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The Responsiveness of GDP to Investment, Broad Money Supply and Remittance: The Case of Bangladesh

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***Abstract* - Throughout the years the increase in the size of GDP in Bangladesh is accompanied with increased investments both public and private, moderate flow of broad money supply and fantastic performance in earning remittance. This paper investigates the significance relationship between GDP, investment, broad money supply and remittance for Bangladesh using annual data from 1976 to 2013. The paper uses time series econometrics tools to investigate the relationship between these variables. The empirical evidence on GDP nexus has been mixed and inconclusive. The estimated results are indicated that the constant conditional variance assumption can be rejected. Moreover, we calculate the ex post forecast intervals from the GARCH processes, that is the forecasting accuracy of the estimated models have varied widely over time with substantial volatility occurring during the 1976 and early 2013.**

Key Words: GDP, Investment, Broad Money Supply (M2), Remittance, GARCH
JEL Code: E20, and E42

I INTRODUCTION

Bangladesh remains a poor, overpopulated, and inefficiently governed nation. In this study, it has been strived to explore out the dependence of GDP to investment, broad money supply (M2) and remittance in Bangladesh. It is customary to define these key macro-economic variables to cater my study in a comprehensive manner.

Gross domestic product (GDP) refers to the market value of all final goods and services produced within a country in a given period. It is often consider an indicator of a country's standard of living. Investment has different meanings in finance and economics. In Finance investment is putting money into something with the expectation of gain that upon thorough analysis has a high degree of security of principle, as well as security of return, within an expected period. In my study, total investment comprises of both public and private investment. Central banks track the growth of “broad money” to help forecast inflation. The exact definition varies between countries, but broad money usually includes things like short-duration deposits and short-term securities other than shares. These are less liquid than currency or demand deposits (which make up “narrow money”) but can be enchased quickly. A remittance is a transfer of money by a foreign worker to his or her home country. Remittance can also refer to the accounting concept of a monetary payment transferred by a customer to a business. The slowdown in the growth of remittance earning in Bangladesh reflected the impact of global recession, particularly on the real estate markets in the Middle East, and on industrial labor demand in some South East Asian economies such as Malaysia. Against this backdrop, the government has been taking several initiatives including diplomatic measures to overcome the situations.

II. LITERATURE REVIEW

There is an extensive body of scholarly literature that covers the relationship among GDP, investment, broad money supply and remittance. This literature tries to map the impacts of these macroeconomic variables on GDP encompassing both national frontiers and international arena. Shamim Ahmed and Md. Ezazul Islam (2004) argued that financial deepening i.e. M_2 as percent of GDP has increased dramatically in recent years and these dramatic patterns suggests higher level of monetization of the economy and increasing financial intermediation of economic activities, thus increasing the level of financial development of Bangladesh. On the other hand, investment- GDP ratio in Bangladesh compares poorly with that of the faster growing countries of South East Asia (e.g. Singapore, Malaysia, Hong Kong, and South Korea) where investment as a percentage of GDP has remained within the range of 35 to 40 percent per year (Islam and Begum 2005). Levine (1997) mentions that the level of financial development is a good predictor of future economic development of a country since there is a strong and positive link between them.

The steady flow of remittances has resolved the foreign exchange constraints, improved the balance of payments, and helped increase the supply of national savings (Quibria, 1986). The contribution of remittance to GDP has also grown from a meager 1 percent in 1977-1978 to 5.2 percent in 1982- 83. During the 1990s, the ratio hovered around 4 percent. However if one takes into account the unofficial flow of remittances, its contribution to GDP would certainly be much higher. Murshed (2000) finds that an increase in remittance by Taka 1 would result in an increase in national income by Tk 3.33. Remittance constitutes an important source of foreign exchange for the poor countries. Remittances are used to make import payments and are used for productive investment by the government (Salim, 1992). World Bank (Ali, 1981) identified overseas remittances achieving a favorable balance of payments and as well as creating a new resources base for the country. In Bangladesh, a significant portion of overseas earnings is spending for consumption purposes, acquisition of assets, investment in trade & business and to finance import of capital goods. It will positively affect the socio economic condition of migrant families.

