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The forecasting of the exports and imports of paper and paper products in Turkey using Box-Jenkins method

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Abstract
In this study, it was aimed to determine the most suitable time series models with Box-Jenkins method, which was the most widely used in prediction studies. Export and import values were predicted by 2020 with the most suitable models. The data used in this study were obtained from the Turkey Statistical Institute. Data were monthly data covering from January 2003 to December 2014. Sum of Squared Errors (SSE) and Mean Squared Error (MSE) criteria were taken into consideration when selecting the best Box-Jenkins models. Also, in order to test the success of forecasting of the models, Root mean Error Square (RMSE), Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE) were used.
As a result of the analyzes, it was determined that the most suitable models for export and import data were ARIMA (2,1,0) $(0,0,1)_{12}$ and ARIMA(3,1,2)$(1,0,1)_{12}$. It was predicted that the rate of exports meeting imports in paper and paper products of Turkey will be approximately 0.86 in 2020.
Key words: Paper and paper products, Box-Jenkins, Exports and Imports

INTRODUCTION

The paper sector is the industry branch that use wood as raw material and produce pulp, paper, paperboard and other cellulose-based products (Atalay 2012). The paper industry consists of two parts: "paper pulp production and bleaching technology" and "paper and paperboard manufacturing technology" (Gavcar et al. 1999).

Paper and paper products sector, which providing significant rate input to chemical products and mining sectors, occupies an important place in terms of number of enterprises and production capacity in Turkey. According to 2014 data, there are 3114 enterprises and 62839 people are employed in this sector (Bayraktar 2014; TSI 2015a; Akyüz et al. 2017). However, the production capacity of paper enterprises in our country is quite low compared to European Union countries, their competitiveness is low in international trade, and they take the pulp used in paper production from outside (Gedik et al. 2005; Akyüz and Yıldırım 2006; Akyüz and Yıldırım 2009; Tutku et al. 2018).

Turkey's production value of paper and paper products in 2008 was 8.182 million Turkish liras, while the production value of this sector in 2014 was realized as 23.990 million Turkish liras (Bayraktar 2014; TSI 2015b).

While total pulp exports in the world were approximately $45.6 billion in 2014, paper and paperboard exports in the same year were approximately $174 billion. Turkey was 45th and 28th in the pulp and paper-paperboard exports, respectively. Considering the import figures, Turkey was ranked as the 18th country that imports most of pulp in the world according to 2014 data (TRADEMAP 2015).

In this study, the optimal time series model was determined by Box-Jenkins method and the exports and imports values of paper and paper products in Turkey have been estimated by 2020 with the most suitable model.

Literature review

Co and Boosarawongse (2007) have tried to estimate the rice export values of Thailand using Box-Jenkins, Holt-Winters and Artificial Neural Networks.

In a study carried out by Emang et al. 2010, the Seasonal Autoregressive Integrated Moving Average model was used to determine the estimated demand for chipboard in Malaysia. Also, this model is compared with seasonal Holt-Winters and ARAR algorithms. They suggested that the Seasonal Autoregressive Integrated Moving Average (SARIMA) model is better than other methods.

Tajdini et al. (2014) used double exponential smoothing, Holt-Winters exponential smoothing and Autoregressive Integrated Moving Average (ARIMA) models to estimate the consumption of wood based panels (chipboard, plywood, veneer) in Iran.

The sale of plastic production using ARIMA method was estimated. For this project, the sales data of plastic factory production in Bandung was used. ARIMA (3,0,2) was found to be the best model for PP Trilene and PP Tintapro products (Siregar et al. 2017).

In this study, it was aimed that is to forecast monthly Headline Consumer Price Index (HCPI) using the Box-Jenkins ARIMA methodology (Jackson et al. 2018).

In a study carried out by Mishra et al. 2018, it was tried to determine estimated the area, production and yield of Sunn hemp in India using Autoregressive Integrated Moving Average (ARIMA) model. It was found that the most appropriate models for the area, production and yield of Sunn hemp were ARIMA(1,1,2), ARIMA(1,1,4) and ARIMA(1,1,5), respectively.

