ANALYSINGVOLATILITY MODELS FOR GROSS DOMESTIC PRODUCT OF SRI LANKA - FROM 2002 TO 2015

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Abstract

Gross domestic product (GDP) is the best way to measure a country's economy. It includes everything produced by all the people and companies that are in the country. The objective of this paper is to empirically characterize the volatility models for GDP of Sri Lanka using seasonally adjusted at 2002 base year constant prices quarterly real GDP data for the period 2002:Q1 to 2015:Q4. The four types of ARCH family models (GARCH, TGARCH, EGARCH, PARCH) were used for the analysis data. Using various specifications for variance equation, study estimated ARIMA(1,2,2) Vs. GARCH(1,1), ARIMA(1,2,2) Vs. TGARCH(1,1), ARIMA(1,2,2) Vs. EGARCH(1,1) and ARIMA(1,2,2) Vs. PARCH(1,1) for real GDP. The comparison indicates that the ARIMA(1,2,2) Vs. EGARCH(1,1) model is the best model to modelling the volatility of real GDP. The results of the study present evidence that the symmetric response volatility of second differenced square root GDP to negative and positive shocks.

Keywords: GDP, ARIMA, GARCH, Unit root, Volatility.

Introduction

Measuring volatility of GDP is important for policy maker.The modeling and forecasting is usually carried out in order to provide an aid to decision makingand planning the future. Analysing volatility of GDP are important inputs for government, businesses sector, policy makers,investors, workers and various individuals for various applications.

Gross domestic product of Sri Lanka

GDP refers to the economic value of goods and services produced within the nation's boundaries, in a particular financial year. When the GDP is estimated at current prices, it exhibits Nominal GDP, whereas Real GDP is when the estimation is made at constant prices. Both the two are considered good indicators for evaluating country's economic growth.

Nominal Gross Domestic Product refers to the monetary value of all goods and services produced during the year, within the geographical limits of the country. The economic worth of all goods and services produced in a given year, adjusted as per changes in the general price level is known as Real Gross Domestic Product. Nominal GDP is the GDP without the effects of inflation or deflation whereas you can arrive at Real GDP, only after giving effects of inflation or deflation.

Nominal GDP reflects current GDP at current prices. Conversely, Real GDP reflects current GDP at past (base) year prices. The value of nominal GDP is greater than the value of real GDP.

Statement of the problem

Gross Domestic Product (GDP) is most important measure of economic activity in a country. GDP is the market value of all officially recognized final goods and services produced within a country in a year, or over a given period of time. GDP per capita is often used as an indicator of a country's material standard of living.

The Study which analyzes the mean equation for real GDP is understanding the underpinnings of the economy. This study aims at modeling real GDP volatility using ARCH-family models and choosing the most suitable model among them.The ARCH model was first introduced by Engle (1982) for capturing time variant variance exhibited by almost all financial time series and many economic time series. The generalized version of ARCH model (GARCH model) was formulated by Bollerslev (1986).Furthermore this study will add more knowledge for economics in analyzing the volatility for GDP through the established model.

Objectives of the study

Construct suitable model of mean equation of GDP in Sri Lanka from 2002 to 2015 quarterly data using time seriesvolatility models such as ARCH, GARCH, TGARCH, EGARCH and PARCH.

The ARIMA(1,2,2) Vs. EGARCH(1,1) model, mean equation is $(1-0.578511B)(1-B)^2x_t = (1+0.397746B^2)u_t$ and variance equation is$\log \sigma_t^2 = 2.929 + 0.185\frac{u_{t-1}}{\sigma_{t-1}} + 1.254\left|\frac{u_{t-1}}{\sigma_{t-1}}\right| - 0.331\log \sigma_{t-1}^2$ for real GDP

This paper is composed into five sections. Section two illustrates review of the literature, section three explains methodology of the research study, in section four data result and discussion are given and conclusions are given in last section.

Abledu and Kobina (2013)examinesempirically characterize the volatility in the growth rate of real Gross Domestic Product (GDP) for Ghana in three sectors using data spanning from 2000 to 2012. The GARCH-type models (GARCH, EGARCH and GJR-GARCH) were used for the analysis of data.

