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A Re-Analysis of Time Series Modelling of Bangladesh Export Values

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Abstract

In this paper we fit a SARIMA$(1,1,0)\times(0,1,1)_{12}$ time series model for Bangladesh export values based on the AICC criterion and we found that its forecasting performance is better than the previously proposed SARIMA$(4,1,2)\times(1,1,0)_{12}$ model by Hossain and Rajeb, 2010.

Keywords and Phrases: Time series, Forecasting, Export values, ARMA, ARIMA, SARIMA.

AMS Classification: Primary 62M10.

1 Introduction

Trade is an integral part of the total developmental effort and national growth of all economies including Bangladesh. Trade particularly plays a central role in the development plan of Bangladesh where foreign exchange scarcity constitutes a critical bottleneck. It's economy is significantly dependent on foreign trade and its dependency will rise as the country tries to liberalize its economy and becomes more market driven. Export trade can largely meet 'foreign exchange gap', and export growth would increase the import capacity of the country that, in turn, would increase industrialization, as well as overall economic activities.

The striking features of Bangladesh's exports are commodity and market concentration. Despite structural limitations in the Bangladesh economy, the export sector performed well throughout the 1990s. Bangladesh's total exports got a significant boost with an annual trend growth rate of 14.24 percent during 1985/86 to 1999/00, compared to an annual trend growth rate of below 10 percent (in nominal US dollar terms) over the earlier period of 1972/73 through 1984/85. Such a pattern of export growth over time largely reflects the effects of progress in Bangladesh's policy reforms over the period.

According to recent reports by the World Bank (2008), Bangladesh stood tall with 11.88 per cent export growth until May 2009 amid tumbling shipments from major Asian countries because of the lingering global financial recession. As recorded in official data, goods worth US$14.14 billion were exported by the country between July 2008 and May 2009, compared to US$12.63 billion during the same period of last year.

Despite repeated emphasis of the government on an export-led growth and the introduction of several export promotion measures, the share of exports in GDP persistently remained below 10 percent. Roy (1991) showed that both demand and supply factors are responsible for the ordinary performance of the export sector. Exports of traditional items are demand determined, while some of the non-traditional exports are supply constrained. Empirical investigation about the long-run relationship between exports and imports has got considerable attention in the area of international trade. Bahmani-Oskoee (1994) has used cointegration technique and examined the long-run relation between Australian exports and imports, and has found that they will converge in the long-run. Al Mamun and Nath (2005) using quarterly data for a period from 1976 to 2003, examined time series evidence to investigate the link between exports and economic growth in Bangladesh. Jesmin (2008) highlighted the potentials of Bangladesh's export to the EU market by analysing the country's strengths and weaknesses, threats and opportunities.

By properly addressing certain weaknesses and overcoming some challenges, Bangladesh can further strengthen its position in the EU market. Rahman (2008) re-examined the effects of exports, FDI and expatriates' remittances on real GDP of Bangladesh, India, Pakistan and Sri Lanka. Annual data from 1976 through 2006 are utilized. The results revealed close similarities of long-run and short-run dynamics of the variables between Bangladesh and India. Uddin (2009) makes an effort to understand the time series behavior of total export and total import of Bangladesh. Unit root tests recognize the existence of random walk in total export and total import time series. Any changes in the international market, either through price of commodities or international demand, and domestic macroeconomic policies- both fiscal and monetary policies- will greatly affect exports, imports and economic growth.

The problem of balance of trade in Bangladesh is also well known. Ever since the independence of the country, export earnings have persistently fallen behind import payments. Consequently, every year the country incurs a huge trade deficit. To arrest the yawning gap, the policymakers pursued various policies about the nature and extent of influence of the export sectors.

To address some of the problems, it will be useful to have a forecasting model. Hence, the present research is intended to provide a suitable model to forecast total exports of Bangladesh. In a recent paper (Hossain and Rajeb, 2010), the authors had proposed a Seasonal ARIMA (SARIMA)$(4,1,2)\times(1,1,0)_{12}$ time series model for forecasting the Bangladesh export values based on the AIC criterion. The AIC statistic is defined as,

$$\mathrm{AIC} = -2\ln L + 2(p+q+1),$$

where L is the Gaussian Likelihood for an ARMA(p,q) process.

