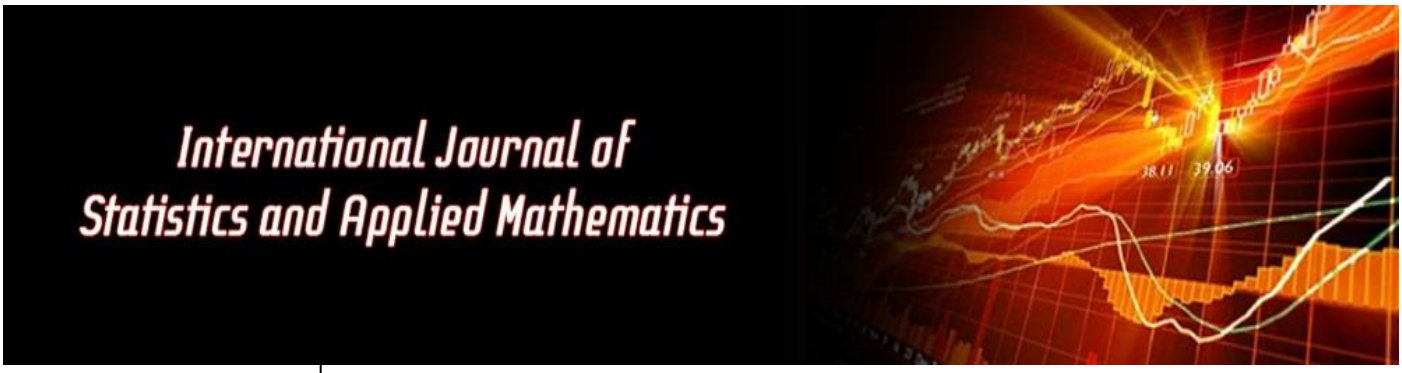

ISSN: 2456-1452
Maths 2023; 8(1): 40-45

https://www.mathsjournal.com
Received: 22-10-2022
Accepted: 25-12-2022

Nahid Salma
Associate Professor, Department of Statistics, Jahangirnagar University, Savar, Dhaka-1342, Bangladesh

Sadia Rahman Lira
MS Student, Department of Statistics, Jahangirnagar University, Savar, Dhaka-1342, Bangladesh

Md. Asraful Alam
Associate Professor, Department of Statistics, Jahangirnagar University, Savar, Dhaka-1342, Bangladesh

Shohel Mahmud
Lecturer, Noakhali Science and Technology University, Noakhali, Bangladesh

Corresponding Author:
Nahid Salma
Associate Professor, Department of Statistics, Jahangirnagar University, Savar, Dhaka-1342, Bangladesh

Performance evaluation of different seasonal adjustment techniques

Nahid Salma, Sadia Rahman Lira, Md. Asraful Alam and Shohel Mahmud

DOI: https://doi.org/10.22271/maths.2023.v8.i1a.928

Abstract
The Central Bank of Bangladesh publishes financial data on a weekly, quarterly, monthly, and yearly basis. Among the published data, GDP, production, export, import, balance payment, wage earners remittance, Stock etc. are time-based and often subject to seasonal variation. But like most of the developed country's central banks such as the USA, Australia, Singapore, UK, French etc. Bangladesh Bank does not publish seasonally adjusted data. These published time series are used by economists, decision-makers, and consumers to inform decisions. They look for key characteristics of economic series like trends, turning points, and coherence with other economic data. Seasonal shifts might occasionally make it challenging to see these features. Therefore, the research aimed to explore the best seasonal adjustment technique for different financial data published by Bangladesh Bank. Here, the non-filter-based seasonal adjustment technique: Ratio to moving average, Ratio to trend, and SARIMA and filter-based techniques: X-11 and X-13-ARIMA-SEATS were applied to monthly import and export data published by Bangladesh Bank. The seasonal adjustment method that produces fewer forecasting errors (MAPE, MASE, MAE, and RMSE) were decided as the best technique for seasonal adjustment and X-13-ARIMA-SEATS method founds the appropriate seasonal adjustment method for our considered data. Therefore, X-13-ARIMA-SEATS method can be recommended to forecast monthly export and import of Bangladesh published by Bangladesh Bank.

