new and not very developed. Period after 2000 was defined with numerous privatizations of public companies, and this has led to stimulation of trading on the secondary market. Until the financial crisis in 2008, the number of listed companies on market and trading volume was increasing, but after the financial crisis outburst, market liquidity has significantly decreased (Petronijević, 2018). Capital market in Serbia is still underdeveloped, with small trading volume and turnover. It is not fully regulated and transparent and the number of domestic and foreign investors is low (Kršikapa-Rašajski & Rankov, 2016). Small number of securities and government bonds are traded, transactions are expensive and slow, market capitalization is low – these are all labels of Serbian stock market today (Prorok & Radović, 2014).

Belgrade Stock Exchange indices Belex15 and Belexline are subject of this research. Belex15 is a leading index of BSE, which contains the most liquid Serbian shares and it is calculated in real time. Belexline is a general, benchmark index, which is calculated at the end of a trading day. Both indices are free-float market capitalization weighted indices, which are not adjusted for paid dividends and are not protected from dilution effect resulting from dividends payout.

Belex15 is composed of shares traded on the Regulated market, which have satisfied criteria for inclusion into the index basket. Each component is limited to a maximum of 20% of the total market capitalization of the index. Purpose of the Belex15 index is to improve the investment process, by measuring performance and stock prices of most liquid Serbian shares. It is calculated and published every working day in real time. Minimum number of index components is 7, whereas maximum is 15 and this decision is made by the Index Committee.

BELEXline is weighted only by free-float market capitalization. It consists of shares traded on the BELEX markets, which have satisfied criteria for inclusion in the index basket. Components limitation is up to 10% of index capitalization. Its purpose is to measure and keep track of price changes of shares which are traded on the BSE (which had fulfilled criteria for index basket) and to give insight into Serbian market movements. The Index Committee decides on composition of the index basket, which can have minimum 70 components and upper limit is not defined, since the purpose is to give good representation of total market movements (*Source: Belgrade Stock Exchange;* https://www.belex.rs/proizvodi_i_usluge/indeksi_opste).

Values of Belex15 and Belexline have been taken from Belgrade Stock Exchange and they are analysed on a daily basis from 5th January 2009 until 31st March 2022. Total number of observations is 3,336 for each index. In Figure 1 are presented movements of Belex15 and Belexline during the analysed period.

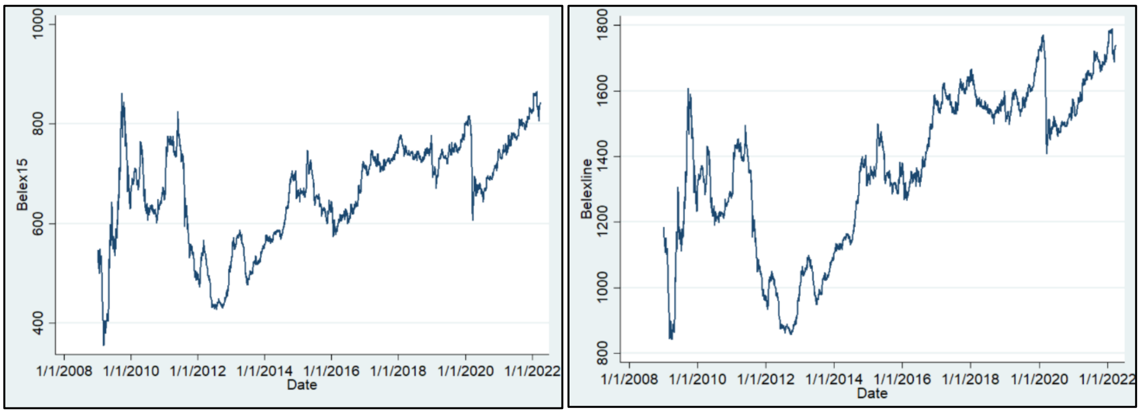

Figure 1. Movement of Belex15 (left figure) and Belexline (right figure) from 5th January 2009 until 31st March 2022

Source: Belgrade Stock Exchange

Graphic overviews point to high volatility of both indices, but also to uniform trend of movement: significant decrease of values of both indices at the beginning of 2009 after the financial crisis outbreak, which was followed by increase of index values until the end of the same year. Until 2011 both indices were fluctuating within certain frameworks (for Belex15 value was fluctuating between 600 and 800 stock exchange points, whereas for Belexline it was fluctuating between 1,200 and 1,600 points). Until the beginning of 2013, values of both indices were significantly decreasing, after which stable growth followed, until the coronavirus pandemic outbreak, when at the beginning of 2020 values of both indices suddenly decreased. After the financial market stabilized, not only in Serbia, but in the whole world, values of stock indices started increasing again.