The major shortcoming of the studies cited above is that they are devoid of critical econometric analysis of data sets. The work of Mahboob and Anita (2010) is an exception in this regard. But the limitation is that they only run a two stage least square method and check only whether the relationship between GDP and M_2 is significant or not on the basis of t statistics. Juan José Molina Flores (2004) just develop his study providing some statistical inferences, namely mean, median, standard deviation omitting any precise relationship between GDP and remittance.

Synchronizing all the related studies do not encompass time series properties like whether the series has stationarity (i.e. are they free from unit root problem) or not. They also do not run any test for volatility to check the long run relationship among variables. This study captures the stationarity of data sets on the basis of both ADF and PP tests of unit root. It also encompasses clustering volatility which has not been conducted before. In addition, time-series analysis requires less subjective judgment on the part of the analyst; model identification and specification are obtained by exploiting systematic relationships in the data. But perhaps the most important reason for the widespread use of these models is their forecasting accuracy. Often, a parsimoniously specified univariate or multivariate time-series model will yield better forecasts than more complex structural econometric models (Brandt and Bessler). There are several possible reasons for the enhanced forecasting performance of time-series models, but the most likely is that these processes use past information optimally. In this circumstance, we use ARCH family model for forecasting accuracy.

III. METHODOLOGY AND ANALYSIS OF THE STUDY

The empirical analysis of the short-run equilibrium relationship among GDP and investment, M_2 and remittance been carried out within. Yearly covering the period 1976 to 2013 have been used for all variables.

All the variables- GDP, investment, broad money supply and remittance are expressed in a unique monetary terms. Therefore, it becomes obligatory to convert the monetary amounts in Crore Taka. Data are collected from the publications of Bangladesh Bank, Bangladesh Economic Reviews and Bangladesh Bureau of Statistics. Most notably, GDP is accounted at constant prices and investment comprises of both public and private investment. Under the framework of Auto regressive regression (ARCH) family modeling tests dealing with the time series properties of data are necessary. The existence of ARCH model among variables requires that they have to be of the stationary. Therefore, the stationarity of the variables have been tested using the ADF and Phillips-Perron unit root test.

A. Specification of the Model

To examine the volatility relationship between the gross domestic product and investment, broad money supply, remittance of Bangladesh the following simple model has been specified:

$GDP_t = \beta_0 + \beta_1 INV_t + \beta_2\, M2 + \beta_3 REM_t + u_t$

Where,

GDP_t= Gross Domestic Product in period t.

INV_t= Total Investment in period t

M2 = Broad Money Supply (M_2) in period t.

REM_t = Remittance in period t.

u_t= Stochastic Error Term.

β_0 = Intercept coefficient, β_1, β_2, β_3= Slope coefficients of respective regressors.

B. Test for Stationarity

Any empirical testing of time series must be preceded by a test to determine whether the variables used are stationary. To deal with this time series properties of the variables the Augmented Dickey Fuller test and Phillips-Perron tests has been applied on the level of all the variables considered. The optimum lag length are determined following the data following the data dependent method as suggested by Perron and Ng (1993) as well as the method suggested by Pesaran and Pesaran (1997) based on AIC and SIC. The results of the ADF and Phillips-Perron unit root tests are presented in the table of the following pages.

C. ADF Tests of Stationarity

At first, consider the ADF (augmented Dickey-Fuller) test. In the previous version of DF test, it was assumed that the error terms are uncorrelated. But in case the error term is correlated. Dickey and Fuller have developed a test, known as the augmented Dickey-Fuller (ADF) test. This is conducted by augmenting the preceding equations of the traditional model by adding the lagged values of the dependent variable.

It is evident from Table 1 that the null hypothesis of non-stationary of any of the variables could be rejected at 10% level of significance suggesting that the variables of the model are stationary at their levels. However, once they are differenced all of them become stationary. Therefore, it may be concluded that all of them are stationary. Let us, elaborate the results of ADF unit root tests for all series i.e. variables.

The calculated value of the GDP for the models without, with intercept and trend and coefficients are 30.580, 10.211 and 2.9643 respectively, but these values are are much greater than 1% critical τ value of with a given degree of freedom. These results suggest that the variable is stationary.

We find similar results for investments, broad money supply and remittance. All of them hold the properties of stationary time series data at level.

