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Forecasting Foreign Trade of Bosnia and Herzegovina for Wood and Articles of Wood, Wood Charcoal by Seasonal ARIMA Model

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Abstract

In this study, it is aimed that the analysis of export and import values of Bosnia and Herzegovina for wood and articles of wood, wood charcoal with seasonal ARIMA model and forecasting of export and import values for next term by the best appropriate seasonal ARIMA model. The data used in this study were obtained from Trade statistics for international business development (TRADEMAP) and monthly data covering the period of January 2007 and December 2015. Augmented Dickey-Fuller test was used for the stationarity test. Temporary model that have smallest values of forecasting accuracy measurement was determined. The appropriateness of the model (whether plot of autocorrelation has white noise) was determined by using the Box-Ljung test. As a result, ARIMA (3,1,0)(0,1,2)$_{12}$ model was found as the best forecasting model for both export and import series. It was estimated that export value of Bosnia and Herzegovina for wood and articles of wood, wood charcoal is approximately 531 million$, while import value is 160 million$ in 2020.

Keywords: Seasonal ARIMA model; wood and articles of wood; wood charcoal; export; import; forecasting

1. Introduction

Export provides to remain in the balance of foreign trade by supply the amount of foreign currency going abroad. In addition, companies are becoming more powerful in global competition by expanding the market network with export and as well negative trend of exports in the future. Export / import that are in a close relationship with GDP, interest rates, inflation, etc. may affect the country's economy. Therefore, the forecasting of accurately value of export/import is very important.

There are many forecasting techniques that including qualitative and quantitative for predicting the future. Quantitative methods are contained in the method of time series analysis [1]. There are many methods for analyzing time series. Box-Jenkins method is one of the most used methods. This method is called as ARIMA (autoregressive integrated moving average) analysis. ARIMA model is divided into two. These are non-seasonal and seasonal ARIMA models. ARIMA model combine differencing with autoregression (AR) and a moving average (MA) models. This model can be expressed as $w_t=c+\phi_1 w_{t-1}+\ldots\ldots+\phi_p w_{t-p}+\theta_1\varepsilon_{t-1}+\ldots+\theta_q\varepsilon_{t-q}+\varepsilon_t$. Here, w_t is the differenced series, p is order of the autoregressive part and q is order of moving average part. Also, we said this an ARIMA (p,d,q), where, d is a degree of difference [2]. General process of ARIMA model is as follows [2];

1. Plot the data. Identify unusual obversations.
2. If necesarry, transform the data to stabilize the variance.
3. If the data are non-stationary, take first difference the data until the data are stationary.
4. Plot the autocorrelation function (ACF)/partial autocorrelation function (PACF) of the differenced data and try to determine possible candidate models.
5. Try your chosen model(s) and use the akaike information criterion (AIC) to search for better model.
6. Check the residuals from your chosen model by plotting the ACF of the residuals and doing a Ljung-Box test of the residuals. If model has not white noise, determine model again.
7. If model has white noise, calculate forecasts.

ARIMA model was applied many studies [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]. In this study, it is aimed that the analysis export and import values of Bosnia and Herzegovina for wood and articles of wood with SARIMA model. In addition, the best appropriate SARIMA model estimated export and import values.

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2. Materials and Method

2.1. Material

In this study, it was used that export and import values of Bosnia and Herzegovina for wood and articles of wood, wood charcoal. The monthly data was used for examine the seasonal and trend components. This data covers the period of January 2007 and December 2015. Data were obtained from Trade statistics for international business development [20]. Data was taken as $1000. Minitab 16 was used for determine the best model while Eviews-8 was used for the analysis of stationary.

2.2. Method

2.2.1. Seasonal ARIMA model

The seasonal ARIMA (SARIMA) model is similar to the ARIMA model which known as a linear approximation for predicting future. This model consists of stages such as identification, estimation, diagnostic checking and forecasting. Accurate predictive models can improve with this model by removing the characteristics of seasonal variation through seasonal differences [21].