MATERIAL AND METHOD

In this study, the exports and imports data of the paper and paper products sector were examined. The monthly data covering the periods of January 2003-December 2014 were used to be examined in more detail by considering the trend and seasonal the components. The data were obtained from the Turkey Statistics Institution. The data was taken as $1000.

Method

Box-Jenkins Method

The Box-Jenkins method was developed by George E.P Box and Gwilym M. Jenkins (1970) and is based on the principle of stinginess. This method, which is one of the single variable models, is called as ARIMA models. Autoregressive Integrated Moving Average (ARIMA) models are the most used method in time series analysis due to the simplicity and adaptability (Chen et al. 2014). These models are divided into two. These: non-seasonal and seasonal ARIMA models. The general expression of the non-seasonal ARIMA(p,d,q) model is as follows (Hyndman and Athanasopoulos 2017):

$$w_t = c + \emptyset_1 w_{t-1} + \emptyset_2 w_{t-2} + \cdots + \emptyset_p w_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} \ldots + \theta_q \varepsilon_{t-q} + \varepsilon_t \qquad (1)$$

where w_t is the differentiated series, c is a constant, p is the order of autoregressive models, q is the order of moving average models, $\emptyset_1, \emptyset_2, \ldots \emptyset_p$ are the autoregressive parameters, $\theta_1, \theta_2, \ldots . \theta_p$ are the moving average parameters, ε_t is the error term at time t. The difference is realized by the $w_t = y_t - y_{t-1} - y_{t-2} - \ldots - y_{t-d}$ formula; where d is the number of differences taken (Hyndman and Athanasopoulos 2017; Chatfield 2000).

The seasonal ARIMA (SARIMA) models are similar to the ARIMA models. In general, Seasonal Autoregressive Integrated Moving Average (SARIMA) model is shown as SARIMA (p, d, q) (P, D, Q); where p is autoregressive term, d is integrated term, q is moving average term, P is seasonal autoregressive term, D is seasonal integrated term and Q is seasonal moving average term. The main condition for SARIMA model applications is that the mean, standard deviation and autocorrelation functions of the time series data should be stationary with time. This model is more suitable for short term than long term forecasting (Jeong et al. 2014).

Autoregressive Integrated Moving Average models consist of 3 steps. These are identification, parameter estimation, and diagnostic checking (Khashei et al. 2012).

a. Identification: At this step, it is firstly investigated whether the time series is stationary and has a seasonal characteristic. Different methods have been developed for the determination of stagnation. Correlogram analysis and unit root tests are the most commonly used in practice. The Augmented Dickey Fuller (ADF), which is one of the unit root tests, was used in this study. The test statistics of the ADF test are performed using the following equation (1) (Arltova and Fedorova 2016).

$$\Delta y_t = (\emptyset_1 \text{-} 1) y_{t-1} + \sum_{i=1}^{p-1} \gamma_i \, \Delta y_{t-i} + \varepsilon_t \qquad (2)$$

Hylleberg-Engle-Granger-Yoo (HEGY) test, which is posed by Hylleberg, Engle, Granger and Yoo (1990), was used to determine whether the series had seasonal features. With HEGY test, seasonal unit root can be tested separately at each frequency. However, the HEGY test was firstly proposed by Franses (1990) for testing seasonal unit roots in quarterly data. Then, Beaulieu and Miron (1992) extended it for monthly data (Meng 2013).

After the stationary and seasonality of series is determined using the ADF and HEGY tests, if the series is not stationary, it is stationarized by taking the logarithm of the series or the difference of the seasonal and/or non-seasonal of series. After the stationary of the series, it is passed to the model determination stage by taking advantage of autocorrelation (ACF) and partial autocorrelation (PACF) functions (Akgül 2003).

b. Parameter estimation: Once the appropriate model is determined, the parameters of the model are estimated depending on the minimum sum of squared errors. Also, it must be checked whether the parameter values are significantly different from zero and non-significant parameters should be discarded from the model (Akgül 2003).