Sigauke (2013) examined 'Volatility modelling of real GDP growth rate in South Africa' An analysis of quarterly real gross domestic product (GDP) growth rates in South Africafor the period 1960 to 2011 is done using ARMA-EGARCH model. The advantage of this approach lies in its ability to capture conditional heteroskedasticity in the data through the ARMA-EGARCH model.Fang et.al., (2008) examined this paper revisits the issue of conditional volatility in real GDP growth rates for Canada, Japan, the United Kingdom, and the United States. Previous studies find high persistence in the volatility. This paper shows that this finding largely reflects a non-stationary variance

Methodology

Data collection

Seasonally adjusted at 2002 base year constant prices quarterly real GDP data for the period 2002 to 2015 is used. Data were collected from CentralBank of Sri Lanka and it consists 56 observations.

Jarque-Bera

Jarque-Bera is a test statistic for testing whether the series is normally distributed. The test statistic measures the difference of the skewness and kurtosis of the series with those from the normal distribution. The statistic is computed as:

$$\text{Jarque} - \text{Bera} = \frac{N}{6}\left(S^2 + \frac{(K-3)^2}{4}\right) \tag{1}$$

where, S is the skewness, and K is the kurtosis.

Unit root test

The stationary of data is usually described by time series plots and correlogram. The unit root test determines whether a given series stationary or non-stationary. The Augmented Dickey-Fuller (ADF) test is mostly used to check stationary. In this paper ADF test and KPSS test have been used.

ARCH Model

The ARCH process introduced by Engle (1982) explicitly recognizes the difference between the unconditional and the conditional variance allowing the latter to change over time as a function of past errors. The ARCH (1) model for the variance of model u_t is that conditional on u_{t-1}, the variance at time t is

$$\mathrm{Var}(u_t|u_{t-1}) = \sigma^2_{(t)} = \alpha_0 + \alpha_1 u^2_{t-1} \tag{2}$$

where,α_0 and $\alpha_1$are parameters to be estimated.

GARCH Model

The Generalized ARCH (GARCH) model was developed by Bollerslev (1986). The specification of theconditional variance equation for GARCH (1, 1) model is given by:

$$\mathrm{Var}(u_t|u_{t-1}) = \sigma^2_{(t)} = \alpha_0 + \alpha_1 u^2_{t-1} + \beta_1 \sigma^2_{t-1} \tag{3}$$

where,α_0, $\alpha_1$and $\beta_1$are parameters to be estimated.

TGARCH Model

The Threshold GARCH (TGARCH) model was introduced by the works of Zakoian (1990) and Glostenet, al., (1993). The main target of this model is to capture asymmetric in terms of negative and positive shocks. The specification of the conditional variance equation for TGARCH (1, 1) model is given by:

$$\mathrm{Var}(u|u_{t-1}) = \sigma^2_{(t)} = \alpha_0 + \alpha_1 u^2_{t-1} + \beta_1 \sigma^2_{t-1} + \delta_1 u^2_{t-1} I \tag{4}$$

where, I takes the value of 1 for $u_t < 0$and 0 for$u_t > 0$. If $I = 1$ there is asymmetry while if $I = 0$ the news impact symmetry.

EGARCH Model

The exponential GARCH (EGARCH) model was developed Nelson (1991), and the variance equation for this model is given by:

$$\log \sigma^2_t = \alpha_0 + \alpha_1 \frac{u_{t-1}}{\sigma_{t-1}} + \delta \left|\frac{u_{t-1}}{\sigma_{t-1}}\right| + \beta_1 \log \sigma^2_{t-1} \tag{5}$$

where,$\alpha_0, \alpha_1, \delta$and$\beta_1$are parameters to be estimated. The log of the variance series makes the leverage effect exponential instead of quadratic and therefore estimates of the conditional variance are guaranteed to be non-negative. The EGARCH models allow for the testing of asymmetry. When, then positive shocks generate less volatility than negative shocks.

Model Selection Criteria
To select the best model Akaike’s Information Criterion and Bayesian Information Criterion are used.

Akaike’s Information Criterion (AIC)

$$\mathrm{AIC} = \log \hat{\sigma}_k^2 + \frac{n+k}{n-k-2} \tag{6}$$

Bayesian Information Criterion (BIC)

$$\mathrm{AIC} = \log \hat{\sigma}_k^2 + \frac{k \log n}{n} \tag{7}$$

where, $\hat{\sigma}_k^2$ is given and k is the number of parameters in the model.

