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TIME SERIES MODELING AND VOLATILITY ANALYSIS OF EXPORTS OF PAKISTAN BY USING ARCH AND GARCH MODEL

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ABSTRACT

In this paper the identification and estimation of the mean and variance components of the monthly exports of Pakistan was done by using mean model ARIMA and variance model GARCH. Data, on monthly export of Pakistan, which are in million of US-dollar, was obtained from State Bank of Pakistan, covering the period January, 1972 to June, 2016.The residuals obtained under the best selected mean and variance is explained by the volatility structure. By applying the OLS methodology the parameters of ARIMA type simple specifications are normally estimated. The presence of ARCH effects or volatility has two disadvantages, the autocorrelation in error term and the presence of ARCH effect. This problem may be determined by employ the ARCH or GARCH variance models. In addition, the forecasting pattern for of exports of Pakistan might be helpful to suggest planners for effective future planning to attain sustainable economic growth.

INTRODUCTION

The developed countries export consumer and industrial goods to low-income countries like Pakistan. Pakistan therefore contributed to international trade by exporting Raw material or semi-functional goods to developed nations against furnished and industrial goods. International trade as import and export is a mean of obtaining and economizing foreign exchange for its development.

According to the Economic Complexity Index (ECI) the 67th largest export economy and the 106th most complex economy in the world is Pakistan. Pakistan exported $28.3B and imported $47.4B, in 2014, resulting in a negative trade balance of $19.1B. In the same year, the GDP of Pakistan was $243B and its GDP per capita was $4.81k.

The difference between the Imports and Exports plays the key role in the establishment of the budget of a country and it also analyses that whether the budget will be in positive that means revenue is higher or it is deficit, in which the expenses are higher. In Pakistan mainly the budget is always in deficit with high imports and less exports, these are a negative trait in the economy of a country. In Pakistan the deficit between the import and export is about 13 billion US Dollars for which Pakistan has to rely on the financial loans from organizations like World Bank and IMF. Due to which economy have to face many crises and failed the economists to develop better policies.

Forecasting procedures used for economic related data sets to understand economic patterns. Statistical models play an important role in describing the underlying structure of the economic variables. Linear modeling approaches limited to model several variables together particularly involving natural (not human controlled) variables.

The modeling of non-linear relationships among variables is a demanding task.The important forms of nonlinear statistical models include bilinear models, threshold autoregressive models, exponential autoregressive model, stochastic models, autoregressive conditional heteroscedasticity (ARCH) models, generalized autoregressive heteroscedasticity (GARCH) model and random coefficientmodels (Chand*et al*.,2012).

Review of Literature

Mustafa and Ahmad (2006) presented a model for the export of kinnow from Pakistan. They estimated past trends in the export of kinnow by applying log linear model and making use of compound interest calculation formula by using Box and Jenkins methodology with four step identification, estimation, diagnostic checking and forecasting. Thus ARIMA (2, 2, 2) was estimated by using the method of least square. They applied a verity of tests for diagnostic checking of the model and did forces export sting at 95% confidence limits. Their proposed ARIMA model forecast export for kinnow from Pakistan up to the year 2023.

Ngailo (2011) modeled the GARCH model on inflation of Tanzania. Time series data were used from January 1997 to December 2010 and fitted the ARCH and GARCH models. GARCH (1, 1) and GARCH (1, 2) were applied on data. According to AIC and BIC, GARCH (1,1) was considered best model for forecasting.

Franses and Dijk (1996) described that to projected weekly stock market unpredictability in this piece of paper they deliberated the non-linear adjustments of the GARCH model and also GARCH model too. In stock exchange directories for instance frequently experiential undesirable skewness, to designate those situations they projected models that were: the Glosten, Jagannathan and Runkle models and Quadratic GARCH models. From the consequences they originate that when the approximation illustration does not hold thrilling observations than the Quadratic GARCH model was finest. Such as in the situation of 1987 smash of stock market they recommended Quadratic GARCH model. For predicting they do not suggested the GJR model.

Materials and Methods

The stationarity of data is usually described by time plots and correlogram. The unit root test determines whether a time series is stable around its level or stable around the difference in its level. Two types of unit root tests are widely used (1) Dickey-Fuller (DF) test and (2) Augmented Dickey-Fuller (ADF) test. The most frequently used test for unit roots is the ADF-test. In this paper the ADF-test (1987) has been used.

ARCH Effect

In volatility analysis pre and post estimation analysis can be tested by using ARCH effect test. The existence of ARCH effects shows the presence of conditional heteroscedasticity done by using post estimation test. This test is applied on the standardized residuals of the best fitted model. To check the ARCH effect in the residuals ARCH LM-test was used (Engle1982). The presence of ARCH effect also checks by using the Normality tests. Normality test can be describe by using the conditional error distribution. GARCH models estimation is done by using the normal distribution. Pre-estimation testing is performed on the Exports and squared exports series, different tests were applied to series to make sure that conditional volatility modeling is suitable. The major tests before essentially estimation of the conditional volatility is done by Engle's ARCH test.