c. Diagnostic checking: The investigation of the suitability of the model generally involves two stages. In the first stage, the autocorrelation functions of the generated and the original series are compared. If the two autocorrelation functions are quite different, the model is determined again. If the difference between these two autocorrelation functions is low, it is passed to the second stage and at this stage; residue analysis of the model is done (Pindyck and Rubinfeld 1998). For residual analysis, autocorrelation and partial autocorrelation functions of residues are generated and with the help of Box-Pierce and Ljung & Box corrected Q statistics, the autocorrelation coefficients are checked. Box-Pierce (1970) and Ljung & Box corrected (1978) Q statistics are as follows (Griffiths et al. 1993):

$$Q=n\sum_{k=1}^{m} r_k^2 \quad (3)$$

$$Q^{o}=n(n+2)\sum_{k=1}^{m} \frac{r_k^2}{n-k} \quad (4)$$

where r_k is the autocorrelation coefficients of sample prediction errors in various lags, k is the number of lag, n is the number of observations, and m is the autocorrelation coefficient.

The calculated Q statistic value indicates that the model is appropriate if it is equal to or lower than the value of $X^2_{(m\text{-}P\text{-}p\text{-}Q\text{-}q \text{ or } m\text{-}p\text{-}q),\alpha}$ table. If the value of the Q statistic is greater than the value of the $X^2_{(m\text{-}P\text{-}p\text{-}Q\text{-}q \text{ or } m\text{-}p\text{-}q),\alpha}$ table, the model is not appropriate and the model must be determined again. (m-P-p-Q-q) is the degree of freedom of the seasonal model, while (m-p-q) is the degree of freedom of the non-seasonal model. Also, α is the confidence level (Akgül 2003).

Table 1. Model evaluation criteria (Göktaş 2005; Kirchgassner and Wolters 2007; Gujarati and Porter 2012)

Criteria	Formula
Root Mean Square Error (RMSE)	$\sqrt{\frac{\sum(\tilde{y}_t - y_t)^2}{n}}$
Mean Absolute Percentage Error (MAPE)	$\sum\left\lvert\frac{\tilde{y}_t - y_t}{y_t}\right\rvert\frac{100}{n}$
Mean Absolute Error (MAE)	$\frac{1}{n}\sum\lvert\tilde{y}_t - y_t\rvert$
Mean Squared Error (MSE)	$\frac{\sum(\tilde{y}_t - y_t)^2}{n}$
Sum of Squared Errors (SSE)	$\sum\lvert\tilde{y}_t - y_t\rvert^2$

If more than one model is considered as a result of the evaluation, the result of the model selection criteria is examined to determine the most suitable model among these models. The evaluation criteria used in this study were given in Table 1. In table 1, n is the number of observations, $\tilde{y}_t$ is the predicted value of the model, and y_t is the actual value of the model.

RESULTS

The models in the study were created with the help of monthly data between January 2003 and December 2013. Monthly data between January 2014 and December 2014 were used to test the forecasting success of the models after the models were created. Then, exports and import data were estimated by 2020 by using models. Eviews-8, Minitab 16.1 and Jmulti 4.24 package programs were used for estimation of import and export time series.

If the series is not stationary, the mean and variance values of the series will change depending on time and the wrong model will be identified. First, the stationarity of the data must be provided. For this purpose, the distribution of series related to exports and imports values of paper and paper products sector was examined graphically and shown in Figure 1.

When Figure 1 is examined, it is seen that the series have an increasing trend and it is not fixed in average over time. That is, the export and import series have a non-stationary structure. In order to make the series stationary, the natural logarithm of the series was first taken. Then, in order to stationarize the natural logarithmized series, the first order difference of the series was taken and the results are shown in Figure 2. The series were stationarized. In addition, the stationarity of the natural logarithmized series was analyzed by the Augmented Dickey-Fuller (ADF) unit root test to ensure the series is stationary and were given in Table 2. As shown in Table 2, it is also seen with unit root test where the series are stationary because the ADF test statistic is greater than the critical value of MacKinnon as absolute values.