D. Phillips-Perron Tests of Stationarity

Now hub on the Phillips- Perron tests of stationarity for the variables. Phillips-Perron test is a non-parametric method to take care of the serial correlation in the error terms without adding the lagged difference terms. This test is very much similar to ADF test. The calculated value (table 1) of the GDP for the models without, with intercept and trend coefficients is 33.441, 12.819 and 17.783 respectively, but these values are in absolute term are much greater than 1% critical PP values of with a given degree of freedom. So in these cases, we can easily accept the null hypothesis is stationary. We get same result for the others variables like Investment, Broad Money Supply and Remittance.

E. Review of linear regression and autoregressive models

The linear regression model is the GDP of economic modeling. A multivariate regression represents a proportionality relationship among variables. Now there is present of regression analysis and the basic assumption of ordinary least square in the following table 2.

The results show that the all coefficients are significance for a significance level of 5%. According to the Breusch-Godfrey Test and the Durbin’s Alternative test, there is no auto correlation. But also this model is normally distributed and white noise. Another important things that wald test also significance that means all coefficients doesn’t individual independent. We call homoscedasticity the assumption that the expected size of the error is constant and do not depend on the size of the explanatory variables. The assumption of homoscedasticity is convenient from a mathematical point of view. However, it is an assumption that must be verified empirically. In many cases, especially if the range of variables is large, the assumption homoscedasticity might be unreasonable. In my case the model is followed by auto regressive conditional Heteroscadasticity.

F. Measuring volatility in time series: the ARCH and GARCH models

In conventional econometrics models, the variance of the disturbance term is assumed to be constant. However, Time series data of GDP, Investment, Broad Money Supply, and Remittance are followed (Figure 1) unusually large volatility by periods of relative tranquility. That means, the assumption of a constant variance is reasonably denied (Table 2). In such circumstances, Thus large returns (of either sign) are expected to follow large returns, and small returns (of either sign) to follow small returns. One of the explanations for this phenomenon, which seems to characterize financial return series, would be the fact that the information arrivals which drive price changes occur in bunches. Therefore, Campbell, Lo and MacKinlay (1997) defined a non-linear data generating process as one where the current value is related non-linearly to current and previous values of the error term:

$GDP_t = f(u_t, u_{t-1}, u_{t-2} \; . \; . \; . \; . \; . \; . \; .)$

Where u_t represents an independent and identically distributed (iid) error term, and f is a non-linear function. According to the researchers, a more specific form of the non-linear model is given by the following equation:

$GDP_t = g(u_t, u_{t-1}, u_{t-2} \; . \; . \; . \; . \; . \; . \; .) + u_t\sigma^2(u_{t-1}, u_{t-2} \; . \; . \; . \; . \; . \; . \; .)$

Where g is a function of past error terms, and σ^2 is the variance term. Campbell, Lo and MacKinlay characterize models with non-linear g as being non-linear in mean and those with non-linear σ^2 as being non-linear in variance. Models can be linear in mean and variance (the classic regression model, ARMA models) or linear in mean, but non-linear in variance (GARCH models). The most commonly used financial models to measure volatility are the non-linear ARCH and GARCH models.

So we can check the clustering volatility and ARCH effect or not. After that we can run ARCH model for short run volatility and forecasting accuracy.

G. Tests for Clustering volatility and ARCH effect

According to figure 1, GDP, Investment, Broad money supply, and Remittance exhibit a decidedly upward trend. Although Investment do not flow as like. On the other hand, the residual seems tranquil alongside periods with large increases and decreases. Such series are called conditionally heteroskedasticity if unconditional variance is constant, but there are periods in which the variance is relatively high. Now recall to the OLS, There is no Autocorrelation, normally distributed, and white noise. Furthermore, it flow Heteroscadasticity problem. So LM test for ARCH effect indicate that there is ARCH (1) effect (Table 3).

H. The autoregressive conditional heteroskedasticity model (ARCH)

We are concerned with stationary and nonstationary variables in the time series economics. But In this paper we concerned with stationary series, but with conditional variances that change over time. As we mentioned earlier another important feature of time series is known as volatility clustering or volatility pooling. This characteristic shows that the current level of volatilitytends to be positively correlated with its level during the immediately preceding periods. Using the ARCH model (Engle, 1982) represents one of the modalities through which a phenomenon of this nature can be parameterized. In order to understand how this model works, a definition of the conditional variance of a random variable u_t is necessary. Thus, the conditional variance of u_t , denoted σ_t^2has the following form:

$\sigma_t^2=\mathrm{var}(u_t/u_{t-1},u_{t-2},...)= E[(u_t- E(u_t))^2/u_{t-1},u_{t-2},...]$

Since $E(u_t) = 0$, equation becomes:

$\sigma_t^2=\mathrm{var}(u_t/u_{t-1},u_{t-2},...)= E[u_t^2/u_{t-1},u_{t-2},...]$

From this Equation states that the conditional variance of a zero mean normally distributed random variable u_t is equal to the conditional expected value of thesquare of u_t . In the case of the ARCH model, the autocorrelation in volatility is modeled by:

$\sigma_t^2=\alpha_0+\alpha_1\times u_{t-1}^2$

The above model is known as ARCH (1) and it shows that the conditional variance of the error term σ_t^2 depends on the immediately previous value of the squared error. The equation represents only a part of the model, since nothing has been specified about the conditional mean. Under the conditions of the ARCH model, the conditional mean equation (which describes how the dependent variable GDP_t varies over time) can take almost any form. One example of a full model would be the following one:

$GDP_t = \beta_0 + \beta_1 INV_t+ \beta_2 BMS_t + \beta_3 REM_t + u_t$

$\sigma_t^2=\alpha_0+\alpha_1\times u_{t-1}^2$

Where $u_t\sim N (0,\sigma^2)$

So the model given by equations can be extended to the general case, where the error variance depends on q lags of squared errors, a model known as ARCH(q):

$GDP_t = \beta_0 + \beta_1 INV_t+ \beta_2 BMS_t + \beta_3 REM_t + u_t$

$\sigma_t^2=\alpha_0+\alpha_1\times u_{t-1}^2+\alpha_2 \times u_{t-2}^2 + ... +\alpha_q \times u_{t-q}^2$

Where $u_t\sim N (0,\sigma^2)$

Since σ^2_t represents the conditional variance, its value must be strictly positive (a negative variance at any point in time is meaningless). So all the coefficients in the conditional variance equation must be positive: $\alpha_i\geq 0$, $(\forall)i=0,1,2,..., q$. A natural extension of the ARCH (q) model is the GARCH model.

The z-statistic of the first-order coefficient suggests (table 4) a not significant ARCH (1). And also coefficients are not positive some of them positive and some of them negative. So according to ARCH model is not satisfied.

I. The generalized autoregressive conditional heteroskedasticity model (GARCH)

One of the shortcoming of an ARCH (q) model is q+1 parameters to estimate. If q is a large number, we may lose accuracy in the estimation. There is an alternative way to capture long lagged effect with fewer parameters. This is called a special generalization of the ARCH model (GARCH).

The GARCH model has been developed independently by Bollerslev (1986) and Taylor (1986). This model allows the conditional variance to be dependent upon previous own lags, so that the simplest equation form of the conditional variance is:

$\sigma_t^2=\alpha_0+\alpha_1\times u_{t-1}^2+ \beta \times\sigma_{t-1}^2$

This is a GARCH(1,1) model and the conditional variance can be interpreted as a weighted function of a long term average value (dependent on α_0), of the information related to the volatility during the previous period ($\alpha_1 \times u_{t-1}^2$) and of the variance during the previous period ($\beta \times\sigma_{t-1}^2$). The general form of the GARCH (1, 2) model, where the conditional variance depends on 1 lags of the squared error and 2 lags of the conditional variance is: $\sigma_t^2=\alpha_0+\alpha_1\times u_{t-1}^2 + \beta_1 \times\sigma_{t-1}^2+ \beta_2 \times\sigma_{t-2}^2$

We also note that $\alpha+ \beta<1$ for stationary; if $\alpha+ \beta\geq 1$ we have a so-called "integrated GARCH" process. Simultaneously we need to get the significance of the coefficient in front ARCH (1) and GARCH (2).

The significance of the coefficient (table 5) in front of σ_{t-2}^2suggest that the GARCH (1, 2) model is better than the ARCH (7). But coefficient of ARCH (1) is not significance at 5%. Another Important thing is that (1.30525-0.15699-0.518382) <1 ($\alpha+ \beta<1$) so this model is stationarity. So the volatility changes with lagged shocks (u_{t-1}^2) but there is also momentum in the system working via σ_{t-2}^2.
Based on the estimated volatility equation, we generate diagnostic check. Volatility can be measured through one-step-ahead forecasts. So we calculate the forecasting variance.