On the other hand, the AICC statistic is defined as,

$$\mathrm{AICC} = -2\ln L + \frac{2(p+q+1)n}{(n-p-q-2)}.$$

Since, the AICC criterion has a more extreme penalty than the AIC statistic it would counteract fitting very large models. Our computations revealed that the AICC value for the SARIMA$(4,1,2)\times(1,1,0)_{12}$ was 1046.29. This value is quite high and therefore in this paper, we re-analyze and fit a new model for the Bangladesh export values based on the AICC criterion.

In Section 2 the methodology and results are discussed and the conclusions are drawn in Section 3.

2 Methodology and Results

The time series models used in this paper is briefly described. When a time series is not stationary usually differencing operations are applied at the appropriate lag in order to achieve stationarity. The mean is then subtracted and a ARMA model is fitted to the data set.

A stationary zero mean ARMA (p,q) model is defined as (see Brockwell and Davis, 2002) a sequence of random variables $\{X_t\}$ which satisfy,

$$X_t - \phi_1 X_{t-1} - \ldots - \phi_p X_{t-p} = Z_t + \theta_1 Z_{t-1} + \ldots + \theta_q Z_{t-q}$$

for every t and where $\{Z_t\}$ is a sequence of uncorrelated random variables with zero mean and constant variance σ^2 . A process is said to be a ARMA process with mean

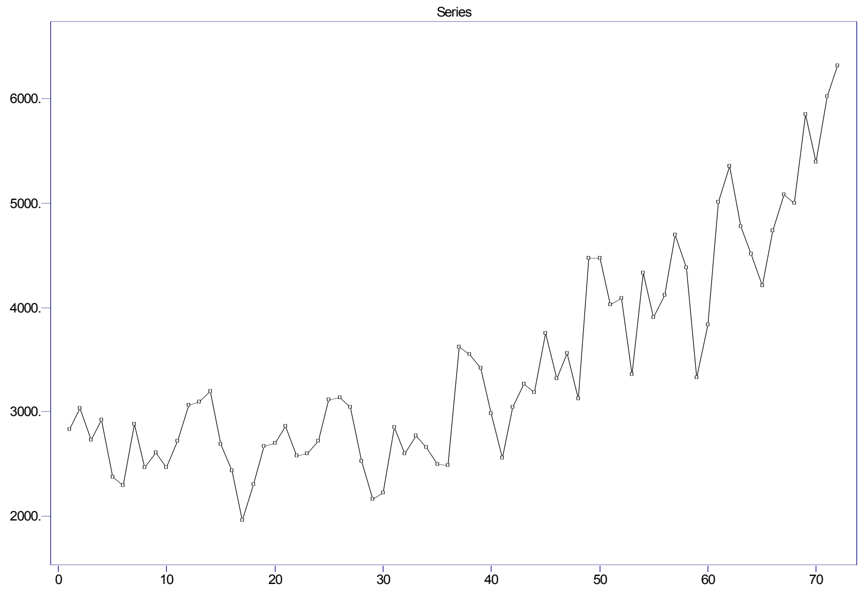

Figure 1: Time Series Plot of Bangladesh export values

μ, if $\{X_t - \mu\}$ is an ARMA(p, q) prosess. A process is called an ARIMA (p, d, q) process if d is a nonnegative integer such that $(1 - B)^d X_t$ is a ARMA (p, q) process and where B is the usual backward shift operator. A process is called a SARIMA $(p, d, q,) \times (P, D, Q)$ process with period s if $Y = (1 - B)^d (1 - B^s)^D X_t$ is given by,

$$\phi(B)\Phi(B^s)Y_t = \theta(B)\Theta(B^s)Z_t,$$

(see Brockwell and Davis, 2002). The exact time series modelling procedures can be found in standard text books.

In this research we used the *Interactive Time Series Modelling (ITSM2000)* package to analyze the data set. The *ITSM2000* package is included in the book by Brockwell and Davis (2002). Annual data on real exports from the Fiscal year July' 2000 to June'2006 are used for this paper. The data obtained from the Economic Trend of Bangladesh, 2000-2006. The data consists of 72 monthly observations from July 2000 to June 2006 and a plot of it is shown in Figure 1.