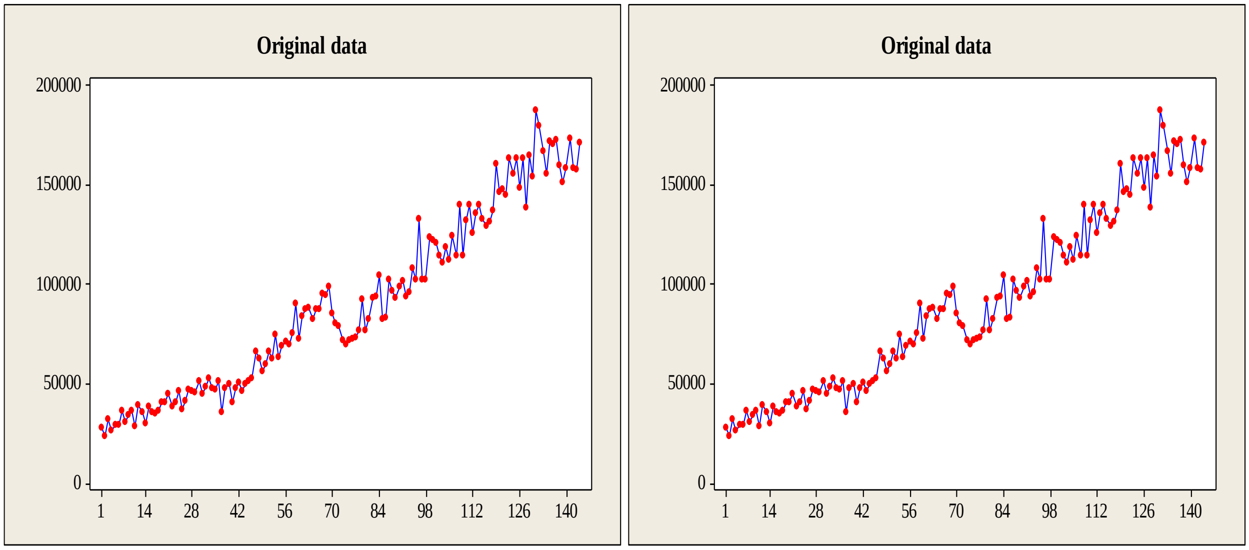

Figure 1. (a) original data for exports, (b) original data for imports

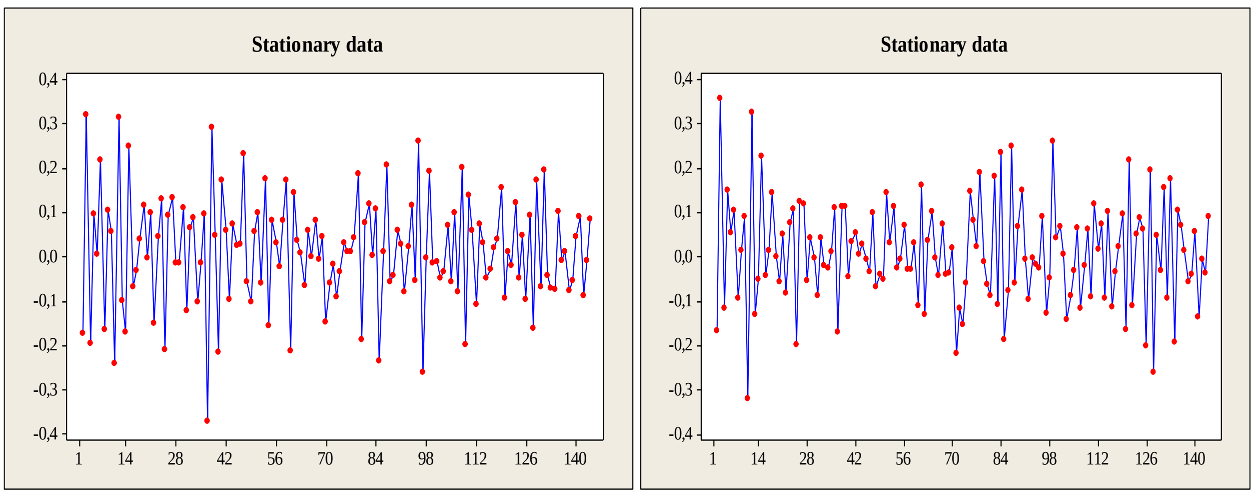

Figure 2. (a) stationary data for exports, (b) stationary data for imports

Table 2. Augmented Dickey-Fuller (ADF) unit root test after difference and log transformation