Keywords: MAPE, MASE, MAE, and RMSE

1. Introduction
A nation's total development is typically correlated with its economic growth, with agriculture, export, import, remittances, and other key economic sectors playing a significant role. Most of these financial and business statistics are time-based data, including GDP, productivity, export, import, balance payment, remittance, etc. Seasonal fluctuations, as we know, is one of the four different components of time series. The seasonal pattern is common in quarterly, monthly, and weekly data. "The regular and predictable movement around the trend line in tiny time intervals, such as one year or less, can be described as seasonal fluctuations." (Brockwell and Davis, 2002) [3]. Data with seasonal variations is difficult to analyze and forecast since data changes for a specified period because of some underlying forces, or due to regularly occurring variation (Box and Jenkins, 1994) [1]. Therefore, the use of raw data for decision making and forecasting will be misleading and seasonal adjustment is required.
The Central Bank of Bangladesh, Bangladesh Bank (BB), publishes financial data on a weekly, quarterly, monthly, and yearly basis but without adjusting seasonal effects whereas most of the developed country's central banks like USA, Australia, Singapore, UK, French etc. published seasonal adjusted data. Among the published data, GDP, production, export, import, balance payment, wage earners remittance, Stock etc. are time-based which often subject to seasonal variation. These published time series are used by economists, decision-makers, and consumers to inform decisions. They look for key characteristics of economic series like trend, turning points, and coherence with other economic data. Seasonal shifts might occasionally make it challenging to see these features. Seasonal adjustment is the assessment and elimination of seasonal changes (Shumway and Stoffer, 2010) [7].

In order to eliminate the seasonal effect, the main objective of seasonal adjustment is to divide a time series into a number of distinct components, including a seasonal component. (Findley, 2005) [4]. The derived seasonally adjusted dataset won't contain the significant seasonal swings that can mask more crucial tiny swings for economists (Bokhari, and Ansari 2009) [2]. Without appropriate seasonal adjustment method, it is not possible to get the better seasonal adjusted data. Among the different seasonal adjustment method, it is also necessary to find best seasonal adjustment method for Bangladeshi time series data. Therefore, the aim of this research project is to explore the best seasonal adjustment technique for different financial data published by Bangladesh Bank.

2. Methodology

2.1 Data Collection

The study utilized secondary data. The monthly data on import and export published by Bangladesh Bank was considered in this study.

2.2 Statistical Analysis

Non-filter based seasonal adjustment methods to remove seasonal effect: ratio to trend method, ratio to moving average method, SARIMA method, and filter based seasonal adjustment method: X-11, and X-13 ARIMA SEATS were employed. The best seasonal adjustment technique was chosen based on forecasting errors such as Mean Absolute Percentage Error (MAPE), Percentage Mean Absolute Deviation (PMAD), Mean Absolute Deviation (MAD), and Root Mean Square Error (RMSE). Statistical Language R and Microsoft Excel were used to conduct the analysis.

3. Results and Discussion

3.1 Analysis of Monthly Export Data

The monthly Export of Bangladesh in million US dollars for the year of July 2010- December 2021 was used. Fig. 1 visualizes the monthly export inflow in million US dollars of Bangladesh and Fig. 2 plotted the decomposition of export series. The monthly export of Bangladesh reveals trends, irregular components, and seasonality.