Autoregressive Conditional Heteroscedasticity (ARCH) Model

Engle (1982) introduced a formal approach in modelling the variance of a time series by conditioning its variance on the squared lagged disturbances in an autoregressive from known as Autoregressive Conditional Heteroscedasticity (ARCH) Model.

The model would be

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2$$

$\boldsymbol{\varepsilon_t}$ denotes the error term and assume that$\boldsymbol{a_o}$>0, $\boldsymbol{a_1} \geq 0$

Generalized Autoregressive Conditional Heteroscedasticity (GARCH) Model

In the presence of many heteroscedasticity situation best modeling will be done by using GARCH family models.The distinctive feature of these models is that they recognize the volatility and correlation are not constant.(Gazda and Tomáš,2003).

$$\sigma_t^2 = a_o + \sum_{i=1}^{q} \alpha_i \mathcal{E}_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2$$

Forecast Evaluation Criteria

To examine the forecasting power of fitted models or measure be applied using some reserved data points from the study period. Some of the measures used for the said purpose forecast errors such as; mean absolute error (MAE) , root mean square error (RMSE) and adjusted mean absolute percentage error (AMAPE). Best model will be selected on the minimum value of such forecast errors.

Results and Discussion

In this part, the stationary and non-stationary condition of the series is checked by using the Box Jenkins methodology, that was used to get the mean and variance models. Unit root test was used to check the stationarity of the series. Augmented Diciky Fuller (ADF) test was applied on both the stationary and non-stationary Export Series The autocorrelation (ACF) plots of both the original non-stationary series and of the first order differencing series were also sustaining this remark. ADF test at original series and also at differencing were applied to for the final selection of best model for forecasting.

Mean Model Identification and Estimation

Autoregressive process (1) and moving average (1) can be applied model is. The results of autocorrelation of both models exhibits similar and random walk. The results of AR(1), AR(2),MA(1),MA(1),ARMA (1,1) and ARMA(2,1) are shown in the table.The criteria of model selecting AIC and SIC will be suggested the best model.

Model	AIC	SIC
AR(1)	12.02	12.03
AR(2)	12.29	12.31
MA(1)	11.97	11.99
ARMA(1,1)	11.96	11.98
ARMA(2,1)	11.97	11.99

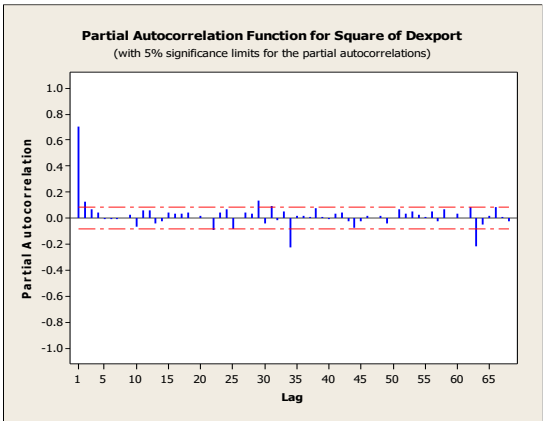
Model selecting criteria is given in table. According to table the AIC and BIC of different models are assumed to select the best model. From it clearly see that the ARMA(1,1) has 11.959 AIC and 11.983 SIC which are the lowest among the all models, so the most fitting mean model is ARIMA(1,1).

ARMA(1,1)

$$y_t = 0.11769y_{t-1} + 1.246 + 0.72403\varepsilon_{t-1}$$

Variance Model Identification and Estimation

To decide about the order of ARCH and GARCH model we use the PACF of squared residual. Significant spike in PACF shows the order of ARCH term. After some gaps the other significant spike shows the order of GARCH term.



Lag plot

At lag 1 and 2 the significant spikes are two so the order of ARCH(q) is 2, and at lag 34 there are only one significant spike so the order of GARCH(q,p) is 1.

ARCH Model

The ARCH(1) , ARCH(2) and ARCH(3) are applied on the series By seeing the ARCH (3) is suitable than ARCH (1) and ARCH(2) by diagnostic checking as well as AIC and SIC.

Criteria of Model Selection

Model	AIC	SIC
ARCH(q)		
ARCH(1)	12.0119	12.0353
ARCH(2)	11.9302	11.9614
ARCH(3)	11.8667	11.9056

GARCH Model

The GARCH(1,1) , GARCH(2,1) and GARCH(1,2) are applied on the series By seeing the GARCH (2,1) is suitable than ARCH (1) and ARCH(2) by diagnostic checking as well as AIC and SIC.

Criteria of Model Selection

Model	AIC	SIC
GARCH(q,p)		
GARCH(1,1)	11.4305	11.4617
GARCH(2,1)	11.3876	11.4266
GARCH(1,2)	11.4808	11.5198

The most appropriate model is selected us the two criteria AIC and BIC. As we see that the ARCH (3) model is best in arch models model did not deliver an acceptable picture of the data. GARCH (2, 1) is

best model in all GARCH models and adequately represent the data.