Clearly from Figure 1, we can see that the time series is not stationary and has a seasonal period 12. We therefore differenced the data once at lag 12 and the plot is shown in Figure 2. This differenced series appeared to be still not stationary and hence we conducted several tests for unit roots. The Augmented Dickey-Fuller (ADF) test statistic value was found to be -2.027. Since $-2.027 > -2.593$ (the 0.10 critical level) , we cannot reject the unit root hypothesis at the 0.10 level. The Phillips-Peron

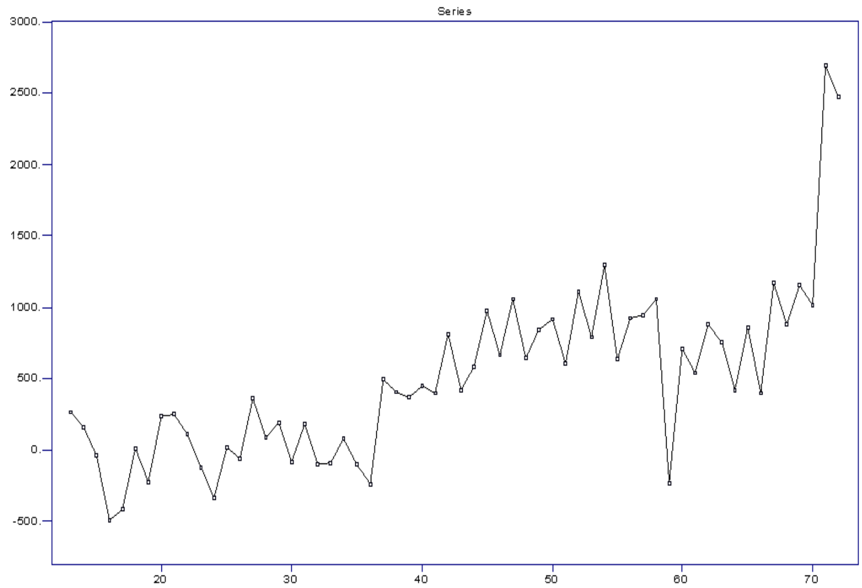

Figure 2: Plot of the Time Series after differencing at lag 12

(PP) (Phillips and Perron, 1988) test statistic value of -1.498 also failed to reject the unit root hypothesis.

As such we differenced the series once again at lag 1. A plot of the differenced series after differencing at lags 12 and l is shown in Figure 3. The corresponding sample ACF and PACF plots are shown in Figure 4.

We then applied the ADF Test to the series shown in Figure 3 and the computed statistic value was -13.15. Since $-13.15 < -2.593$, the ADF test clearly rejected the null hypothesis of unit root. Similarly, the PP Test was found to be -13.47 clearly indicating that there is no unit root. Further the KPSS Test (Kwiatkowski, Phillips, Schmidt and Shin, 1992) for *stationarity* was found to be 0.2291 failing to reject the null hypothesis of *stationarity*. Hence, we can safely conclude that the series in Figure 3 (after differencing at lags 12 and 1) is stationary.

We subtracted the mean of the differenced series (37.4068) and considered many models. After an extensive search the SARIMA$(1,1,0)\times(0,1,1)_{12}$ emerged to be a plausible model with an AICC value 864.52 which is much lower than the AICC value (1046.29) for the earlier proposed SARIMA$(4,1,2)\times(1,1,0)_{12}$ model.

Hence our fitted SARIMA$(1,1,0)\times(0,1,1)_{12}$ model is given as,

$$(1 + 0.4514B)((1 - B)(1 - B^{12})Y_t - 37.4068) = (1 - 0.4351B^{12})Z_t, \qquad (1)$$

where Y_t is the original time series (i.e. Bangladesh export values) and Z_t is white noise with mean 0 and variance 115,556. More specifically in equation (1), $\hat{\phi}_1 = -0.4514$