The SARIMA model consists of seasonal autoregressive term (P), seasonal integrated term (D), and seasonal moving average term (Q) as well as autoregressive term (p), integrated term (d), and moving average term (q). Generally, the SARIMA model represents as SARIMA (p, d, q)(P, D, Q) and is expressed by equations in follow

$$\varphi_p(B)\,\Phi_p(B^S)(1-B)^d(1-B^S)^D y_t=\delta+\theta_q(B)\Theta_Q(B^S)\alpha_t \quad (1)$$

$$\varphi_p(B)= 1- \varphi_1 B- \varphi_2 B^2-\ldots- \varphi_p B^p \quad (2)$$

$$\theta_q(B)= 1- \theta_1 B- \theta_2 B^2-\ldots- \theta_q B^q \quad (3)$$

$$\Phi_p(B^S)= 1-\Phi_S B^S-\Phi_{2S} B^{2S}-\ldots-\Phi_{PS} B^{PS} \quad (4)$$

$$\Theta_Q(B^S)= 1- \Theta_S B^S-\Theta_{2S} B^{2S}-\breve{g}-\Theta_{QS} B^{QS} \quad (5)$$

Here, y_t is the observation value at time t, α_t is the lagged error at time t, B is the lag operator defined by $B_k y_t= y_{t-k}$; φ_p (p=1,2,…p), Φ_P (P=1,2,…,P), θ_q (q=1,2,..q) and Θ_Q (Q=1,2,…Q), p and q are the order of non-seasonal autoregressive and non-seasonal moving average, P and Q is the order of seasonal autoregressive and seasonal moving average, d is order of regular difference, D is order of seasonal difference and S is a seasonal length [21, 22].

2.2.2. Forecasting Accuracy Measurements

For the series, forecasting values are calculated and compared with the actual values of the series. There are several criteria for forecasting accuracy measurement. Forecasting accuracy measurements used in this study were given as follows:

Mean Absolute Percentage Error;

$$(MAPE)=\sum\left|\frac{\breve{y}_t-y_t}{y_t}\right|\frac{100}{n} \quad (6)$$

$$\text{Mean Square Error (MSE)}=\frac{\sum(\breve{y}_t-y_t)^2}{n} \quad (7)$$

Here, $\breve{y}_t$ is the forecasting value of model, y_t is the actual value of model and n is the number of observations [19, 23]. The criteria of MAPE for model evaluation were in Table 1.

Table 1. MAPE values for model evaluation [24]

MAPE (%)	Evaluation
MAPE ≤ 10%	High accuracy forecasting
10% < MAPE ≤ 20%	Good forecasting
20% < MAPE ≤ 50%	Reasonable forecasting
MAPE > 50%	Inaccurate forecasting

3. Results

Firstly, it must be provided to export and import series of stationary condition. For this, the stationary of export and import series were analyzed with Augmented Dickey-Fuller (ADF) unit root test and results shown in Table 2. It was seen that series is stationary in the 5% significance level according to ADF test when taken difference of the natural logarithm series. The 1stdifference of series was taken. Distribution graph of natural logarithm and differenced of export and import series were shown in Figure 1 and 2.

Table 2.Augmented Dickey-Fuller (ADF) test results

		Level	Natural logarithm	1st difference
Export series	Augmented Dickey-Fuller test statistic	-0,075962	0,245091	-2,867914
Import series	Augmented Dickey-Fuller test statistic	-0,376831	-0,108246	-2,645649
Test critical values	1% Level	-2,589531	-2,589531	-2,589531
	5% Level	-1,944248	-1,944248	-1,944248
	10% Level	-1,61451	-1,61451	-1,61451