In Table 1 are presented basic descriptive statistics for indices Belex15 and Belexline. This Table presents data about the mean, standard deviation, minimum and maximum for both indices. Total number of observations is 3,336 for both indices, which points to balanced data.

Table 1. Basic descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Belex15	3,336	659.125	103.340	354.39	865.06
Belexline	3,336	1,359.479	239.507	841.99	1,789.15

Source: Author's calculation

First BSE index for which forecast has been performed is Belex15 index.

Precondition for using ARIMA model for forecasting is stationarity of analysed data. If data is not stationary, it must be differentiated and afterwards checked does differentiated data satisfy the criteria of stationarity. Graphic overview of index Belex15 historical movement (Figure 1 – left figure) points to non-stationary data because of significant oscillations. In Figure 2 is presented differentiated data for Belex15 which is stationary.

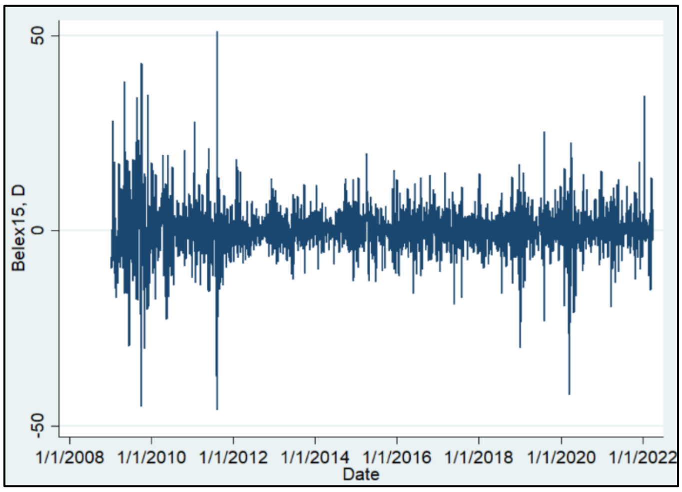

Figure 2. Differentiated Belex15 data

Source: Author's calculation

Stationarity of differentiated data can be confirmed with Dickey-Fuller test and these results are presented in Table 2.

Table 2. Dickey-Fuller test – differentiated data of Belex15

Dickey-Fuller test for unit root			**Number of obs = 3,334**				
						Z (t) has t-distribution	
	Test Statistic	**1% Critical Value**	**5% Critical Value**		**10% Critical Value**		
Z (t)	-48. 847	-2.327	-1.645		-1.282		
		p-value for Z(t) = 0.0000					
D2.Belex15	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]		
Belex15 LD.	-.834389	.0170816	-48.85	0.000	-.8678806	-.8008975	
_cons	.0756504	.1012637	0.75	0.455	-.1228949	.2741957	

Source: Author's calculation

In order to determine potential ARIMA models, it is necessary to define values of *p,d,q*. Value of *d* is 1, since data is differentiated only once, while for defining values of *p* and *q* partial autocorrelation function (PAC) and autocorrelation function (AC) have been performed respectively. In Figure 3 are presented models for autocorrelation and partial autocorrelation for differentiated data in order to define potential *p* and *q* values for the ARIMA model.