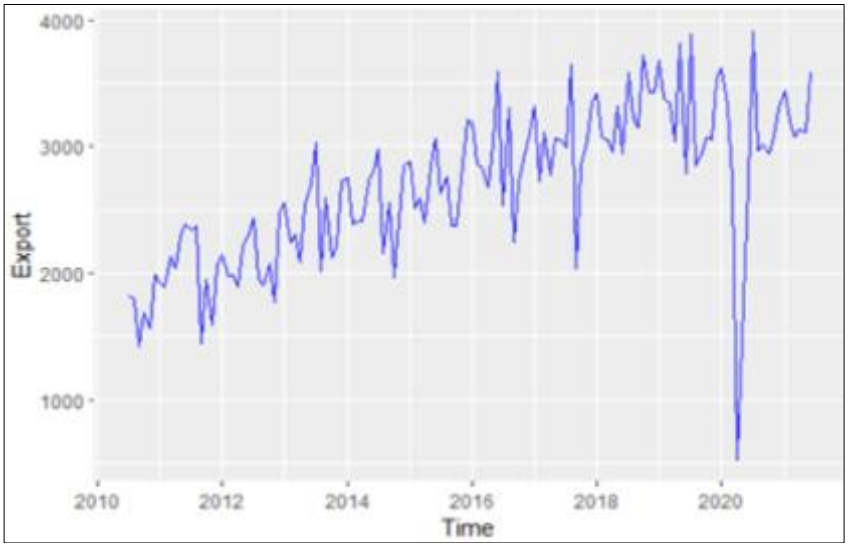

Fig 1: Plot of monthly export data of Bangladesh from July 2010-December 2021.

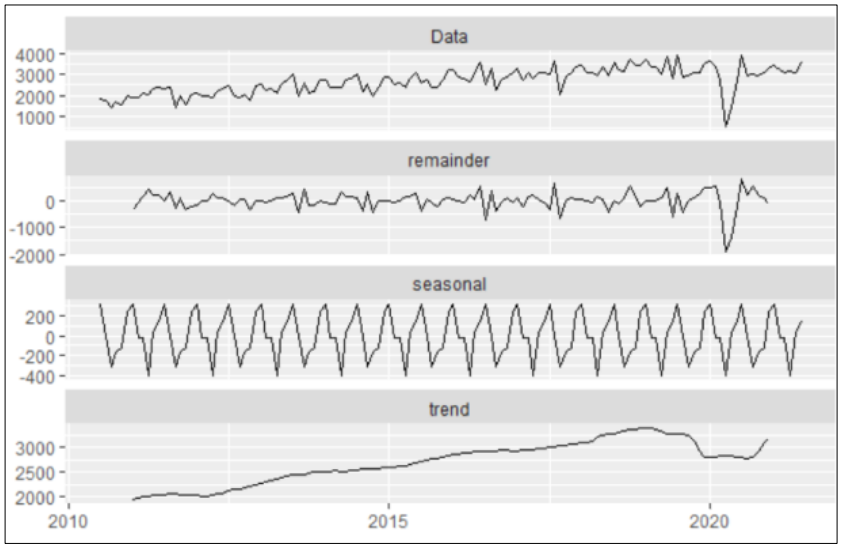

Fig 2: Decomposition Plot of monthly export of Bangladesh from July, 2010- December, 2021

3.1.1 Comparison of Different Seasonal Adjustment Method for Monthly Export Data

The performance of filter and non-filter based seasonal adjustment methods are reported with their forecasting accuracy measures including Mean Absolute Percentage Error (MAPE), Mean percentage error (MPE) Mean Absolute Error (MAE), Mean Absolute Scaled Error (MASE) and Root Mean Square Error (RMSE).

Table 1 Measuring forecasting accuracy of different seasonal adjustment methods for Export Data.

Methods of Seasonal Adjustment	MAD/MAE	MAPE	RMSE	MPE	MASE
Ratio to Moving Average	252.78	12.77	379.68	-0.05	1.00
Ratio to Trend	257.82	12.71	400.74	-0.47	0.79
SARIMA	268.24	13.20	387.69	-0.03	0.82
X11-Procedure	257.82	12.17	400.74	-0.05	0.72
X-13 ARIMA SEATS	251.38	12.17	251.38	-0.45	0.71

Table 1, reveals that, the X-13-ARIMA-SEATS method contains lowest error as compared to other seasonally adjustment procedures. Therefore, X-13-ARIMA-SEATS technique is the best seasonally adjustment method compared to all other ways for export data in terms of minimum error value of various error statistic.