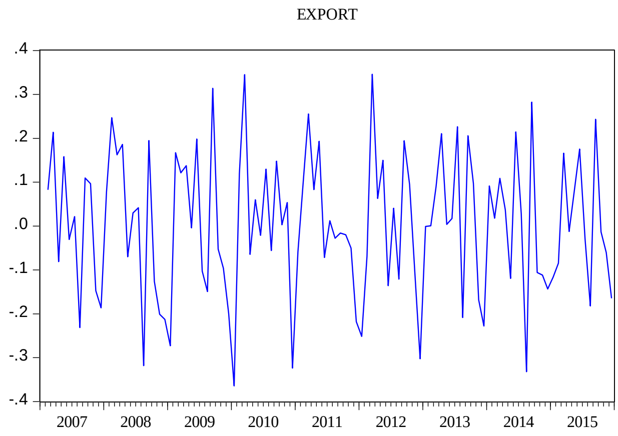

Figure 1.Stationarized export series of graphics

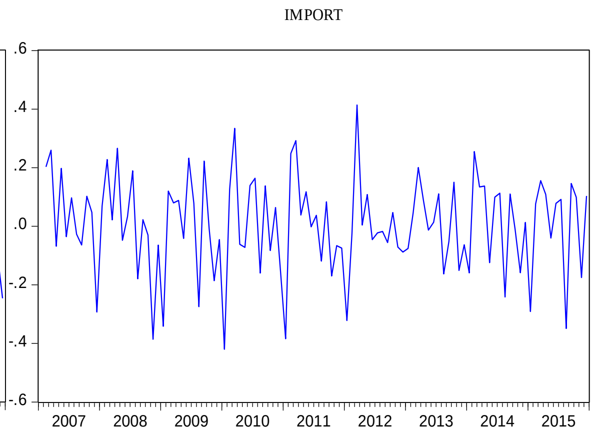

Figure 2.Stationarized import series of graphics

According to Figure 1 and 2, the mean and variance of export and import series are a constant. But, series comprise seasonality. For this, natural logarithm and differenced of export and import series were taken seasonal difference (12st difference). After obtaining these series of stationary conditions, a variety of ARIMA $(p,d,q)(P,D,Q)_{12}$ models has been tested by autocorrelation and partial autocorrelation graphics of the export and import series. Autocorrelation and partial autocorrelation graphics of stationarized these series were shown in Figure 3, 4, 5 and 6.