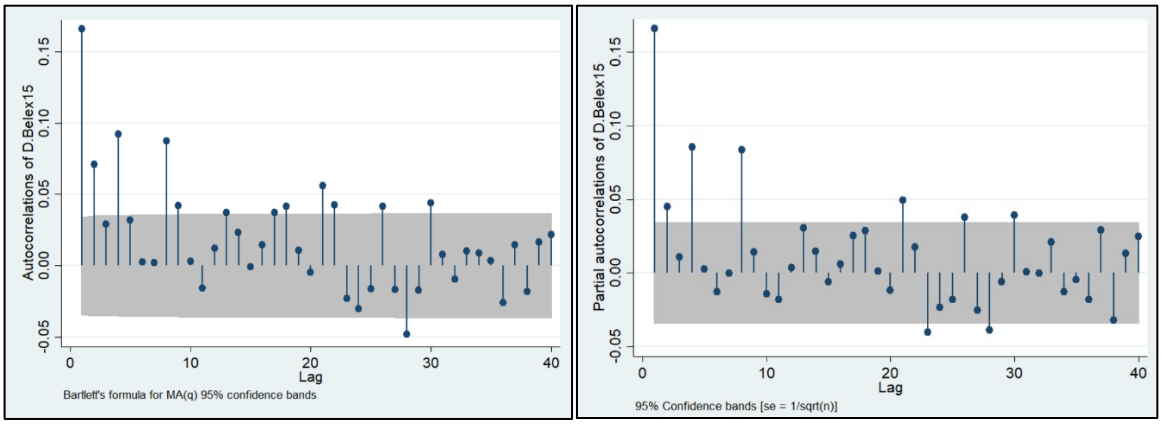

Figure 3. Autocorrelation (left figure) and partial autocorrelation (right figure) of differentiated data for Belex15

Source: Author's calculation

By using the autocorrelation function, in the graph overview the following lags stand out: *p*=1,2,4,8, whereas for partial autocorrelation these lags are *q*=1,2,4,8. By combining potential values of *p* and *q*, following ARIMA models have been tested to determine the most appropriate one: (1,1,1), (1,1,2), (1,1,4), (1,1,8), (2,1,1), (2,1,2), (2,1,4), (2,1,8), (4,1,1), (4,1,2), (4,1,4), (4,1,8), (8,1,1), (8,1,2), (8,1,4), (8,1,8).

In Table 3 is presented data about the number of p-values which are statistically significant (p<0.05), sigma SQ value, log likelihood, AIC and BIC. Model ARIMA (8,1,8) is not presented, since statistical processing indicates that results of this model cannot be defined.

Table 3. Analysed ARIMA models for Belex15

ARIMA Model	p-value	Sigma	Loglikelihood	AIC	BIC
ARIMA (1,1,1)	1/2	5.846	-10,621.56	21,249.12	21,267.45
ARIMA (1,1,2)	3/3	5.836	-10,616.11	21,238.22	21,256.55
ARIMA (1,1,4)	2/5	5.839	-10,618.13	21,246.26	21,276.82
ARIMA (1,1,8)	1/9	5.814	-10,603.40	21,226.79	21,287.91
ARIMA (2,1,1)	2/3	5.840	-10,618.17	21,244.34	21,268.79
ARIMA (2,1,2)	2/4	5.835	-10,615.21	21,240.42	21,270.98
ARIMA (2,1,4)	1/6	5.818	-10,605.64	21,223.29	21,259.96
ARIMA (2,1,8)	2/10	5.790	-10,589.65	21,201.30	21,268.53
ARIMA (4,1,1)	3/5	5.818	-10,605.63	21,223.27	21,259.94
ARIMA (4,1,2)	2/6	5.818	-10,605.62	21,223.25	21,259.92
ARIMA (4,1,4)	8/8	5.811	-10,601.58	21,219.15	21,268.05
ARIMA (4,1,8)	3/12	3.773	-10,597.31	21,218.63	21,291.97
ARIMA (8,1,1)	4/9	5.797	-10,593.70	21,207.40	21,268.52
ARIMA (8,1,2)	3/10	5.797	-10,593.46	21,206.91	21,268.03
ARIMA (8,1,4)	5/12	5.785	-10,586.68	21,199.37	21,278.82

Source: Author's calculation

Following criteria has been used to define the most appropriate ARIMA model:

1. Significance of ARMA parameters – choosing the model which has the most parameters that are statistically significant (p<0.05)
2. Sigma SQ – measure of volatility, choosing the model that has the lowest indicator
3. Log Likelihood – choosing the model which has the highest indicator