3.1.2 Forecasting with X-13-ARIMA-SEATS for Monthly Export Data

Using the best-fit model X-13-ARIMA-SEATS, which is depicted in Fig. 4, Bangladesh's monthly exports have been predicted for the next 24 months (Table 2). In Fig. 3, the original series and the seasonal adjusted series are graphically compared. It can be seen that the seasonal adjusted series (green color) differed very slightly from the original series (blue), proving that the fitted series behaves in the same way as the original series. As a result, the corrected series actually provides a more accurate picture of Bangladesh's original export series.

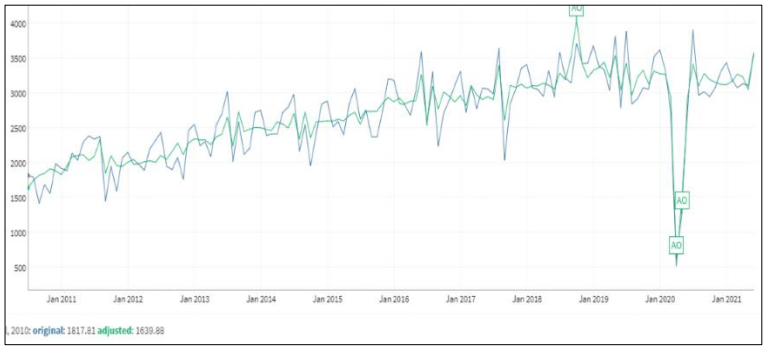

Fig 3: Bangladesh's original and seasonally adjusted monthly export data from 2010 to 2021 are plotted.

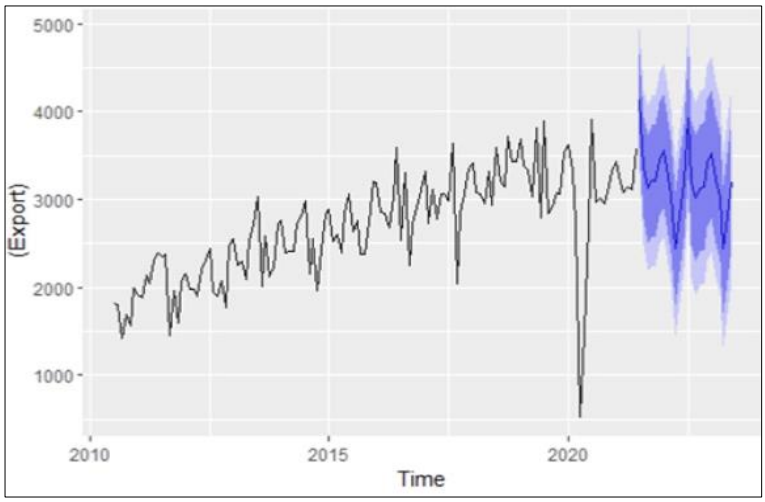

Fig 4: Forecast plot of export of Bangladesh using X-13-ARIMA-SEATS Procedure

Table 2: Forecasted monthly export of Bangladesh after seasonal adjustment based on X-13-ARIMA-SEATS method

Point		Forecast	Lo 80	Hi 80	Lo 95	Hi 95
Jul	2021	4125.931	3587.290	4664.571	3302.151	4949.710
Aug	2021	3364.314	2788.926	3939.702	2484.333	4244.294
Sep	2021	3121.970	2504.006	3739.934	2176.875	4067.065
Oct	2021	3214.252	2583.998	3844.507	2250.361	4178.144
Nov	2021	3208.449	2568.992	3847.907	2230.484	4186.415
Dec	2021	3451.875	2808.793	4094.957	2468.366	4435.384
Jan	2022	3552.610	2907.277	4197.944	2565.657	4539.563
Feb	2022	3251.116	2604.762	3897.470	2262.603	4239.629
Mar	2022	3040.767	2393.835	3687.698	2051.370	4030.164
Apr	2022	2445.140	1797.928	3092.352	1455.315	3434.966
May	2022	2809.095	2161.731	3456.458	1819.038	3799.152
Jun	2022	3199.583	2552.143	3847.022	2209.409	4189.756
Jul	2022	3922.241	3221.173	4623.310	2850.049	4994.434