According to the figure 2, there is the 99% confidence interval for GDP along with the actual GDP series. The results in figure 2 show that the confidence intervals associated with the one-step-ahead forecasts during this period are much closer to actual value. So, there is a tendency for large and small forecast errors to cluster together, which is indicative of the GARCH process. GARCH (1, 2) model is normally distributed but no heteroskedasticity (table 6). Moreover In this model, autocorrelation has been detected in few lags (Table 7) also stationary so this is not followed by integrated GARCH process. Furthermore, we try to adjust this process for accuracy of forecasting.

J. The Threshold autoregressive conditional heteroskedasticity model (T-ARCH)

Now we conduct a model which one explain the asymmetric effects on volatility. In this case we construct A standard ARCH model treats bad "News" (negative $u_t<0$) and good "news" (positive $u_t>0$) symmetrically, the specification of the conditional variance is
$\sigma_t^2=\alpha_0+\alpha_1\times u_{t-1}^2 + \lambda \text{ x } d_{t-1}\times u_{t-1}^2+ \beta \times\sigma_{t-1}^2$

$$d_t=\begin{cases} 1 \;\; ut < 0 & (bad\ news) \\ 0 \;\; ut \geq 0 & (good\ news) \end{cases}$$

Where λ is known as the asymmetry or leverage term. When λ=0, the model collapses to the standard GARCH form. Otherwise, when the shock is positive (i.e., good news) the effect on volatility is α_1, but when the news is negative (i.e., bad news) the effect on volatility is $\alpha_1+ \lambda$. Hence, if λ is significant and positive, negative shocks have a large effect on σ_t^2 than positive shocks.

According to the table 8, the market observes good news (u_{t-1}^2), the contribution of u^2 to volatility σ_{t-2}^2 is by a factor 1.5293. And also overall positive shock creates less volatility in the forecasting.

We also concern on the identification and diagnostic checking (Figure 4 and Figure 5) of the appropriate lag structure for the conditional variance equation in a GARCH process. In this article there are three ARCH family models among them which one is better. In this concern matter, we compare between ARCH (7) and GARCH (1, 2) we find out that coefficient of ARCH (7) are not significance also AIC and SIC are less than GARCH (1, 2). So GARCH (1, 2) is the better than ARCH (7) model. On the other hand, adjusted R^2 and DW test are typically used when identifying and checking the time-series behavior of GARCH (1, 2) and TARCH (1, 2, 1). We find that significantly different from GARCH (1, 2) model. The tested results are suggested to take GARCH (1, 2) model. Moreover The GARCH process is stationary (Table 5). So this is not appropriate for integrated GARCH. Following this identification and selection process, it is determined that a GARCH (1, 2) process is found to be more suitable for explaining the conditional variances of the GDP and Investment, M2 and Remittance series.

Even though the estimated GARCH models result in confidence intervals that are more naturally appealing than those of the AR models, this is no assurance that the GARCH process is a statistically valid improvement over the ARCH process. In other words, it is desirable to have a formal test of the GARCH hypothesis that conditional forecast variances are nonconstant. This can be accomplished by performing a standard likelihood ratio test in which, under the null hypothesis, the parameters u_{t-1}^2 and σ_{t-2}^2 are constrained to zero (the standard AR representation). The alternative hypothesis is that the model follows a GARCH form. The results in table 6 are encouraging and lend support to our contention that the conditional forecast variances of GDP have been stationary during the past thirty eight years.

IV. CONCLUSION

The results of this study indicate that recent advances in the econometrics literature may be fruitfully applied to macroeconomics data. There are many instances where additional knowledge pertaining to forecast variances derived from a GARCH process could be beneficial. In addition, the normality assumption associated with the conditional distribution does not present a limitation; other distributions could be used as well. The empirical examples presented here should encourage a wider acceptance of GARCH models in applied time-series modeling for stationary forecasting accuracy.