4. AIC – choosing the model with lowest indicator
5. BIC – choosing the model with lowest indicator

Regarding the first criteria (significance of ARMA parameters) – models ARIMA (1,1,2) and ARIMA (4,1,4) are most appropriate, since for both models all ARMA parameters are statistically significant: 3/3 and 8/8 respectively. Sigma SQ is lowest within ARIMA (4,1,8), loglikelihood is highest within ARIMA (8,1,4), AIC is lowest within ARIMA (8,1,4) and BIC is lowest within ARIMA (1,1,2). This leads to the conclusion that both ARIMA (1,1,2) and ARIMA (8,1,4) have 2/5 fulfilled criteria. Neither of these two models is unequivocally chosen, since only 2/5 criteria are met, but since model ARIMA (8,1,4) has only 5/12 parameters which are statistically significant, chosen ARIMA model for forecast is ARIMA (1,1,2). In Table 4 are presented its results, whereas in Table 5 are presented results of AIC and BIC tests.

Table 4. ARIMA (1,1,2) – corresponding model for Belex15

Sample: 09jan2009-31mar2022				**Number of obs = 3,334**		
				Wald chi2 (3) = 56,916.60		
Log likelihood = -10,616.11				**Prob > chi2 = 0.000**		
D2.Belex15	**Coef.**	**OPG Std. Err.**	**z**	**P > |z|**	**[95% Conf. Interval]**	
ARMA						
Ar						
L1.	.595	.038	15.54	0.000	.520	.671
Ma						
L1.	-1.452	.047	-31.07	0.000	-1.544	-1.361
L2.	.452	.045	10.02	0.000	.364	.541
/sigma	5.836	-	-	-	-	-

Source: Author's calculation

Table 5. Akaike & Bayesian information criteria (AIC & BIC) for ARIMA (1,1,2) – Belex15

Model	**Obs**	**11(null)**	**11 (model)**	**df**	**AIC**	**BIC**
-	3,334	-	-10,616.11	3	21,238.22	21,256.55

Source: Author's calculation

After the appropriate ARIMA model has been chosen, a forecast of movement of Belex15 has been conducted for the coming 11 trading days (until 15th April 2022.). In Table 6 are presented results of forecast from 1st April 2022 until 15th April 2022, as well as the real index value during this period (data of real values of Belex15 has been taken from Belgrade Stock Exchange).

Table 6. Forecasted and real values of Belex15

Date	**Forecasted value**	**Real value**
01.04.2022.	844.468	836.00
04.04.2022.	844.878	835.78
05.04.2022.	845.159	834.80
06.04.2022.	845.361	837.87
07.04.2022.	845.518	843.55
08.04.2022.	845.647	847.95
11.04.2022.	845.759	851.15
12.04.2022.	845.862	857.23
13.04.2022.	845.959	854.22
14.04.2022.	846.052	853.27
15.04.2022.	846.144	855.73

Source: Author's calculation

Real value of Belex15 index has been lower compared to forecasted values until 7th of April, as from when the real value started to grow faster compared to forecasted value. The biggest absolute deviation between forecasted and real value has been on 12th of April and this deviation was 1.33%.

As for the Belex15 forecast, the same steps were taken for the Belexline index, and results are presented below.

Same as for historical data of Belex15, which is not stationary, values of Belexline had similar movement, so Belexline data is not stationary either. Differentiation has been performed and differentiated data is presented in Figure 4 – it meets the condition of stationarity.

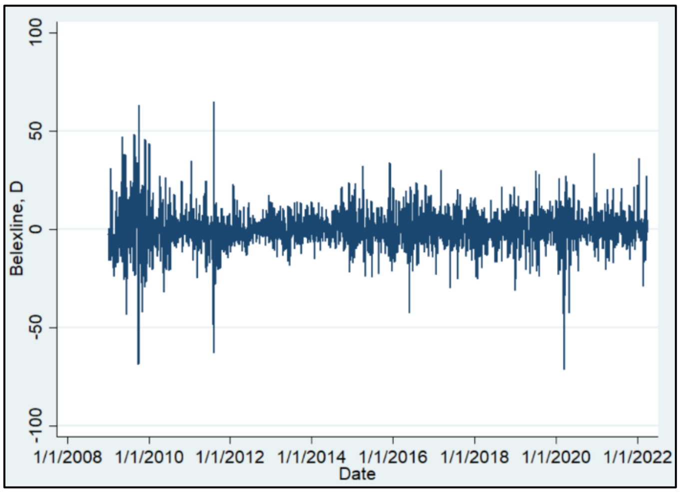

Figure 4. Differentiated Belexline data

Source: Author's calculation

Table 7 presents results of Dickey-Fuller test, which confirms stationarity of differentiated data for Belexline.