Aug	2022	3185.607	2476.946	3894.268	2101.803	4269.410
Sep	2022	3009.384	2291.732	3727.036	1911.830	4106.937
Oct	2022	3125.269	2404.871	3845.667	2023.515	4227.023
NOV	2022	3148.495	2426.042	3870.947	2043.599	4253.391
Dec	2022	3406.710	2683.434	4129.987	2300.555	4512.866
Jan	2023	3521.161	2797.375	4244.948	2414.226	4628.097
Feb	2023	3227.974	2503.955	3951.993	2120.683	4335.266
Mar	2023	3024.387	2300.237	3748.538	1916.895	4131.880
Apr	2023	2433.226	1709.012	3157.441	1325.636	3540.816
May	2023	2800.594	2076.345	3524.843	1692.951	3908.237
Jun	2023	3193.434	2469.168	3917.700	2085.765	4301.104

3.2 Analysis of Monthly Import Data

Fig. 5 visualizes the monthly import in million US dollars of Bangladesh and Fig. 6 plotted the decomposition of export series. The monthly landed import of customs of Bangladesh reveals trends, irregular components, and seasonality.

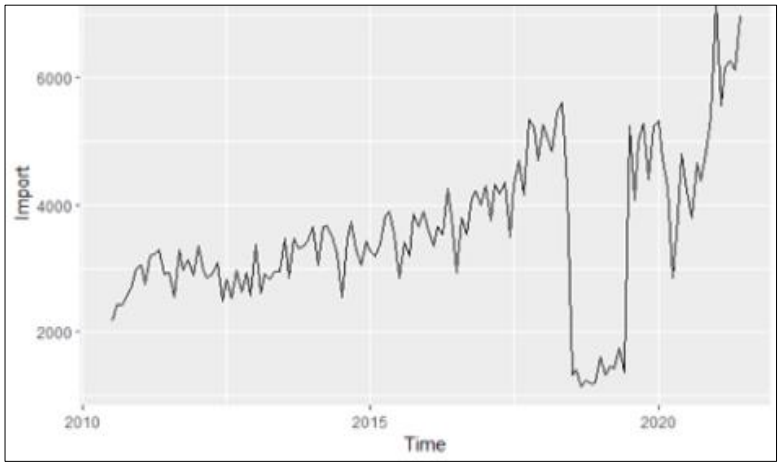

Fig 5: Plot of monthly landed import of customs of Bangladesh from July 2010-December 2021.

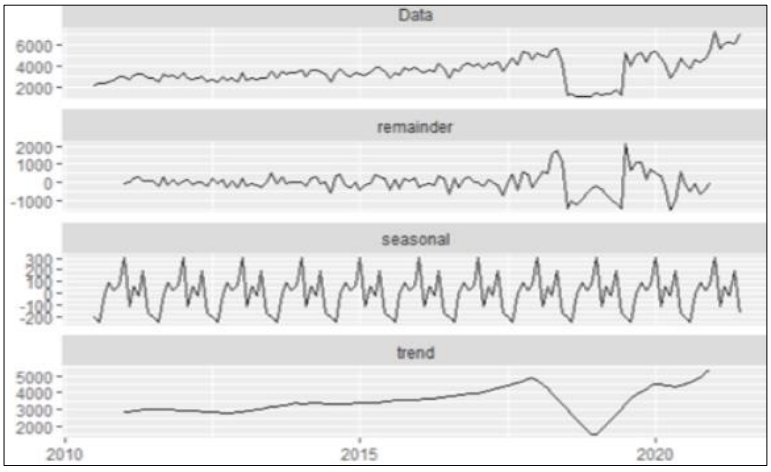

Fig 6: Decomposition Plot of monthly landed import of Bangladesh from July 2010- December 2021

3.2.1 Comparison of Different Seasonal Adjustment Methods for Monthly Import Data

The performance of non-filter based seasonal adjustment methods: ratio to moving average, ratio to trend, SARIMA and the filter-based method: X-11, X-13-ARIMA_SEATS are reported with their forecasting accuracy measures including Mean Absolute Percentage Error (MAPE), Mean percentage error (MPE) Mean Absolute Error (MAE), Mean Absolute Scaled Error (MASE) and Root Mean Square Error (RMSE).