Results and Discussion

From table-1, the mean and standard deviation of GDP are 630504.5 and 164353.3respectively. The high standard deviation of the GDP with respect to mean implies that there is high volatility exists. According to the Jarque-Bera statistic, the GDP is normally distributed at 5% significance level, (p=0.143773).

Table 1: Descriptive statistic of Real GDP. [Q1 2002 to Q4 2015]

Statistic Measures	**Values**
Mean	630504.5
Median	596269.0
Maximum	964687.0
Minimum	394341.0
Standard Deviation	164353.3
Skewness	0.385349
Kurtosis	1.966334
Jarque-Bera	3.879033
Jarque-Bera (Probability)	0.143773
CI for Mean (at 95%)	[586490 , 674519]

From the figure-1, the real GDP has been fluctuation over time. It can easily be seen that real GDP has been increasing and variance is increasing with time. Thus, it is not stationary. Also, this result is confirmed by unit root test and this result is shown in table 2.

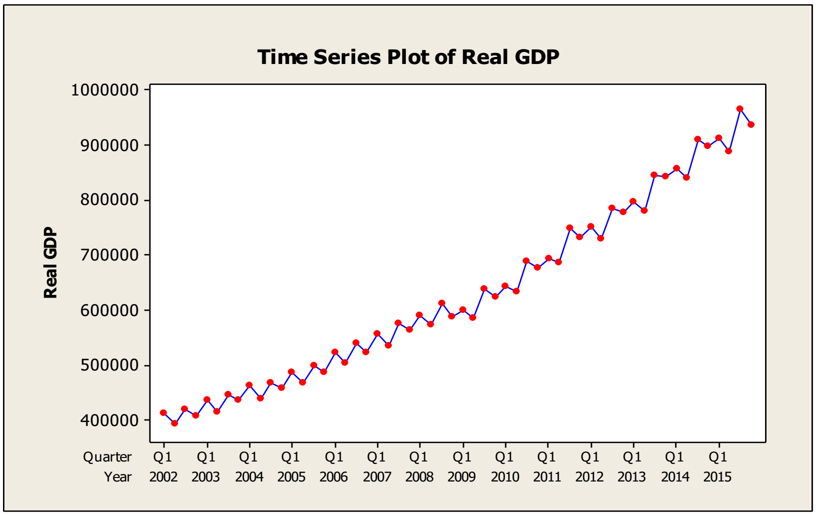


Figure 1:Time series plot for Real GDP [Q1 2002 to Q4 2015].

Augmented Dickey-Fuller test statistic is in table-2, real GDP probability value is greater than the 0.05 (p=0.9208), thus the null hypothesis not reject at the 5% significance level and null hypothesis is used as the GDP series is nonstationary.

Table 2:Results of the unit root test for Real GDP

Augmented Dickey-Fuller Test Statistic		t-Statistic	Probability
		-1.088235	0.9208
Test Critical Values	1% level	-4.152511	
	5% level	-3.502373	
	10% level	-3.180699	

Descriptive analysis of square root, first and second difference of GDP

Descriptive statistics of square root GDP (Sqrt(GDP)), first difference square root of GDP (DSqrt(GDP)) and second difference square root of GDP (D^2Sqrt(GDP)) are given in table 3.