		ADF test statistic	Prob.*
Exports		-15.55671	0.000
Imports		-17.89146	0.000
	1% level	-3.47614	
Test critical values	5% level	-2.88154	
	10% level	-2.57751	

*MacKinnon (1991) one-side p-values

The deterministic and stochastic seasonality of the natural logarithmized series were analyzed by Hylleberg-Engle-Granger-Yoo (HEGY) test and the results were given in Table 3 and 4. As a result of the HEGY test, the t-statistic values of seasonal dummy variables calculated by models with and without trend were shown in Table 3. According to Table 3, since the absolute values of the t-statistic of all variables in the trend model of exports and imports of paper and paper products, and the D3 variable in the non-trend model of imports of paper and paper products are higher than the table value (1.96) at 5% significance level, it is accepted that there are deterministic seasonality in the series.

Table 4 shows "t" and "F" statistic values of parameters calculated by models with and without trend, and the table values of 5% significance level calculated by Franses and Hobjin (1997) in parenthesis. Since the t-statistic values of the π_1 and π_2 parameters in all series are higher than table values with and without trend (Sivri 2004), it shows that the series have non-seasonal unit root. Since the calculated F statistics are smaller than the critical values in Franses and Hobjin (1997) (Hamori 2001), it is seen that there are the unit root "at models with and without trend of the exports of paper and paper products and at the frequency of (1/2)π[(3/2)π]" and "at models with and without trend of the imports of paper and paper products and at the frequency of (2/3)π[(4/3)π]". It was found that the exports and imports series have a seasonal feature.

Table 3. Deterministic seasonality results for export and import series

	Exports		Imports	
	Trend	Non-trend	Trend	Non-trend
D1	**2.3183**	0.2867	**2.3722**	1.5658
D2	**2.3968**	0.7807	**2.3924**	1.6178
D3	**2.4677**	1.2279	**2.5804**	**2.0869**
D4	**2.4179**	0.9105	**2.5276**	1.9519
D5	**2.4355**	1.0220	**2.5218**	1.9380
D6	**2.4030**	0.8164	**2.4391**	1.7315
D7	**2.4628**	1.1929	**2.4784**	1.8271
D8	**2.3701**	0.6105	**2.4033**	1.6411
D9	**2.4163**	0.8991	**2.3681**	1.5542
D10	**2.4396**	1.0449	**2.4849**	1.8419
D11	**2.4475**	1.0925	**2.4736**	1.8125
D12	**2.4580**	1.1555	**2.4123**	1.6614

Table 4. Stochastic seasonality results for export and import series

	Exports		Imports	
	Trend	Non-trend	Trend	Non-trend
$t(\pi_1)$	**2.4030(-3.35)**	**1.0220(-2.81)**	**2.4391(-3.35)**	**1.9380(-2.81)**
$t(\pi_2)$	**2.4628(-2.81)**	**0.8164(-2.81)**	**2.4784(-2.81)**	**1.7315(-2.81)**
$F(\pi_3.\pi_4)$	**3.5422(6.35)**	**4.3306(6.35)**	8.9269(6.35)	9.1137(6.35)
$F(\pi_5.\pi_6)$	16.8671(6.48)	15.6856(6.48)	14.7377(6.48)	14.2058(6.48)
$F(\pi_7.\pi_8)$	12.2119(6.30)	11.2423(6.33)	9.8273(6.30)	8.9928(6.33)
$F(\pi_9.\pi_{10})$	8.8772(6.40)	8.0861(6.41)	**5.6056(6.40)**	**5.4546(6.41)**
$F(\pi_{11}.\pi_{12})$	11.7970(6.46)	10.1556(6.47)	12.9533(6.46)	12.1698(6.47)