Table 3: Measuring forecasting accuracy of different seasonal adjustment methods for Import.

Different Seasonal Adjustment Methods	MAD/MAE	MAPE	RMSE	MPE	MASE
Ratio to Moving Average	666.09	27.88	1034.56	-0.12	1.00
Ratio to Trend	653.42	27.98	653.42	-0.14	1.00
SARIMA	425.12	13.12	652.76	-1.44	0.38
X11- Procedure	432.87	13.56	652.21	-1.62	0.93
X-13 ARIMA SEATS	432.87	13.11	6 42.91	-1.62	0.38

Table 3 demonstrated that, when compared to other seasonally adjusted methods, the X-13-ARIMA-SEATS technique has the lowest error. Thus, X-13-ARIMA-SEATS technique is best seasonally adjustment method compared to all other methods for our import data.

3.2.2 Forecasting with X-13-ARIMA-SEATS of Monthly Import Data

The anticipated remittances and 95% confidence interval for 24 months are provided in Table 4 and Fig. 8 using the best fitted model X-13-ARIMA-SEATS. In Fig. 7, the original series and the corrected series are graphically compared. The original series (blue) and the adjusted series (green) differed from each other by a very minor amount, demonstrating that the adjusted series behaves in the same way as the original series.

Fig 7: Plot of original and adjusted monthly Landed Import of Customs data of Bangladesh (2010-2021).

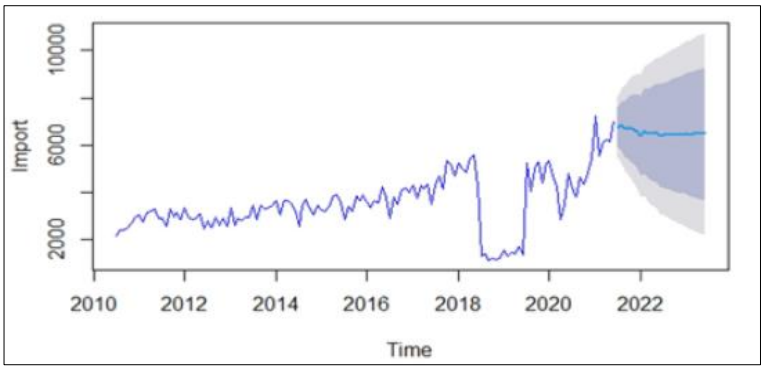

Fig 8: Forecasted plot using X-13-ARIMA-SEATS Procedure of Landed Import of Customs Data.

Table 4: Forecasted monthly import of Bangladesh after seasonal adjustment based on X-13-ARIMA-SEATS method