GARCH(2,1)
GARCH = 4.82779468164 +
0.114934037675*RESID(-1)^2
+0.133403280071*RESID(-2)^2 +
1.02477891985*GARCH(-1)

Forecasting

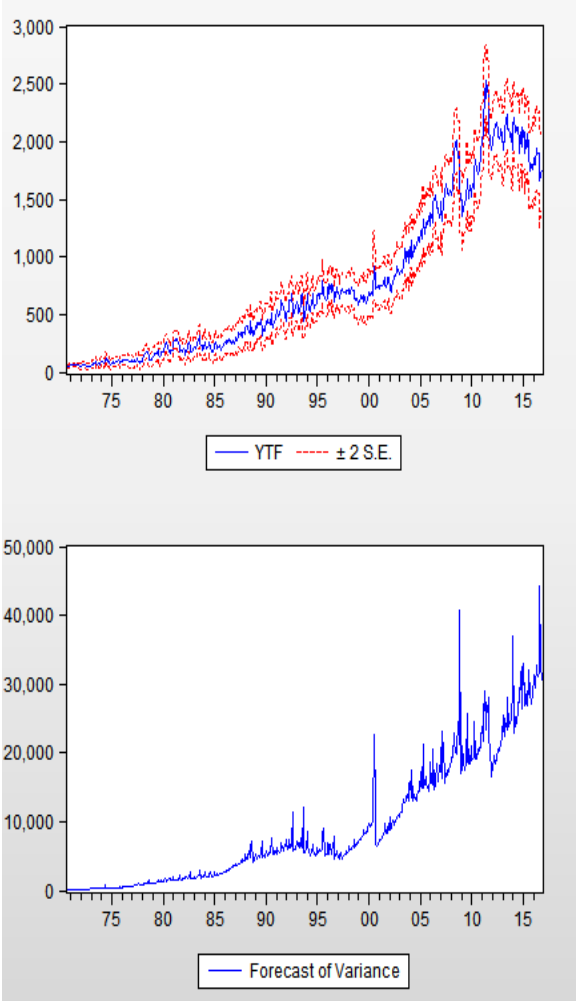
We used three forecasting criteria to check the performance of forecast RMSE, MAE and MAPE. The performance of forecasting of export using GARCH (2,1) is overall best. It had MAE 248577.4629,MAPE 310.211766 and RMSE is 37.9983902.So the results revealed that GARCH (2,1) is the perfect model for forecasting among these models and forecasting export for year of 2016 by this model. The performance of forecasting by the GARCH (2, 1) and variance forecasting is given in figure.

Model Selection

Model	MAE	MAPE	RMSE
ARCH(3)	1871956.27	1061.6753	45.977622
GARCH(2,1)	248577.463	310.21177	37.99839
EGARCH(2,2)	1785055.24	1032.4948	80.000924
TGARC(1,1)	356443.251	380.76146	65.344439

Forecasting

t	1-Aug-16	1-Sep-16	1-Oct-16	1-Nov-16	1-Dec-16	1-Jan-17
Export	1773.46	1796.788	1757.2	1837.211	1827.47	1779.07
t	1-Feb-17	1-Mar-17	1-Apr-17	1-May-17	1-Jun-17	1-Jul-17
Export	1923.65	1906.222	1883.45	1911.213	1688.67	1668.61



Conclusion

Pakistan is a developing country its export are not consistently increased or decreased i.e. called its volatility. This study is conducted for finding the best model of forecasting the export in Pakistan from 1970 to 2016. The data shows the non-constant mean and variance reveals of non-stationarity of data. For time series, model fitting requires the data should be stationary so transformation technique known as differencing used for getting stationarity. By fitting AR(1), AR(2), MA(1),ARIMA(1,1) and ARMA(2,1) we concluded that the ARMA(1,1) which is best model in these models containing lowest value of AIC and SIC but this model has some deficiencies and also not appropriate by diagnostic tests. Its squared residuals represent the autocorrelation which indicating of heteroscedasticity in the data and need heteroscedasticitymodels like ARCH and GARCH.

Firstly the primary model of GARCH family ARCH(1),ARCH(2) and ARCH(3) are applied and ARCH(3) is the better than ARCH(1) and ARCH(2) also by the criteria of AIC and SIC as well as the fulfilling the properties of model. Then GARCH model with order (1,1), (1,2), and (2,1) are applied in which GARCH(2,1) is more appropriate model with lowest AIC and SIC. GARCH (2, 1) is the most appropriate model according to minimum AIC and SIC and also capturing the volatility in the monthly Exports of Pakistan. It is best model for forecasting monthly export by the lowest MAE RMSE and MAPE in all ARCH type. And it recommended as the best model as well as forecasting the monthly export of Pakistan and policy making for future.

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