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ANNEX

Table 1: Unit Root Test of Variables at Level

Variables	Model	ADF Test		Phillips-Perron Test	
		ADF Statistics	Optimum Lag length	Test Statistics	Optimum Bandwidth
GDP	Without Trend	30.5799*	0	33.44*	3
	With Trend	10.2191*	0	12.82*	4
	Without Trend &	2.9643*	0	17.78*	5

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	Intercept				
Investment	Without Trend	-1.8681	0	-1.86	1
	With Trend	-3.4635***	0	-3.61***	2
	Without Trend & Intercept	-1.2860	0	-1.26	1
Broad Money Supply	Without Trend	1.5364	0	34.34*	4
	With Trend	3.5629**	0	26.64*	9
	Without Trend & Intercept	1.2045	0	37.56*	2
Remittance	Without Trend	12.2564*	0	11.78*	1
	With Trend	-2.1870	0	6.65*	0
	Without Trend & Intercept	15.1471*	0	14.53*	1

Note:*,**,***denotes significant at 1 percent, 5 percent and 10 percent level respectively.

Table 2: Review of OLS process

GDP	Coefficient	P value
Constraint	95440.58	0.000
Investment	0.7404	0.000
Broad Money Supply(M2)	1.5266	0.000
Remittance	-5.0135	0.000
R-squared	0.9844	
Breusch-Godfrey Serial Correlation LM test (F-statistic)	0.4902	0.6171
Durbin’s Alternative Test for Auto Correlation	0.491	0.4833
Cumulative Periodogram White-Noise Test	0.90	0.3898
Portmanteau test for white noise	16.2685	0.5049
Shapiro-Wilk W test for normal data	0.9433	0.0537
Jarque-Bera test for normality	4.1747	0.1240
Wald Test (All coefficient equal zero)	779.865	0.0000
Breusch-Godfrey test for heteroskedasticity	19.35	0.0002
ARCH effect on lag 1	7.826	0.0051

Table 3: Durbin’s alternative test, Breusch-Godfrey LM test for autocorrelation and LM test for ARCH effect

	Durbin’s Alternative Test	Breusch-Godfrey LM test	LM test for ARCH
Lags(p)	1	1	1
Chi2	0.491	0.558	7.826
df	1	1	1

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Probability	0.4833	0.4552	0.0051

Table 4: Variance Equation of ARCH (7) model

	Coefficient	Probability Value
α_0	118469372.3722	0.0867
u_{t-1}^2	0.2439	0.7946
u_{t-2}^2	0.0989	0.9114
u_{t-3}^2	0.0725	0.9229
u_{t-4}^2	-0.0440	0.9599
u_{t-5}^2	0.0007	0.9993
u_{t-6}^2	-0.1577	0.7927
u_{t-7}^2	-0.1605	0.7261
AIC	21.8417	
SIC	22.3588	
DW test	1.5653	

Table 5: Variance equation of GARCH (1, 2) model

	Coefficient	Probability
Constant	93633026	0.0319
u_{t-1}^2	1.30525	0.0560
σ_{t-1}^2	-0.15699	0.4240
σ_{t-2}^2	-.518382	.0000
Adjusted R^2	0.9812	
AIC	21.3761	
SIC	21.7208	
DW test	1.2829	

Table 6: Heteroskedasticity Test for GARCH (1, 2)

	ARCH LM test	White Test
F-statistic	0.5751	1.3748
Prob.F(1,35)	0.4534	0.2460
Obs*R-squared	0.5981	11.6461
Prob.Chi-Square(1)	0.4393	0.2340

Table 7: Autocorrelation Test for GARCH (1, 2)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.304	0.304	3.7917	0.052
		2	0.071	-0.024	4.0044	0.135
		3	0.333	0.351	8.8293	0.032
		4	0.270	0.083	12.078	0.017
		5	0.108	0.028	12.613	0.027
		6	-0.000	-0.151	12.613	0.050
		7	0.027	-0.051	12.650	0.081
		8	0.031	-0.045	12.699	0.123
		9	-0.013	0.018	12.708	0.176
		10	-0.182	-0.187	14.497	0.152
		11	-0.190	-0.098	16.529	0.123
		12	0.053	0.149	16.692	0.162
		13	-0.176	-0.178	18.579	0.137
		14	-0.194	0.080	20.973	0.102
		15	0.070	0.132	21.296	0.128
		16	-0.067	-0.098	21.608	0.156

Table 8: Variance equation of T-ARCH (1) Model

	Coefficient	Probability
c	93633026	0.0991
u_{t-1}^2	1.5293	0.0000
$d_{t-1} \times u_{t-1}^2$	-0.8931	0.0002
σ_{t-1}^2	0.2158	0.4796
σ_{t-2}^2	-0.8300	0.0000
Adjusted R^2	0.9815	
AIC	21.5015	
SIC	21.8894	
DW test	1.4664	