Table 7. Dickey-Fuller test – differentiated data for Belexline

Dickey-Fuller test for unit root			**Number of obs = 3,334**			
			Z (t) has t-distribution			
	Test Statistic	**1% Critical Value**	**5% Critical Value**		**10% Critical Value**	
Z (t)	-46.900	-2.327	-1.645		-1.282	
p-value for Z(t) = 0.000						
D2.Belexline	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
Belexline LD.	-.795	.017	-46.90	0.000	-.829	-.762
_cons	.133	.154	0.86	0.388	-.169	.435

Source: Author's calculation

In Figure 5 are presented models for autocorrelation and partial autocorrelation for differentiated data of Belexline.

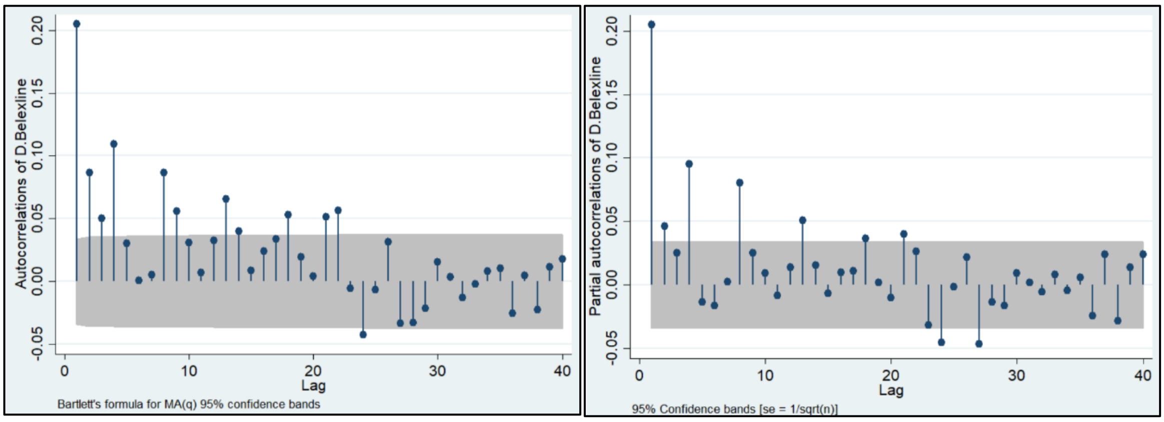

Figure 5. Autocorrelation (left figure) and partial autocorrelation (right figure) for differentiated data of Belexline

Source: Author's calculation

P-values for potential ARIMA models are *p*=1,2,4,8 and *q*-values *q*=1,2,4,8,13. For Belexline, following ARIMA models have been analysed: (1,1,1), (1,1,2), (1,1,4), (1,1,8), (1,1,13), (2,1,1), (2,1,2), (2,1,4), (2,1,8), (2,1,13), (4,1,1), (4,1,2), (4,1,4), (4,1,8), (4,1,13), (8,1,1), (8,1,2), (8,1,4), (8,1,8), (8,1,13).

In Table 8 are presented results of all analysed ARIMA models. Model ARIMA (2,1,2) is not presented, since results of this model couldn't be defined by statistical processing.