After the series are stationary, many models have been tried to determine the appropriate model in the estimation of series. The most suitable model among the candidate models was determined according to the model evaluation criteria. The criteria used in the evaluation are: Sum of Squared Errors (SSE) and Mean Squared Error (MSE). ARIMA(2,1,0)(0,0,1)$_{12}$ for export series and ARIMA(3,1,2) (1,0,1)$_{12}$ for import series were determined as the most suitable models. When the parameter estimation results of ARIMA(2,1,0)(0,0,1)$_{12}$ model were examined, all variables were found to be significant (Table 5). While the constant term is significant at the 5% error level, the other parameters are significant at 1% level. In the ARIMA(3,1,2)(1,0,1)$_{12}$ model, the constant term and AR(3) are insignificant (Table 6). According to Ljung and Box (1978) Q statistic test; 12, 24, 36 and 48 lag levels were applied individually and the critical values were calculated as $Q_{LB}<X^2$ with 5% error. The results of the Ljung-Box test statistics are given in Tables 7 and 8.

Table 5. Values of ARIMA(2,1,0) (0,0,1)$_{12}$ model

Variables	Coefficient	Standard error	t-statistic	Probability
Constant	0.03009	0.01145	2.63	0.010
AR(1)	-0.6814	0.0831	-8.20	0.000
AR(2)	-0.3751	0.0823	-4.56	0.000
SMA(12)	-0.4792	0.0812	-5.90	0.000
Error Sum of Squared (SSE)			0.995897	
Mean Squared Error (MSE)			0.007842	

Table 6. Values of ARIMA(3,1,2) (1,0,1)$_{12}$ model

Variables	Coefficient	Standard error	t-statistic	Probability
Constant	0.00782	0.01169	0.67	0.505
AR(1)	-1.0441	0.1142	-9.14	0.000
AR(2)	-1.0765	0.1245	-8.65	0.000
AR(3)	-0.2053	0.1042	-1.97	0.051
SAR(12)	0.7768	0.1242	6.25	0.000
MA(1)	-0.5987	0.0660	-9.08	0.000
MA(2)	-0.8932	0.0580	-15.39	0.000
SMA(12)	0.3831	0.1802	2.13	0.036
Error Sum of Squared (SSE)			0.926650	
Mean Squared Error (MSE)			0.007534	

Table 7. Ljung-Box statistic for ARIMA(2,1,0)(0,0,1)$_{12}$

Lag	12	24	36	48
Chi-Square	12.8	27.0	45.7	56.2
DF	8	20	32	44
P-Value	0.118	0.136	0.055	0.102

Table 8. Ljung-Box statistic for ARIMA(3,1,2) $(1,0,1)_{12}$

Lag	12	24	36	48
Chi-Square	4.9	16.8	39.7	46.1
DF	4	16	28	40
P-Value	0.297	0.400	0.070	0.235

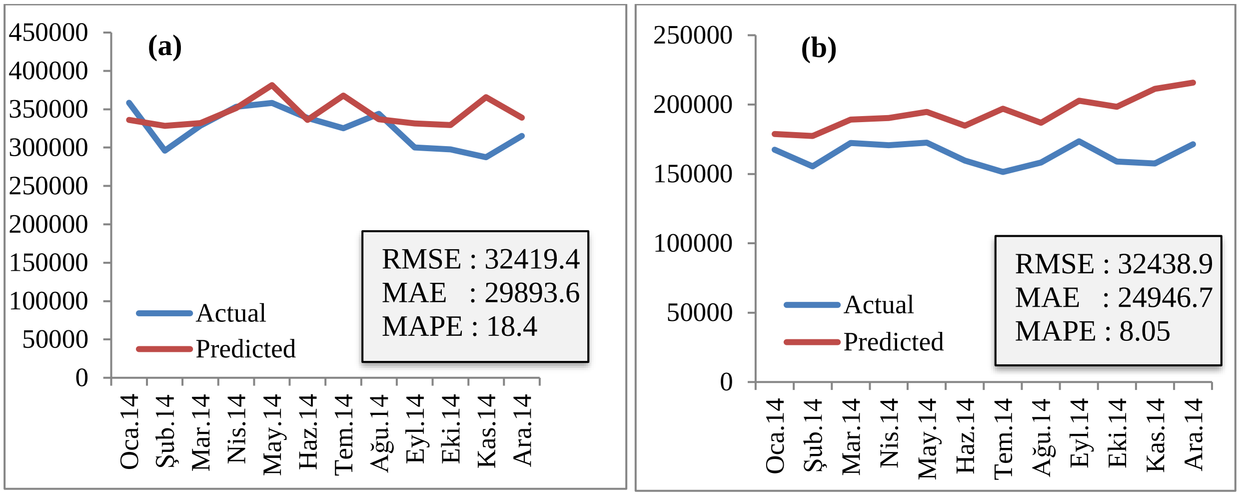

Figure 3. Graphical representation of actual and predicted values for 2014 ($1000): (a) Exports and (b) Imports