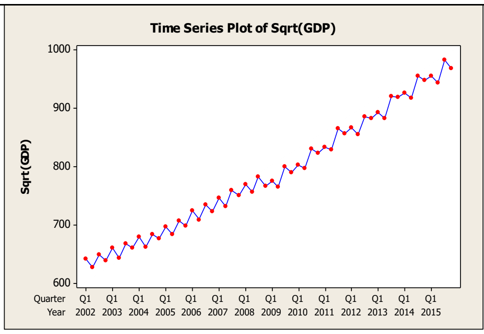
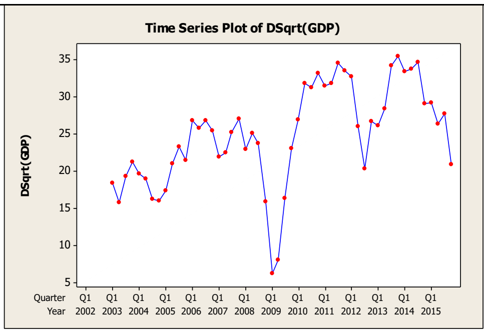
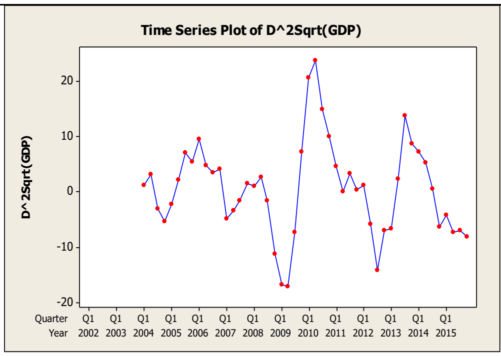
The GDP series is nonstationary (due to variance and up-ward trend).Then, the GDP series was transformed into the second difference square root of GDP (D^2Sqrt(GDP).From the table-3, the Jarque-Bera statistic, the null hypothesis of the series is normally distributed. All p values are greater than 0.05.Therefore, Sqrt(GDP), DSqrt(GDP) and D^2Sqrt(GDP) are normally distributed at 5% significance level.

Table 3: Descriptive statistic

Statistic Measures	Sqrt(GDP)	DSqrt(GDP)	D^2Sqrt(GDP)
Mean	787.4991	24.82755	0.613983
Median	772.1783	25.62070	1.127471

Maximum	982.1848	35.41112	23.69629
Minimum	627.9658	6.235607	-17.06538
Standard Deviation	102.6536	6.740739	8.453649
Skewness	0.230185	-0.491555	0.327671
Kurtosis	1.866810	3.010446	3.517988
Jarque-Bera	3.490808	2.094334	1.395566
Jarque-Bera (Probability)	0.174574	0.350931	0.497687

Table 4: Time series plot and Unit root test

<table>
<tr><th>Time series plot</th><th colspan="4">Unit root test</th></tr>
<tr><td rowspan="4">
</td><td colspan="2">Augmented Dickey-Fuller Test Statistic</td><td>t-Statistic
-1.501538</td><td>Prob.
0.8160</td></tr>
<tr><td rowspan="3">Test Critical Values</td><td>1% level</td><td>-4.152511</td><td rowspan="3"></td></tr>
<tr><td>5% level</td><td>-3.502373</td></tr>
<tr><td>10% level</td><td>-3.180699</td></tr>
<tr><td rowspan="4">
</td><td colspan="3">Kwiatkowski-Phillips-Schmidt-Shin Test Statistics</td><td>LM-St.
0.0512</td></tr>
<tr><td colspan="2" rowspan="3">Asymptotic Critical Values</td><td>1% level</td><td>0.216</td></tr>
<tr><td>5% level</td><td>0.146</td></tr>
<tr><td>10% level</td><td>0.119</td></tr>
<tr><td rowspan="4">
</td><td colspan="2">Augmented Dickey-Fuller Test Statistic</td><td>t-Statistic
-4.016918</td><td>Prob.
0.0149</td></tr>
<tr><td rowspan="3">Test Critical Values</td><td>1% level</td><td>-4.170583</td><td rowspan="3"></td></tr>
<tr><td>5% level</td><td>-3.510740</td></tr>
<tr><td>10% level</td><td>-3.185512</td></tr>
</table>

From table -4, the Sqrt(GDP), DSqrt(GDP) and D^2Sqrt(GDP) have been fluctuation over time. It can easily be seen that Sqrt(GDP) series has been increasing and variance is increasing with time. Thus, it is not stationary.DSqrt(GDP)series, trend has been removed.But not perfectly. So that DSqrt(GDP) is nonstationary.D^2Sqrt(GDP)series, trend has been removed. But, it is obvious that the series is stationary. Also, this results are confirmed by unit root test.