	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
Ju1 2021	6758.576	5919.551	7597.601	5475.398	8041.754
Aug 2021	6812.772	5783.540	7842.004	5238.698	8386.847
Sep 2021	6704.059	5514.658	7893.460	4885.027	8523.090
Oct 2021	6739.595	5409.170	8070.019	4704.886	8774.304
Nov 2021	6682.753	5224.883	8140.623	4453.133	8912.373
Dec 2021	6609.537	5034.500	8184.574	4200.726	9018.348
Jan 2022	6372.358	4688.286	8056.429	3796.793	8947.923
Feb 2022	6586.972	4800.508	8373.436	3854.812	9319.132
Mar 2022	6510.301	4627.004	8393.598	3630.047	9390.556
Apr 2022	6497.613	4522.223	8473.002	3476.515	9518.710
May 2022	6513.563	4450.188	85/6.939	3357.903	9669.224
Jun 2022	6406.558	4258.798	8554.318	3121.842	9691.274
Ju1 2022	6433.582	4230.999	8636.166	3065.021	9802.143
Aug 2022	6426.622	4163.589	8689.654	2965.612	9887.631
Sep 2022	6440.584	4118.675	8762.492	2889.531	9991.636
Oct 2022	6436.020	4056.692	8815.348	2797.152	10074.888
NOV *2022*	6443.320	400/.926	88/8./14	2/18./07	1016/.933
Dec 2022	6452.723	3962.525	8942.920	2644.294	10261.152
Jen *2023*	6483.183	3939.362	9027.004	2592.744	10373.622
Feb 2023	6455.621	3859.283	9051.958	2484.865	10426.376
Mar 2023	6465.467	3817.655	9113.280	2415.987	10514.947
Apr 2023	6467.097	3768.791	9165.403	2340.394	10593.799
May 2023	6465.048	3717.177	9212.919	2262.542	10667.555
Jun 2023	6478.791	3682.232	9275.349	2201.824	10755.757

4. Discussion and Conclusion

Most economic and financial data are time-based and frequently involve seasonal variation. Examples include production, export, import, GDP, remittance, balance payment, and others. Data with seasonal variations is difficult to analyze and forecast since data changes for a specified period and therefore needs to remove this effect. Finding the optimum seasonal adjustment method for Bangladeshi Time Series data was the goal of this project. Hence, different seasonal adjustment method was compared according to the smaller forecast errors. From the results, we find that all three financial time series data: monthly export and import and import data of Bangladesh contain seasonal variation.

For the non-filter-based seasonal adjustment method, ratios to moving average, ratio to trend filter-based seasonal adjustment method X-13-ARIMA-SEATS, X-11, and SARIMA, various forecasting errors (the RMSE, MASE, MAPE, and MAE) were calculated. In comparison to the forecasting mistakes produced by the Ratio to Moving Average, Ratio to Trend, SARIMA, and X-11 methods for each of the three-time series data sets under consideration, the X-13-ARIMA-SEATS method was found to have the lowest forecasting errors.

Using the best method, the study also forecasted for the next 24 months' monthly export and import value for Bangladesh using X-13-ARIMA-SEATS. The projected values acquired are closer to the original series in the graph, as shown by a comparative line graph of forecasted values for both the original and forecasted values. Finally, it can be concluded that the X-13-ARIMA-SEATS method outperforms all other methods in the case of seasonal adjustment of export and import of Bangladesh. Therefore, X-13-ARIMA-SEATS method can be recommended to forecast the export, import and remittance of Bangladesh published by Bangladesh Bank.

5. Funding

The research did not get any specific grant from any agency.

6. Conflict of Interest

No known conflict of interest or personal relationships may influence the work reported in this research.

7. Consent for publication

Not applicable

8. Data availability

All data related to the research will be supplied if necessary.

9. Code availability

Codes will be supplied if necessary.

10. References

1. Box GEP, Jenkins GM, Riensel G. Time Series Analysis, Forecasting and control, 3rded. Prentice Hall, New York; c1994.
2. Bokhari SH, Ansari IA. Seasonal adjustment of some financial indicators of Pakistan. IBT Journal of Business Studies (JBS), 2009;5(2):107-123
3. Brockwell PJ, Davis RA. An Introduction to Time Series and Forecasting, 2nd ed, Springer Verlag, New Work; c2002.
4. Findley DF. Some Recent Developments and Directions in Seasonal Adjustment. Journal of Official Statistics. 2005;21(2):343-365.
5. Islam S, Khan MSI, Rashed MSU. Seasonal adjustment of selected financial published data of Bangladesh bank. 2017;4(1):59-65.
6. Saeed AA. Comparison among different seasonal adjustment methods in forecasting export of jute goods. Journal of Science and Technology. 2019;104:110.
7. Shumway RH, Stoffer DS. Time Series Analysis and Its Applications, 3rd ed., Springer Verlag, New York; c2010.