Table 8. Analysed ARIMA models for Belexline

ARIMA Model	p-value	Sigma	Loglikelihood	AIC	BIC
ARIMA (1,1,1)	2/2	8.883	-12,016.68	24,037.36	24,049.59
ARIMA (1,1,2)	3/3	8.867	-12,010.30	24,026.60	24,044.94
ARIMA (1,1,4)	4/5	8.870	-12,011.81	24,033.63	24,064.19
ARIMA (1,1,8)	1/9	8.824	-11,994.06	24,008.12	24,069.24
ARIMA (1,1,13)	1/14	8.795	-11,984.11	23,996.23	24,081.79
ARIMA (2,1,1)	2/3	8.874	-12,013.03	24,034.05	24,058.50
ARIMA (2,1,4)	5/6	8.829	-11,995.82	24,003.63	24,040.31
ARIMA (2,1,8)	2/10	8.793	-11,982.50	23,987.00	24,054.23
ARIMA (2,1,13)	1/14	8.787	-11,979.86	23,991.71	24,089.50
ARIMA (4,1,1)	4/5	8.831	-11,996.62	24,003.24	24,033.80
ARIMA (4,1,2)	3/6	8.830	-11,996.41	24,004.82	24,041.49
ARIMA (4,1,4)	4/8	8.794	-11,982.51	23,979.02	24,021.81
ARIMA (4,1,8)	4/12	8.788	-11,981.40	23,988.81	24,068.26
ARIMA (4,1,13)	4/17	8.772	-11,974.77	23,985.54	24,095.56
ARIMA (8,1,1)	5/9	8.800	-11,985.04	23,988.08	24,043.09
ARIMA (8,1,2)	6/10	8.797	-11,983.82	23,987.63	24,048.75
ARIMA (8,1,4)	5/12	8.787	-11,980.35	23,986.69	24,066.15
ARIMA (8,1,8)	2/16	8.759	-11,969.49	23,972.98	24,076.89
ARIMA (8,1,13)	4/21	8.737	-11,963.52	23,969.04	24,097.39

Source: Author's calculation

Models ARIMA (1,1,1) and ARIMA (1,1,2) fulfil the criteria of significance of ARMA parameters, since all parameters are statistically significant – 2/2 and 3/3 respectively. Sigma is lowest within ARIMA (8,1,13), loglikelihood is highest within ARIMA (8,1,13), AIC is lowest within ARIMA (8,1,13) and BIC is lowest within ARIMA (4,1,4). Model ARIMA (8,1,13) fulfills 3/5 criteria, but only 4/21 ARMA parameters are statistically significant which is a lack for this model. Since the appropriate model is chosen by the majority of fulfilled criteria, ARIMA (8,1,13) will be used to forecast Belexline movement. Results of this model are presented in Table 9 and results of AIC and BIC tests are presented in Table 10.

Table 9. ARIMA (8,1,13) – corresponding model for Belexline

Sample: 09jan2009-31mar2022				**Number of obs = 3,334**		
				Wald chi2 (20) = 585,157.78		
Log likelihood = -11,963.52				**Prob > chi2 = 0.000**		
D2.Belexline	**Coef.**	**OPG Std. Err.**	**z**	**P > |z|**	**[95% Conf. Interval]**	
ARMA						
Ar						
L1.	-.242	.148	-1.64	0.101	-.531	.047
L2.	-.796	.163	-4.89	0.000	-1.115	-.476
L3.	.850	.207	4.11	0.000	.445	1.256
L4.	.230	.157	1.46	0.143	-.078	.538
L5.	1.077	.136	7.94	0.000	.811	1.343
L6.	-.075	.179	-0.42	0.675	-.427	.276
L7.	.071	.133	.54	0.592	-.189	.331
L8.	-.573	.133	-4.30	0.000	-.845	-.312
Ma						
L1.	-.567	-	-	-	-	-
L2.	.494	30.043	0.02	0.987	-58.388	59.376
L3.	-1.577	154.913	-0.01	0.992	-305.200	302.046
L4.	.426	58.020	0.01	0.994	-113.290	114.142
L5.	-.902	44.175	-0.02	0.984	-87.484	85.680
L6.	1.024	63.969	0.02	0.987	-124.353	126.402
L7.	-.137	7.966	-0.02	0.986	-15.750	15.477
L8.	.784	101.609	0.01	0.994	-198.366	199.935
L9.	-.500	64.981	-0.01	0.994	-127.860	126.861
L10.	.086	.611	0.14	0.888	-1.111	1.283
L11.	-.104	12.785	-0.01	0.993	-25.163	24.954
L12.	.047	6.840	0.01	0.994	-13.358	13.453
L13.	-.075	10.779	-0.01	0.994	-21.201	21.051
/sigma	8.737	629.689	0.01	0.494	0	1,242.905