Model Selection criteria for ARIMA Model

Table 5:ARIMA model for D^2Sqrt(GDP)

Model	Coefficient	P value	AIC, SIC	Log likel.	DW value
ARIMA(2,2,0)	AR(1) = 1.190358 AR(2) = -0.547747	0.0000 0.0001	5.975757 6.055263	-135.4424	2.204460
ARIMA(0,2,2)	MA(1) = 1.030375 MA(2) = 0.332448	0.0000 0.0290	6.184773 6.262739	-146.4345	1.696163
ARIMA(2,2,2)	AR(1) = 0.932478 AR(2) = -0494191 MA(2) = 0.938869	0.0000 0.0006 0.0000	5.816431 5.935690	-130.7779	1.887598
ARIMA(1,2,1)	AR(1)=0.605740 MA(1)=0.549831	0.0001 0.0005	6.084581 6.163311	-140.9877	1.922370
ARIMA(1,2,2)	AR(1)=0.626752 MA(2)=0.950325	0.0000 0.0000	6.027985 6.106715	-139.6577	1.372099

Table-5 indicates that, there is the three models have the minimum value of Akaike Information Criterion (AIC) and Schwartz Information Criterion (SIC) and maximum value of Log likelihood respectively in ARIMA(2,2,2), ARIMA(2,2,0) and ARIMA(1,2,2) models. The coefficients of ARIMA(2,2,2), ARIMA(2,2,0) and ARIMA(1,2,2) models, significant at 5% significance level.

Residual Diagnostics of ARIMA(2,2,2), ARIMA(2,2,0) and ARIMA(1,2,2) Model

Table 6: Results for residual diagnostics

Residual Diagnostics	ARIMA(2,2,2)	ARIMA(2,2,0)	ARIMA(1,2,2)
Correlograms of Squared Residuals	No Serially Correlated	No Serially Correlated	Serially Correlated
Histogram and Normality Test	(p=0.96454) Normally distributed	(p=0.271633) Normally distributed	(p=0.564134) Normally distributed
Serial Correlation LM Test	(p=0.015) Serially Correlated	(p=0.2428) No Serially Correlated	(p=0.0033) Serially Correlated
Heteroskedasticity Tests (ARCH)	(p=0.2716) No ARCH effect	(p=0.1082) No ARCH effect	(p=0.0089) ARCH effect

Table-6 indicates that, the results for residual diagnostics of this three model. According to that there is no ARCH effect in the ARIMA(2,2,2)and ARIMA(2,2,0) models. ARIMA(1,2,2) model has been ARCH effect.

ARCH family model

Table 7: Comparing the ARIMA (1,2,2) Vs. ARCH (1) model

Mean Equation				
Variable	Coefficient	Standard Error	z-Statistic	Probability
AR(1) MA(2)	0.633383 0.338063	0.137583 0.167906	4.603633 2.013411	0.0000 0.0441
Variance Equation				
C RESID(-1)^2	13.25065 0.610950	5.554461 0.610950	2.385588 1.513167	0.0171 0.1302

[AIC = 6.168448, BIC = 6.325907, Log Likelihood = -140.9585]

Table-7 indicates that, the coefficient of related with AR(1) and MA(2) in equation for mean of ARIMA (1,2,2) Vs. ARCH (1) is statistically significant (p=0.0000 and p=0.0441 respectively) at 5% significance level and the equation for variance ,the coefficient of ARCH term is statistically not significant (p=0.1302) at 5% significance level.

The estimated ARCH (1) model is:

$$\mathrm{Var}(u_t|u_{t-1}) = \sigma^2_{(t)} = 13.25065 + 0.610950u^2_{t-1}$$

If $u_t$appears to be white noise and u^2_tappears to be AR(1), then an ARCH(1) model for the variance is suggested.

GARCH Model

GARCH can capture asymmetric response of negative and positive shocks on volatility.