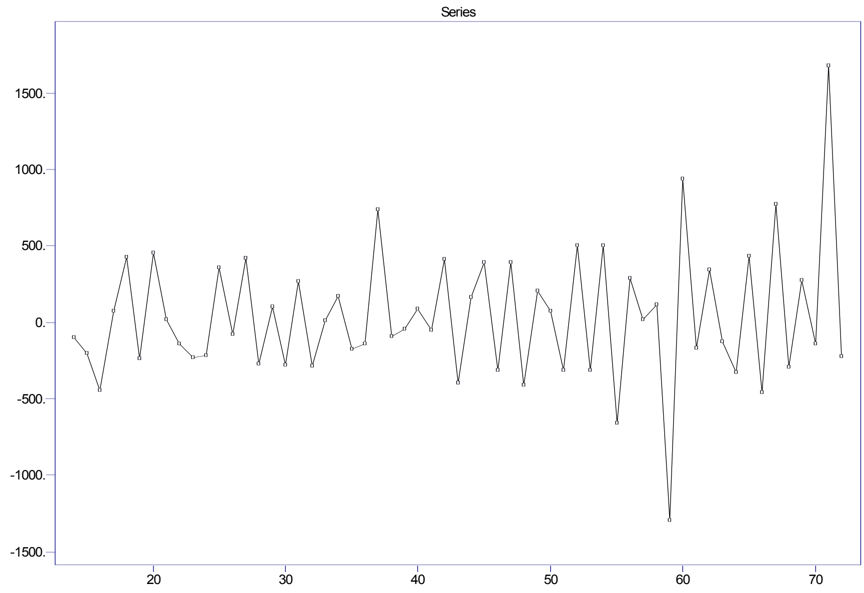

Figure 3: Plot of the Time Series after differencing at lag 12 and lag 1

and its standard error is 0.1166 while $\hat{\Theta}_{12} = 0.4351$ and its standard error was found to be 0.1541. The exact details of time series modelling can be found in Brockwell and Davis (2002).

To validate our fitted model, several randomness tests on the residuals were performed and the results are shown in Table 1. The null hypothesis is that the residuals are white noise and hence if the p-value is greater than 0.05, we will not reject the null hypothesis. Since all the randomness test in Table 1 had p-values greater than 0.05, it indicates that the residuals behave like white noise and as such our fitted model seems appropriate.

Table 1: Results of Randomness Tests on Residuals

Test	Computed Statistic value	Distribution of Test Statistic	p-value
Ljung-Box	18.31	$\chi^2(20)$	0.5670
McLeod-Li	14.65	$\chi^2(22)$	0.8768
Turning Points	38.00	$AN(38, 10.17)$	1.0000
Difference sign	26.00	$AN(29, 5.00)$	0.1797
Rank Test	986.00	$AN(855.5, 5845.98)$	0.0879

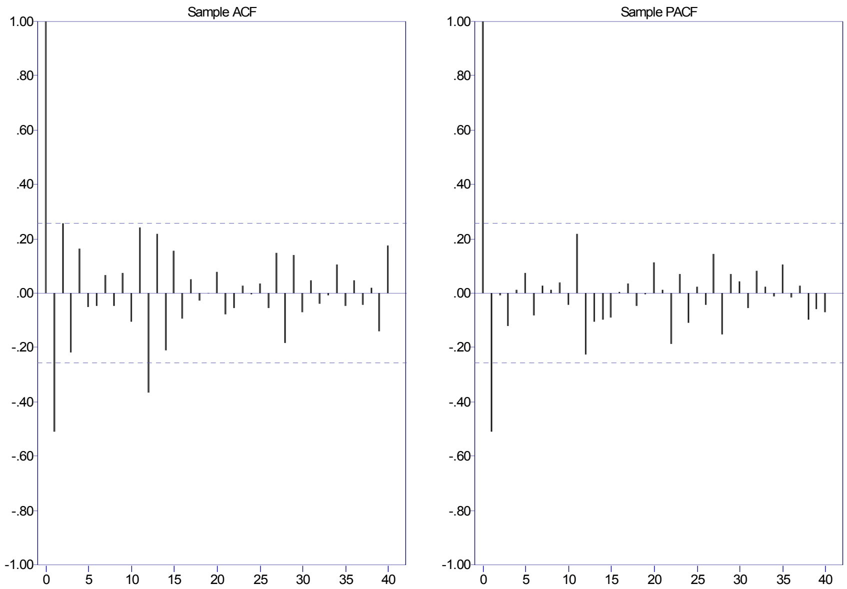

Figure 4: Sample ACF and Sample PACF Plots

Using the model given in (1), we produced forecast from July, 2005 to June 2006 (12 periods) and a plot of the forecast values is shown in Figure 5. The forecasted values are given in Table 2.