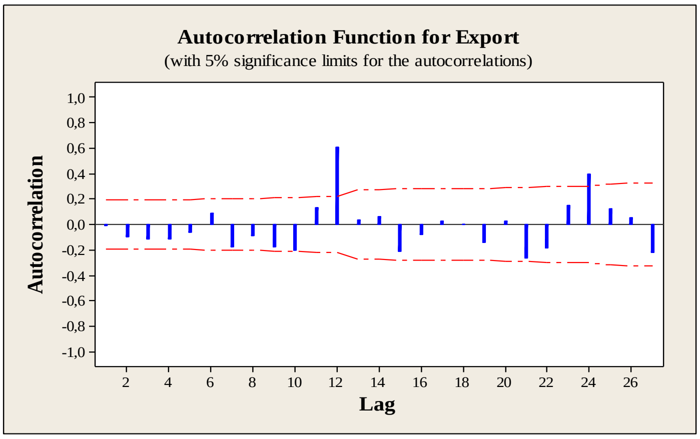

Figure 3. Autocorrelation graphic of stationarized export series

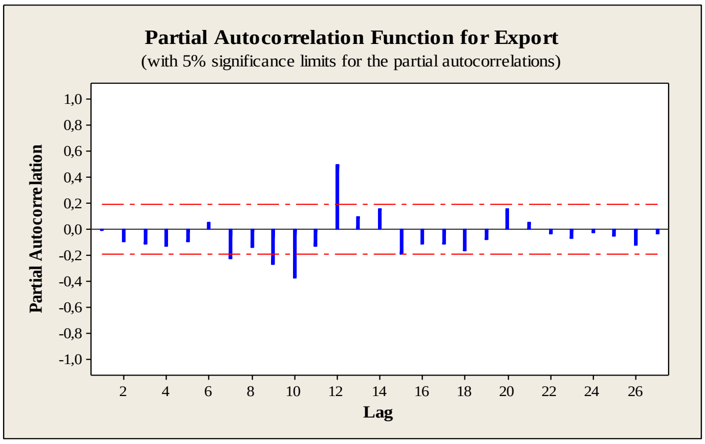

Figure 4. Partial autocorrelation graphic of stationarized export series

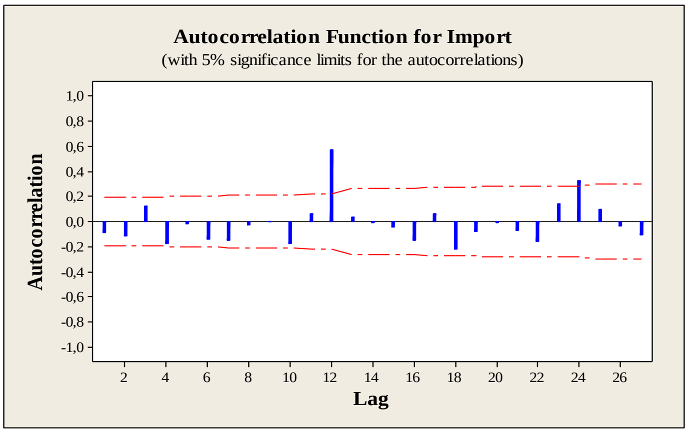

Figure 5. Autocorrelation graphic of stationarized import series

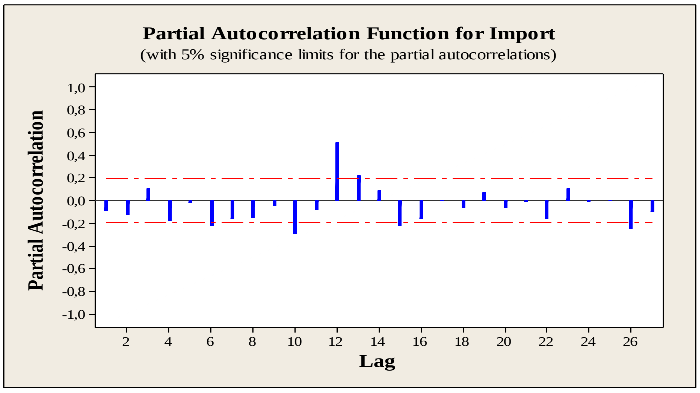

Figure 6. Partial autocorrelation graphic of stationarized import series

As a test results, ARIMA $(3,1,0)(0,1,2)_{12}$ model which have smallest values of the error sum of squares (SSE) and the mean square error (MSE) was determined as temporary model for both export and import values of Bosnia and Herzegovina for wood and articles of wood, wood charcoal. The results related to the model were given in Table 3 and 4. The suitability of models were tested with Ljung-Box Q statistic and results shown in Table 5 and 6.

Table 3.Analysis results of ARIMA $(3,1,0)(0,1,2)_{12}$ model for export

Variable	Coefficient	Std. Error	t-Statistic
AR(1)	-0,251	0,1023	-2,45
AR(2)	-0,074	0,107	-0,69
AR(3)	0,2464	0,1022	2,41
SMA(12)	0,5397	0,1066	5,06
SMA(24)	0,3528	0,1116	3,16
Number of observations		108	
After differencing		95	
The error sum of squares		0,945841	
The mean square error		0,010509	

Table 4.Analysis results of ARIMA$(3,1,0)(0,1,2)_{12}$ model for import

Variable	Coefficient	Std. Error	t-Statistic
AR(1)	-0,3234	0,1019	-3,17
AR(2)	-0,0659	0,1072	-0,61
AR(3)	0,2847	0,0998	2,85
SMA(12)	0,422	0,1098	3,84
SMA(24)	0,4456	0,1134	3,93
Number of observations		108	
After differencing		95	
The error sum of squares		0,845125	
The mean square error		0,00939	

Table 5.The Q_{LB} statistic and X^2 values of ARIMA (3,1,0)(0,1,2)$_{12}$ model residuals in different lags for export

Lags	$Q_{statistic}$	X^2_{table}(α=0.05)	Degree of freedom
12	13.9	14.07	7
24	27.6	30.14	19
36	36.9	43.77	31≈30
48	52.3	55.76	43≈40

Table 6.The Q_{LB} statistic and X^2 values of ARIMA (3,1,0)(0,1,2)$_{12}$ model residuals in different lags for import

Lags	$Q_{statistic}$	X^2_{table}(α=0.05)	Degree of freedom
12	12.8	14.07	7
24	19.9	30.14	19
36	28.6	43.77	31≈30
48	44.8	55.76	43≈40

While the actual and forecasting export values for wood and articles of wood, wood charcoal were shown in Figure 7, actual and forecasting export values in Figure8. In addition, the forecasting values for export and import were given in Table 7 and 8.