Table 8: Comparing the ARIMA (1,2,2) Vs. GARCH (1,1) model

Mean Equation				
Variable	Coefficient	Standard Error	z-Statistic	Probability
AR(1) MA(2)	0.718672 0.096825	0.121264 0.184863	5.926514 0.523767	0.0000 0.6004
Variance Equation				
C RESID(-1)^2 GARCH(-1)	17.37460 0.481048 -0.236486	9.565949 0.324716 0.244685	1.816296 1.481444 -0.966491	0.0693 0.0693 0.3338

[AIC = 6.097487, BIC = 6.294311, Log Likelihood = -138.2910]

Table-8 indicates that, the coefficient of related with AR(1) in equation for mean of ARIMA (1,2,2) Vs. GARCH (1,1) is statistically significant (p=0.0000) and MA(2) is statistically not significance (p=0.6004) at 5% significance level and the equation for variance ,the coefficient of constant, ARCH and GARCH terms are statistically not significant (p=0.0693, p=0.0693 and p=0.3338 respectively) at 5% significance level.Therefore, the GARCH(1,1) can't capture asymmetric response of negative and positive shocks on volatility

The estimated GARCH (1,1) model is:

$$\mathrm{Var}(u_t|u_{t-1}) = \sigma^2_{(t)} = 17.375 + 0.481u^2_{t-1} - 0.236\sigma^2_{t-1}$$

TARCH Model

TGARCH model was estimated to find out the asymmetric response of volatility is termed as leverage effect. The results are reported in table 9.

Table 9: Comparing the ARIMA (1,2,2) Vs. TGARCH (1,1) model

Mean Equation				
Variable	Coefficient	Std Error	z-Statistic	Prob.
AR(1) MA(2)	0.635285 0.210485	0.142023 0.123397	4.473115 1.705748	0.0000 0.0881
Variance Equation				
C RESID(-1)^2 RESID(-1)^2*(RESID(-1)<0) GARCH(-1)	18.54834 0.536129 0.099569 -0.202840	11.66295 0.407571 0.644367 0.350803	1.590364 1.315426 0.154522 -0.578217	0.1118 0.1884 0.8772 0.5631

[AIC = 6.186295, BIC = 6.422484, Log Likelihood = -139.3779]

Table-9 indicates that, the coefficient of related with AR(1) in equation for mean of ARIMA (1,2,2) Vs. TGARCH (1,1) is statistically significant (p=0.0000) and MA(2) is statistically not significance(p=0.0881) at 5% significance level and the equation for variance, the coefficient of the all terms are statistically not significant at 5% significance level. Therefore, the TGARCH(1,1) no symmetric response of volatility is termed as leverage effect.

The estimated TGARCH (1,1) model is:

$$\mathrm{Var}(u|u_{t-1}) = \sigma^2_{(t)} = 18.548 + 0.536u^2_{t-1} - 0.203\sigma^2_{t-1} + 0.099u^2_{t-1}I$$

EGARCH Model

EGARCH model was estimated to find out the asymmetry in response of conditional variance to negative and positive shocks. The results are reported in table 10.

Table 10: Comparing the ARIMA (1,2,2) Vs. EGARCH (1,1) model

Mean Equation				
Variable	Coefficient	Std Error	z-Statistic	Prob.
AR(1) MA(2)	0.578511 0.397746	0.081698 0.107464	7.081113 3.701191	0.0000 0.0002
Variance Equation				
C ABS(RESID(-1)/@SQRT(GARCH(-1))) RESID(-)/@SQRT(GARCH(-1))LOG(GARCH(-1))	2.928628 1.253981 0.185174 -0.330903	1.056298 0.459677 0.284701 0.286780	2.772539 2.727961 0.650416 -1.153855	0.0056 0.0064 0.5154 0.2486

[AIC = 6.102271, BIC = 6.338460, Log Likelihood = -137.4034]

Table-10 indicates that, the coefficient of related with AR(1) and MR(1) in equation for mean of ARIMA (1,2,2) Vs. EGARCH (1,1) is statistically significant (p=0.0000 and

p=0.0002 respectively) at 5% significance level and the equation for variance, the coefficient of the constant and ABS(RESID(-1)/@SQRT(GARCH(-1))) terms are statistically significant at 5% significance level(p=0.0056 and p=0.0064 respectively). Although, table 4.16 shows that the coefficient of the RESID(-1)/@SQRT(GARCH(-1)) and LOG(GARCH(-1)) terms are statistically not significant at 5% significance level, this is evidence of symmetric response volatility of second differenced square root GDP to negative and positive shocks.
The estimated EGARCH (1,1) model is:

$$\log \sigma_t^2 = 2.929 + 0.185 \frac{u_{t-1}}{\sigma_{t-1}} + 1.254 \left|\frac{u_{t-1}}{\sigma_{t-1}}\right| - 0.331 \log \sigma_{t-1}^2$$