Source: Author's calculation

Table 10. Akaike & Bayesian information criteria (AIC & BIC) for ARIMA (8,1,13) - Belexline

Model	**Obs**	**11 (null)**	**11 (model)**	**df**	**AIC**	**BIC**
-	3,334	-	-11,963.52	21	23,969.04	24,097.39

Source: Author's calculation

In Table 11 are presented results of forecast for the following 11 trading days, as well as real values of Belexline.

Table 11. Forecasted and real values of Belexline index

Date	Forecasted value	Real value
01.04.2022.	1,743.467	1,732.07
04.04.2022.	1,745.202	1,734.43
05.04.2022.	1,745.102	1,730.73
06.04.2022.	1,745.760	1,735.43
07.04.2022.	1,747.383	1,740.18
08.04.2022.	1,749.036	1,745.12
11.04.2022.	1,749.572	1,750.03
12.04.2022.	1,750.431	1,756.38
13.04.2022.	1,751.277	1,749.34
14.04.2022.	1,752.575	1,746.44
15.04.2022.	1,754.675	1,748.98

Source: Author's calculation

Forecasted values of Belexline have been higher compared to real values of this index for a few points, with the exception of 11th, 12th and 13th of April, when real index values overcame forecasted values. The highest percentage difference has been noted on 5th of April and it was around 0.8%.

Discussion of results

After appropriate ARIMA models have been chosen for indices Belex15 and Belexline and their movement has been forecasted, in graphical overview are presented movements of real and forecasted values of these indices, in order to determine accuracy of ARIMA model for short-term forecast.

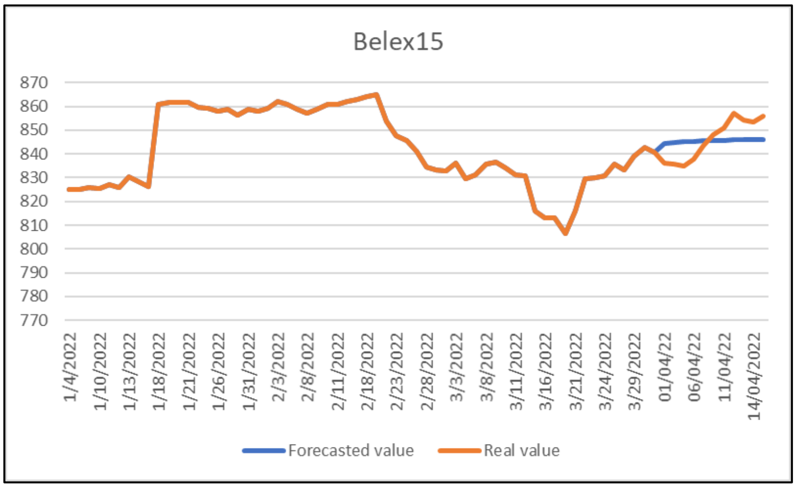

Figure 6. Movement of real and forecasted values of Belex15

Source: Author's calculation

Movement of Belex15 is presented from the beginning of 2022 until 15th of April, which is the last day of the forecast (Figure 6). Forecasted values have more stable growth of index value, without significant oscillations, whereas in reality there have been some oscillations. Even though there are some deviations between forecasted and real values, highest deviation was around

1.33%, which points to the conclusion that ARIMA model is suitable for short-term forecast of Belex15 index.

In Figure 7 are presented real and forecasted values of Belexline.

