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Research Article

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Determinants of Gross Capital Formation Volatility in Kenya; the Garch (1, 1) Model

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Abstract:

In 2016, the Kenyan government capped interest rates to 14% per annum in order to spar investments through cheaper credit acquisition from commercial banks but the levels of investments declined from 21.2% in 2015 to 17% in 2016; however the trend analysis on Gross Capital Formation (GCF), has fluctuated since 1964 through to 2016. The study seeks to investigate this trend through the perspective of real interest rate and GDP fluctuations, adopting the Keynesian hypothesis. Correlational research design and the World Bank Time series data from 1972 to 2016 were used. GARCH (1,1) model was formulated and results indicated that Real Interest Rate (RIR) was insignificant to determine GCF i.e. ($\beta_1 = -0.580393; p = 0.1794$), ARCH($\beta_4 = -0.134864; p = 0.0052$); and GARCH term ($\beta_5 = 1.114372; p = 0.0000$) were significant while GDP was not significant($\beta_6 = -9.458093; p = 0.6368$) in determining GCF volatility. The conclusion was that RIR internal shocks significantly affected GCF volatility hence real interest rate stability must be enhanced by the policy makers.

Keywords: Volatility, GARCH, Gross Capital Formation

Introduction:

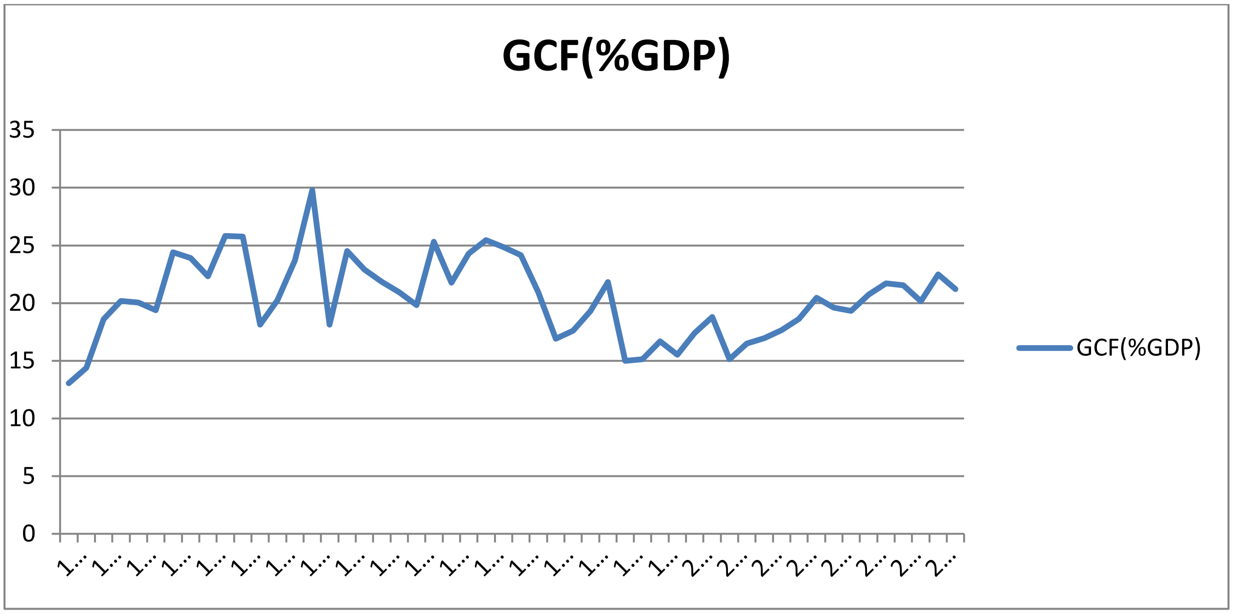
Gross capital formation (GCF), a proxy for investment, defines an outlay on additions to the fixed assets of the economy plus net changes in the level of inventories. According to (Organization for Economic Co-operation and Development[OECD], 2001) , GCF measures the value of acquisitions of new or existing fixed assets by the business sector, governments and households less disposals of fixed assets. Based on this definition, GCF defines how much of the new value added in the economy is invested rather than consumed, i.e. it is a flow. As observed by (Pavelescu, 2008), sustainable economic growth must enhance capital accumulation (investments).

According to (Suman, n.d), one of the reasons for low Gross capital formation is the low level of real national as well as the per capita income since, these, limits the motives of savings and investments and the end result is low levels of GCF as well as the lack of supply of capital which then leads to the absence of basic business and industries so the production falls down.