PARCH Model

Table 11: Comparing the ARIMA (1,2,2) Vs. PARCH (1,1) model

Mean Equation				
Variable	Coefficient	Std Error	z-Statistic	Prob.
AR(2)	0.886834	0.096023	9.235638	0.0000
MA(2)	-0.934010	0.045446	-20.55217	0.0000
Variance Equation				
C	0.359818	2.066850	0.174090	0.8618
(ABS(RESID(-1))-β* RESID(-1))	0.125933	0.302970	0.415662	0.6777
RESID(-1)	0.999800	2.016313	0.495856	0.6200
@SQRT(GARCH(-1))	0.845471	0.580905	1.455438	0.1455
γ	0.941491	2.231356	0.421936	0.6731

[AIC = 6.328475, BIC = 6.604029, Log Likelihood = -141.7192]

Table-11 indicates that, the coefficient of related with AR(1) and MR(1) in equation for mean of ARIMA (1,2,2) Vs. EGARCH (1,1) is statistically significant (p=0.0000 and p=0.0000 respectively) at 5% significance level and the equation for variance, the coefficient of the all terms are statistically not significant at 5% significance level.

Therefore, the PARCH(1,1) model is not important

The estimated PARCH (1,1) model is:

$$\sigma_t^{0.941} = 0.3598 + 0.126(|u_{t-1}| + 0.999u_{t-1})^{0.941} + 0.845\sigma_{t-1}^{0.941}$$

Model Selection criteria of ARCH Family Model

Table 12: Model selection result of ARCH family model

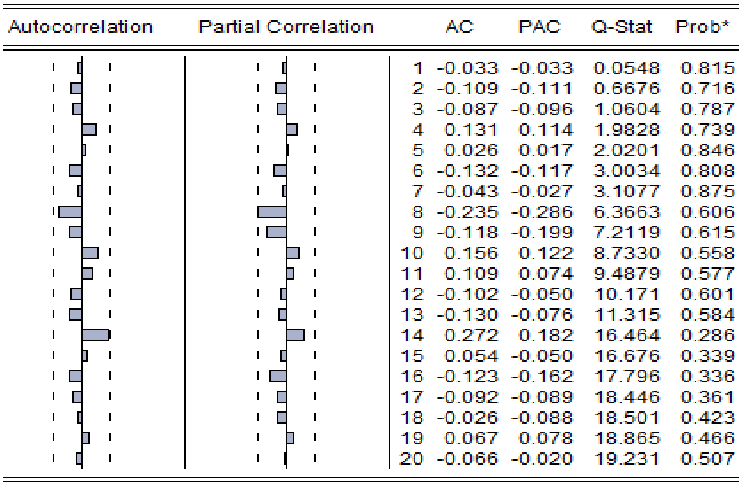
Models	**AIC**	**SIC**	**Log likelihood**
ARIMA(1,2,2) Vs. GARCH(1,1)	6.097	6.294	-138.291
ARIMA(1,2,2) Vs. TGARCH(1,1)	6.186	6.422	-139.378
ARIMA(1,2,2) Vs. EGARCH(1,1)	6.102	6.338	-137.403
ARIMA(1,2,2) Vs. PARCH(1,1)	6.328	6.604	-141.719

Table-12 indicates that, the two models have the minimum value of Akaike Information Criterion (AIC) and Schwartz Information Criterion (SIC) and maximum value of Log likelihood respectively in ARIMA(1,2,2) Vs. GARCH(1,1) and ARIMA(1,2,2) Vs. EGARCH(1,1) model. But, the coefficient of GARCH(1,1) model for GDP series is not significant at 5% significance level. After that both lowest AIC and SIC values and high log likelihood value from EGARCH (1, 1) model is the compared with other three models. The coefficient of EGARCH (1, 1) modelfor GDP series, constant and ABS(RESID(-1)/@SQRT(GARCH(-1))) terms are statistically significant at 5% significance levelTherefore the ARIMA(1,2,2) Vs. EGARCH(1,1) is the best model to determine the volatility of 2002 base year quarterly real GDP series.