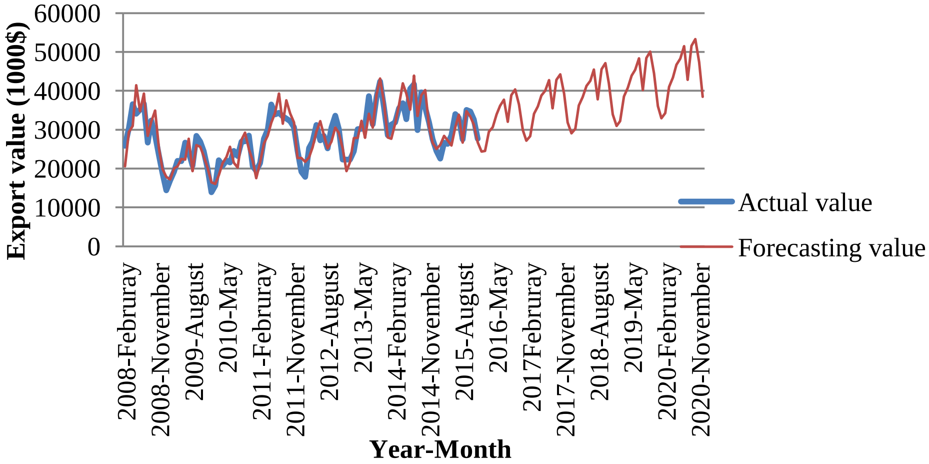

Figure 7. Actual and forecasting values for export (2008-2020)

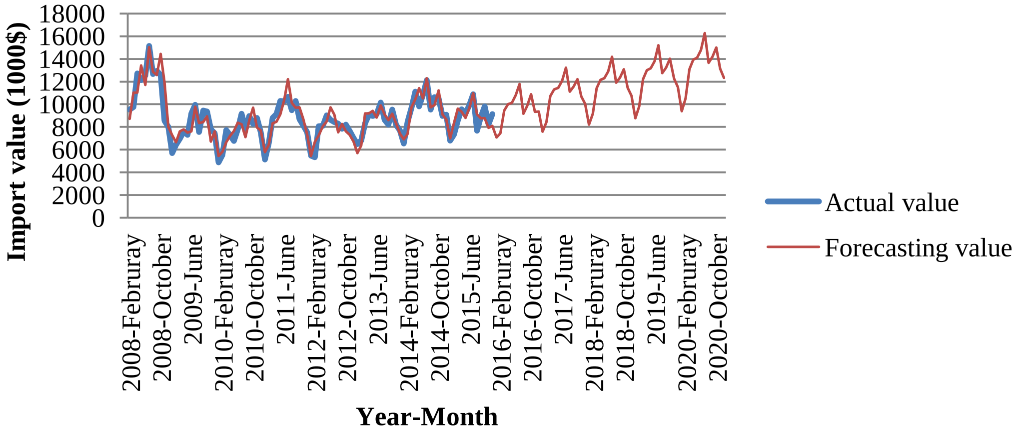

Figure 8. Actual and forecasting values for import (2008-2020)

Table 7.The forecasting values for export in 2016-2020 (1000$)

Months	**2016**	**2017**	**2018**	**2019**	**2020**
January	24404	27161	29070	30935	32919
Februray	24570	28367	30222	32160	34222
March	29440	34061	36248	38572	41046
April	30604	35988	38346	40805	43422

May	33925	38751	41234	43878	46691
June	36141	40055	42621	45354	48262
July	37683	42714	45469	48384	51487
August	32024	35528	37803	40227	42807
September	38846	42786	45529	48449	51555
October	40333	44238	47079	50098	53311
November	36483	39281	41798	44478	47331
December	29865	31885	33930	36106	38421

Table 8.The forecasting values for import in 2016-2020 (1000$)

Months	**2016**	**2017**	**2018**	**2019**	**2020**
January	7092	7587	8196	8779	9400
Februray	7442	8428	9171	9818	10513
March	9453	10716	11409	12215	13078
April	10007	11311	12151	13012	13932
May	10137	11441	12298	13167	14098
June	10802	12068	12882	13792	14768
July	11780	13237	14197	15202	16277
August	9177	11113	11908	12750	13652
September	9876	11559	12362	13236	14172
October	10875	12211	13085	14011	15002
November	9342	10695	11452	12262	13129
December	9365	10033	10738	11498	12311

4. Conclusions

The export and import values of Bosnia and Herzegovina for wood and articles of wood, wood charcoal with seasonal ARIMA model were estimated with seasonal ARIMA model. The natural logarithm, regular difference and seasonal difference of the series were taken. ACF and PACF graphics of the series for determine the appropriate models were examined. Q statistics were calculated for the appropriateness of the model. ARIMA $(3,1,0)(0,1,2)_{12}$ model was found as the best forecasting model for both export and import series. It was found that MAPE value of model for export is 8.12%, while MAPE value for import is 7.54%. It was estimated that export value of Bosnia and Herzegovina for wood and articles of wood, wood charcoal is approximately 531 million$, while import value is 160 million$ in 2020.

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