To evaluate the forecasting performance of this model we used the Mean Absolute Error (*MAE*), Root Mean Square Error (*RMSE*) and the Mean Absolute Percentage Error (*MAPE*) which are defined respectively by the following equations,

$$MAE = n^{-1} \sum_{i}^{n} \mid y_i - \hat{y}_i \mid, \tag{2}$$

$$RMSE = \sqrt{n^{-1} \sum_{i}^{n} (y_i - \hat{y}_i)^2}, \tag{3}$$

$$MAE = n^{-1} \sum_{i}^{n} \left| \frac{y_i - \hat{y}_i}{y_i} \right| \times 100\%, \tag{4}$$

where y_i and $\hat{y}_i$ are the actual observed values and predicted values, respectively.

In Table 3 the computed *MAE*, *RMSE* and *MAPE* values are shown. Based on all three criteria, clearly we can see that the SARIMA$(1,1,0)\times(0,1,1)_{12}$ model has smaller values and hence outperforms the SARIMA$(4,1,2)\times(1,1,0)_{12}$ model.

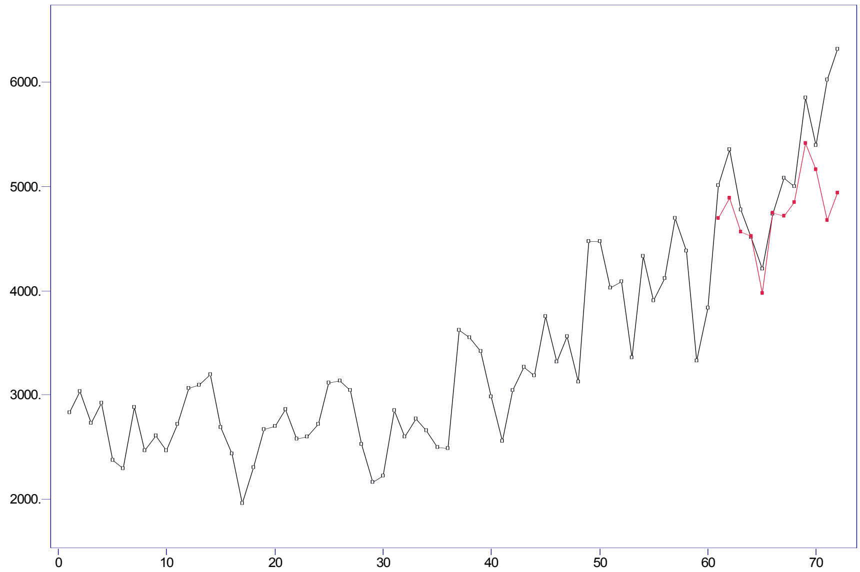

Figure 5: Forecast Plot

Table 2: Actual and Forecasted Values

Month	Actual values	Predicted values using SARIMA(4,1,2)$\times(1,1,0)_{12}$	Predicted values using SARIMA(1,1,0)$\times(0,1,1)_{12}$
July 2005	5006	4761.5	4692.3
Aug 2005	5349	5161.5	4886.6
Sept 2005	4775	5012.8	4561.5
Oct 2005	5414	4985.9	4520.6
Nov 2005	4212	4099.1	3974.2
Dec 2005	4731	4484.2	4740.5
Jan 2006	5081	4215.7	4718.9
Feb 2006	4999	4466.0	4845.6
Mar 2006	5852	5031.8	5410.1
Apr 2006	5397	5157.2	5155.3
May 2006	6018	4379.8	4673.6
June 2006	6309	4776.1	4936.1

3 Conclusions

The objective of this research was to re-analyze and fit a new model for the Bangladesh export values based on the AICC criterion. We found that the

Table 3: *MAE*, *RMSE* and *MAPE* values

Model	*MAE*	*RMSE*	*MAPE*
SARIMA(4,1,2)×(1,1,0)$_{12}$	594.24	776.99	10.8 %
SARIMA(1,1,0)×(0,1,1)$_{12}$	429.99	613.40	7.6%

SARIMA(1,1,0)×(0,1,1)$_{12}$ model has smaller AICC value compared to SARIMA(4,1,2)×(1,1,0)$_{12}$ model. We also found that the MAE, RMSE and MAPE values are also smaller for the SARIMA(1,1,0)×(0,1,1)$_{12}$ model. Hence, it is suggested that the SARIMA(1,1,0)×(0,1,1)$_{12}$ model may possibly be an appropriate forecasting model for Bangladesh export values.

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