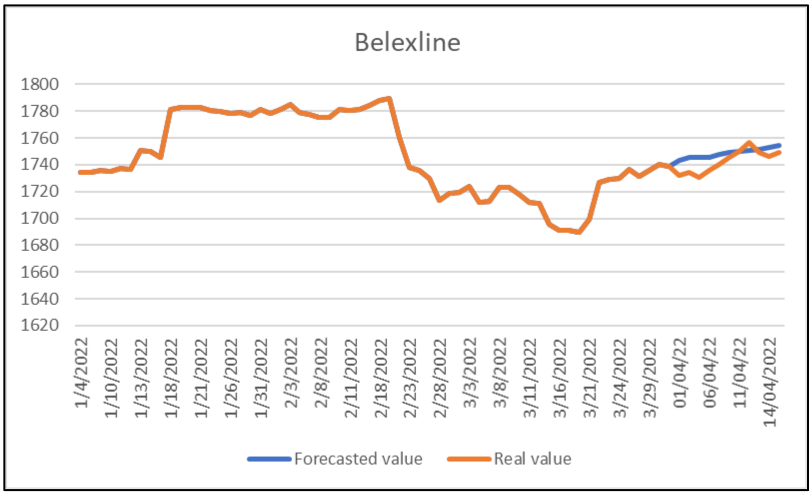

Figure 7. Movement of real and forecasted values of Belexline

Source: Author's calculation

As presented for Belex15, forecasted values have a more stable ascending path compared to real index values. First half of the forecasted period had higher oscillations, which was followed by more accurate forecast during the second half of the analysed period. Highest deviation was less than 1%, so the conclusion is that the ARIMA model is suitable for forecasting the Belexline index as well.

Even though there have been some differences with both indices, since they are not significant, the ARIMA model is appropriate for short-term forecasts for both Belgrade Stock Exchange indices. Observed deviations are lower with Belexline, so ARIMA model is more suitable for forecasting of this index compared to Belex15.

The ARIMA model has proven to be appropriate for short-term forecast in stock exchanges around the world, which leads to the conclusion that historical data can be used as a good starting point for a short-term forecast. Obtained results in this research are in accordance with Rotela, Salomon & de Oliveira Pamplona (2014) who have confirmed accuracy of short-term forecast of Bovespa stock index; Wadi, Almasarweh & Alsaraireh (2018) came to the same conclusion for forecast of index Amman Stock Exchange; Li, Yang & Li (2017) have forecasted Shanghai Composite Index movement by using ARIMA model. When it comes to using ARIMA model for short-term forecast of Belgrade Stock Exchange indices, results by Petrović (2020) are in accordance with this paper's results and they confirm accuracy of ARIMA model for short-term forecast of Belex15.

The disadvantage of both ARIMA models chosen for forecast is that none of them have fulfilled all criteria for choosing the most appropriate ARIMA model. When it comes to Belex15, two models (ARIMA (1,1,2) and ARIMA (8,1,4)) have fulfilled 2/5 criteria, so a decision about using ARIMA (1,1,2) has been made based on statistical significance of ARMA models. With the Belexline index, ARIMA (8,1,13) fulfilled 3/5 criteria, but the small number of ARMA parameters is statistically significant.

CONCLUSION

In this paper a short-term forecast of stock indices Belex15 and Belexline has been conducted (from 1st until 15th of April 2022) by using ARIMA model, in order to determine whether this model is suitable for forecast of movement of these indices. Indices values have been forecasted for the following 11 trading days based on historical data from 5th January 2009 until 31st March 2022.

ARIMA (1,1,2) was a suitable model to forecast Belex15 values. Forecasted values of this index have more stable growth compared to real values, which recorded some oscillations. Since there have not been significant differences between forecasted and real values of index Belex15, conclusion is that ARIMA model is suitable for short-term forecast and that Hypothesis H1 cannot be rejected.

ARIMA (8,1,13) is the corresponding model for Belexline index forecast and same as for forecasted values for Belex15, forecasted values have more stable movement compared to real values of this index. Oscillations between forecasted and real values of Belexline are smaller compared to ones for Belex15, which points to the conclusion that ARIMA model is suitable for short-term forecast and that Hypothesis H2 cannot be rejected.

Obtained results prove high potential of ARIMA model for short-term forecast when it comes to Belgrade Stock Exchange indices. Executed analysis should be observed as a starting point for researching possibilities of forecasting domestic indices and expanded additionally with other econometric methods for forecasting, in order to conclude if it is possible to use other methods for financial forecast besides ARIMA model.

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Article history:	Received: May 20, 2022
	Revised: July 3, 2022
	Accepted: July 7, 2022