Residual Diagnostics of ARIMA(1,2,2) Vs. EGARCH(1,1)

Correlograms of Squared Residuals

To check the serial correlation of residuals, the correlagram of squared residual obtained and shown in figure 2.



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.033	-0.033	0.0548	0.815
		2	-0.109	-0.111	0.6676	0.716
		3	-0.087	-0.096	1.0604	0.787
		4	0.131	0.114	1.9828	0.739
		5	0.026	0.017	2.0201	0.846
		6	-0.132	-0.117	3.0034	0.808
		7	-0.043	-0.027	3.1077	0.875
		8	-0.235	-0.286	6.3663	0.606
		9	-0.118	-0.199	7.2119	0.615
		10	0.156	0.122	8.7330	0.558
		11	0.109	0.074	9.4879	0.577
		12	-0.102	-0.050	10.171	0.601
		13	-0.130	-0.076	11.315	0.584
		14	0.272	0.182	16.464	0.286
		15	0.054	-0.050	16.676	0.339
		16	-0.123	-0.162	17.796	0.336
		17	-0.092	-0.089	18.446	0.361
		18	-0.026	-0.088	18.501	0.423
		19	0.067	0.078	18.865	0.466
		20	-0.066	-0.020	19.231	0.507

Figure 2: Correlograms of Squared Residuals of ARIMA(1,2,2) Vs. EGARCH(1,1)

Figure-2 shows that, the null hypothesis is no serial correlation in the residual, also all p-values of autocorrelations are statistically not significant at 5% significance level. Therefore, residuals are serially correlated.

Histogram and Normality Test

To check the normality of the residuals, the Jarque-Bera test obtained and shown in figure 3.

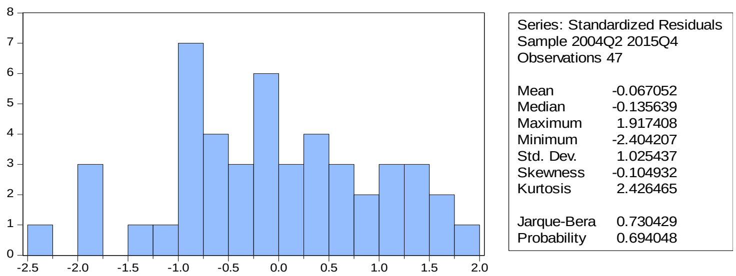


Figure 3: Histogram and Normality test of ARIMA(1,2,2) Vs. EGARCH(1,1)

From the figure-3, according to the results of p-value of Jarque-Bera test is not significant at 5% significance level (p=0.694048). Thus, it is confirmed that residual series is normally distributed.

Heteroskedasticity Tests (ARCH LM Test)

Result of ARCH effect of ARIMA(1,2,2) Vs. EGARCH(1,1)

Heteroskedasticity Test: ARCH			
F-Statistic	0.048786	Probability F(1,44)	0.8262
Obs*R-Squared	0.050947	Probability Chi-Square(1)	0.8214

Table-13 indicates that, the Obs*R-squared is statistically not significant (p=0.8214) at 5% significance level. Therefore, the null hypothesis of no ARCH effect in the residual can’t be rejected. Hence, there is no ARCH effect in the residual. All assumptions of residual satisfied in the ARIMA(1,2,2) Vs. EGARCH(1,1) model. Hence, the EGARCH(1,1) model is the best model to modelling the volatility of real GDP.

Conclusion

The objective of this study was to analysing volatility modelsfor Gross Domestic Product (GDP) of Sri Lanka from 2002 to 2015. The real GDP data is not stationary at 5% significance level. By second differences of square root transformed the series of the real GDP data becomes stationary. The study identified several ARIMA models, ARIMA(1,2,2) model is best.

Then various ARCH family models were estimated. The GARCH-type models to characterize the volatility in the growth rate of real GDP. The main objects of interest were the unconditional volatility (σ^2) and conditional volatilities (σ_t^2). The comparative performance of these GARCH models have checked and verified by using the model selection procedure (AIC and SIC) and log likelihood. The comparison indicates that the ARIMA(1,2,2) Vs. EGARCH(1,1) model is the best model to modelling the volatility of real GDP. All assumptions of residual satisfied in the ARIMA(1,2,2) Vs. EGARCH (1,1) model.

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