In perspective, the differences in the investment rates (GCF) between countries reflect the different levels of economic development of such countries. Among the countries in the world, Bhutan has the highest ratio of GCF to GDP fluctuating around 56.41% followed by Equatorial Guinea with 54.44%. However, the country with the lowest GCF as a percentage of its GDP (9.83%) was Greece followed by Angola with 10.34%.

Kenya on the other hand had 21.2% by 2015, (World Bank[WB], 2016) but this has dropped to 17% in 2016 (Trading Economics, 2018).
This drop may have been possible following the interest rate capping (a fluctuating interest rate that is not allowed to surpass a stated level) law, which became operational on September 14, 2016 due to the high cost of credit which then discouraged a lot of people from accessing funds from the financial intermediaries. However, despite the cap, (Central Bank of Kenya, 2018) observed that there is reduced financial intermediation by commercial banks seen from the declining loan accounts attributed to smaller borrowers being locked outside the loaning brackets.

Although the occurrences between 2015 and 2016 may be explained by the supposed decline in capital supply, the trend analysis on GCF in Kenya has also exhibited variations since 1964 through to 2015. It is this trend that the study seeks to investigate its cause through the perspective of real interest volatility as well as GDP movements.



Source (World Bank[WB], 2016)

According to (Kokemuller, n.d), interest rate volatility refers to the variability of interest rates on loans and savings over time. It's study/ knowledge is important to Businesses and individuals in take advantage of high savings rates and low borrowing rates. Besides, it also allows gauging the uncertainty surrounding market expectations with regards to the future path of the monetary policy rate, (Vincent & Allain, 2013). The variations in interest rates forms the bedrock upon which financiers rely on turn resources to less riskier investments opportunities such as government securities, (Hillebrand & Koray, 2008).
Looking at GDP as a determinant of GCF, (van Bezooijen & Bikker, 2017) acknowledged that there is scarcity of literature on the relationship between financial structure and macroeconomic volatility and those studies that exists only focuses on financial structure indicators based on the relative size and activity of the stock markets to that of banks and does not include corporate bond markets. However, the relationship between financial development and macroeconomic volatility is embedded in the external financing needs of firms that are financially constrained and whose borrowing capacity is influenced by the existence of financial market imperfections, (Wei & Kong, 2016).
Because the study used time series data and such data displays time-varying dispersion, or uncertainty such that large (small) absolute changes tend to be followed by other large (small) absolute changes, therefore

changes in variances are thus necessary, through time to allow for current developments, (Andersen, Bollerslev, & Hadi, 2010) and because of this tendency, estimating such variables are better done using the GARCH and ARCH models.

An ARCH (autoregressive conditionally heteroscedastic) model is a model for the variance of a time series and are used to describe a changing or perhaps a volatile variance but, they can as well be used to describe a gradually increasing variance over time. They are mostly used in situations experiencing short periods of increased variation, (The Pennsylvania State University, 2018). They were originally used in modeling inflationary uncertainty but are currently useful in the analysis of financial time series, (Andersen, Bollerslev, & Hadi, 2010), where real interest rate and investments as well as GDP are categorized.

Because ARCH models are extremely general, and do not provide empirical investigation without additional assumptions on the functional form, or smoothness, GARCH models are therefore used. The generalized autoregressive conditional heteroskedasticity (GARCH) process refers to an approach used to estimate volatility in financial markets and the choice of it is because it provides a more real-world context than other forms of estimation when trying to predict the prices and rates of financial instruments. As explained by (Rossi, 2004) heteroskedasticity is useful where observations do not move in a linear pattern and describes the irregular variation of an error term, or variable, in a statistical model. In such circumstances, measuring such variables without GARCH process may lead to unreliable drawing of conclusions. Since they are used to determine prices and to judge which assets may provide higher returns, as well as in forecasting the returns of current investments to help in their asset allocation, and portfolio optimization decisions, this study found it as the best method for use.

As observed by (Colin & Gil, 2012), historical volatility can be measured on a monthly, quarterly or yearly but the most preferred is the daily or weekly measures. But again daily volatility is preferred to weekly volatility because they can provide many data points. However, weekly volatility is preferred in circumstances where long period of time is being examined between two different markets. However, this study considered annual data for the parameters due to the absence of such historical data on quarterly or monthly basis.

Objectives of the study:

The general objective of this study was to extract the determinants of Gross capital formation in Kenya.