Figure 1: Clustering Volatility

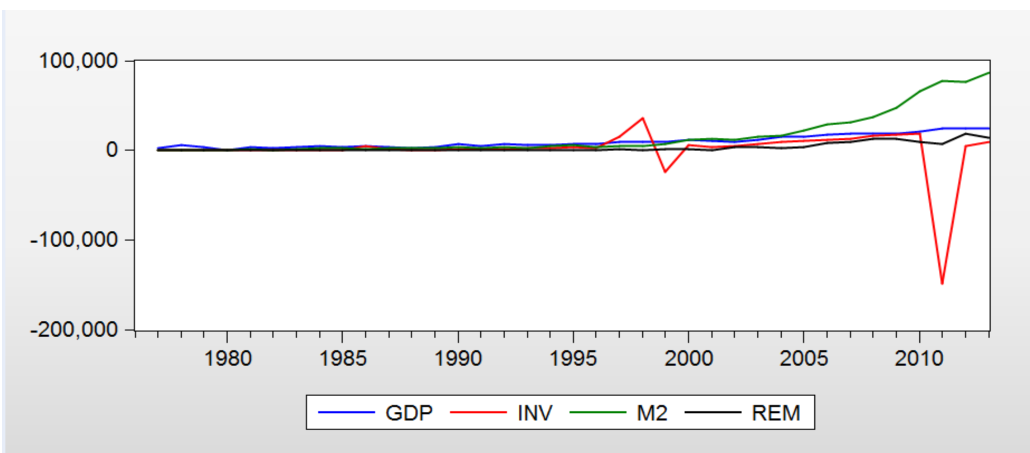

Figure 2: One-step-ahead forecasts

Figure 3: Normality Test

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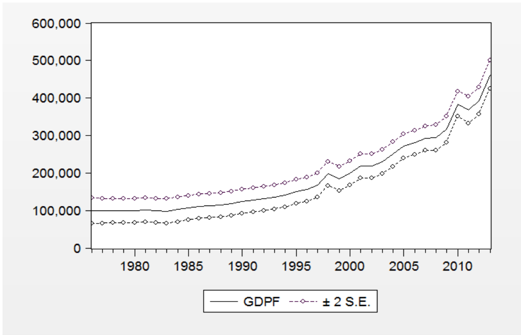


Figure 4: one-step-ahead forecasts

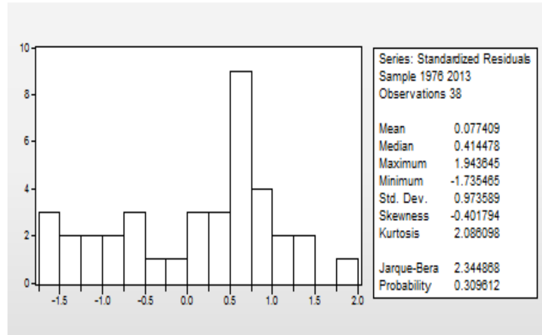
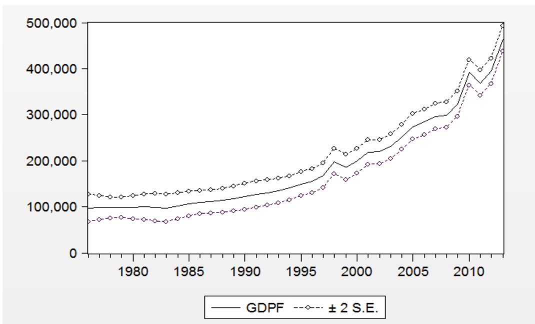
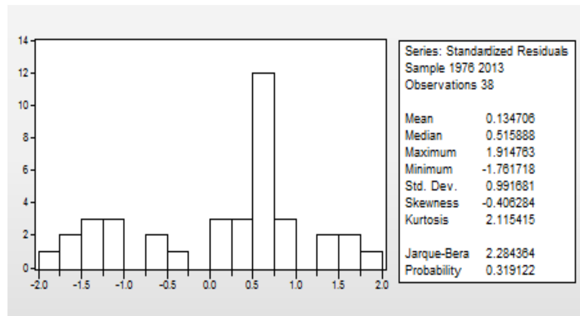


Figure 5 : Normality Test





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