Fig. 3 shows the forecasting values calculated by the generated models. In order to obtain the original export and import values, the values were collected with the previous values. Then, antilogarithm of values was taken. The values in Figure 3 are the original values. Performance evaluation criteria such as Mean Absolute Percentage Error (MAPE), Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) have been used to determine whether the models have a successful forecast and the results were in Figure 3. As shown in Figure 3, the values obtained with the help of the models are close to the actual values. Also, it is seen that the models are suitable models according to performance evaluation criteria. After deciding on the suitability of the models, with the help of ARIMA (2,1,0) $(0,0,1)_{12}$ and ARIMA (3,1,2) $(1,0,1)_{12}$ models, the export and import values of the paper and paper products sector for the period 2015-2020 were estimated. Estimates for export and import were given in Tables 9 and 10, respectively.

CONCLUSION

In the present paper, it was aimed to establish the prediction of exports and imports of paper and paper products in Turkey. The monthly time series data was used for determining the forecasting of exports and imports values. As a result of HEGY and ADF tests, it was found that the series were not stationary and had seasonal characteristics. SSE and MSE were used to determine the most suitable models. After determining the most suitable models, the prediction success of the models was determined by RMSE, MAE and MAPE evaluation techniques. The results shown that ARIMA $(2,1,0)(0,0,1)_{12}$ was the best model for paper and paper products exports prediction while ARIMA$(3,1,2)(1,0,1)_{12}$ was the best model for imports.

Table 9. The forecasting values of monthly paper and paper products exports for the period 2015-2020 ($1000)

	2015	2016	2017	2018	2019	2020
January	214166	257930	307438	366441	436767	520590
February	220169	261742	311969	371841	443204	528262
March	223302	265594	316567	377321	449736	536048
April	225567	269508	321232	382882	456364	543948
May	229643	273482	325967	388525	463090	551965
June	232903	277511	330771	394251	469915	560099
July	236131	281601	335645	400062	476840	568354
August	239801	285752	340592	405958	483868	576730
September	243283	289963	345612	411940	490999	585230
October	246831	294236	350705	418012	498235	593855
November	250515	298573	355874	424172	505578	602607
December	254189	302973	361119	430423	513029	611488

Table 10. The forecasting values of monthly paper and paper products imports for the period 2015-2020 ($1000)

	2015	2016	2017	2018	2019	2020
January	362361	399283	444780	497401	557398	625971
February	362046	399054	443329	496070	557433	627778
March	368910	410201	455892	508090	568615	638649
April	378773	416907	463307	516899	578231	648587
May	408444	441314	483109	534289	594739	664810
June	375130	417880	465432	519944	583069	655896
July	396345	435461	482633	537179	599883	672076
August	372813	414138	463399	521103	587448	663087
September	373350	418711	469197	526919	593387	669651
October	367349	413761	467052	527207	595316	672819
November	399474	440288	489706	547914	615107	692031
December	381914	428661	481047	541071	610097	689134

The models are also confirmed by the MAPE value. The MAPE values of ARIMA(2,1,0)$(0,0,1)_{12}$ and ARIMA(3,1,2)$(1,0,1)_{12}$ are 18.4 and 8.05, respectively. According to the MAPE statistical classification used by Lewis (1982), ARIMA(3,1,2)$(1,0,1)_{12}$ is included in the "very good model" category, while ARIMA(2,1,0)$(0,0,1)_{12}$ is in the "good model" category. Up to the year 2020, exports of paper and paper products will be approximately 6.78 billion dollars and imports of it will be approximately 7.92 billion dollars. According to imports, paper and paper products exports of Turkey are predicted to increase further.

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