The specific objectives were the following:

1. Establish the relationship between Real Interest Rate(RIR) and Gross Capital Formation in Kenya;
2. To determine the ARCH effect upon the Gross Capital Formation in Kenya;
3. To determine the GARCH effect upon the Gross Capital Formation in Kenya;
4. To determine the effect of GDP on Gross Capital Formation in Kenya.

Literature Review:

Effect of Real Interest Rates volatility (RIR) on GCF

While looking at the Interest Rate Targeting upon the economic growth in Nigeria using Stakeholders' Approach, (Obadeyi, Akingunola, & Afolabi, 2013) defined Interest rate as a return on investment or cost of capital. They emphasized that it plays a major roles in the pursuit of macro-economic stabilization in Nigeria besides pointing out that the adverse effect it has upon the economic growth is a matter of concern and because its determination is done by the financial institution, the levels of investments depends on it and by proxy, the existence of a sound/stable financial sector.

As noted by (Agagi, n.d), Capital formation defines the process of building-up nation's capital stock through investing in the production of plants, tools and equipment as well as increasing the levels of capital through the efficient utilization of human and physical resources.

As cited by (Khurshid, 2015), many empirical studies have given mixed results relating to the relationship between interest rate and GCF (investment). Despite high interest rates, the developed nations still thrives, a contrasting scenario to what is happening to the developing nations where a rise in the levels of interest rates results into a decline in the levels of economic growth. While studying the effect of interest rate on investment in Jiangsu Province, China, (Khurshid, 2015) looked at the causality between interest rates and investments and found that there was a bi-directional causality between interest rate and investment hence concluded that both may promote each other.

Observed by (Malawi & Bader, 2010), there are two conflict views regarding the relationship between real interest rate and the level of private investment. One such view observes that high interest rate level dampens the level of private investments because of the rise in the real cost of capital especially in the LDCs where there are poorly developed financial markets with most people opting to save rather than investments. In their study of the Jordanian economy, using Cointegration approach, there was a negative impact of the real interest rate on investment and recommended the inclusion of other variables like foreign aid.

In assessing the interest rate volatility on investments, (Bo & Sterken, 2002) observed that volatility is caused by the levels of uncertainty which again has an ambiguous influence on the levels of investments i.e. (Caballero & Pindyck, 1996)observed a negative correlation while (Bar-Ilan & Strange, 1999) argued that the correlation is positive only if the intensity of investment is taken into account. This study will therefore demystify this ambiguity in the Kenyan context by finding out the relationship real interest rate and GCF and on whether the GARCH or the ARCH effect significantly influences the levels of GCF.

Methodology:

Research Design

Correlation research design was used. After establishing the diagnostic test on the variables and ensuring their stationarity, the time series properties on the variables that included the testing for cointegration, correlation, Vector error correction mechanism as well as causality, GARCH (1,1) model, i.e. one ARCH and one GARCH, was used in determining the uncertainty/ the variability of the variables, GCF becoming the dependent variable. Results relied on the percentage time series data gathered from the World Bank data base on Kenya from 1972 to 2016. The reliability of the results was assured by the inclusion of the percentage annual increase in GDP which acted as a controlled for variable and the study adopted the Keynesian hypothesis on the dependability of Investments on interest rates.

According to (Justiniano & Primiceri, 2008), the GARCH (1,1) can be broken into two sets of equation namely the mean equation and the variance equation. The mean equation describes the behavior of the mean of a time series data i.e. it is basically a linear regression function that contains a constant and another explanatory variables. It was modeled as follows.

$$GCF_t = \beta_0 + \beta_1 RIR_t + \mu_t \text{...} (1)$$

Where;

$\beta_0 =$ Constant and is the intercept,

$GCF_t =$ Gross Capital Formation at time t,

$RIR_t =$ Real Interest Rate at time t,

$\beta_1 =$ The coefficients of RIR_t

$\mu_t =$ The disturbance term

$\mu_t \sim IID(0, \sigma_\varepsilon^{\ 2})$

In the above model (1), the consideration was given to the annual data of the respective variables owing to the difficulty to ascertain the daily, weakly, quarterly data on GCF. The intention to model the data as in equation (1) above was for the generation of the residuals.

The variance equation, which basically looking at how the error variance behaves was modeled as follows;

$H_t = \beta_3 + \beta_4 H_{t-1} + \beta_5 \mu_{t-1}^2 + \beta_6 GDP_t + \varepsilon_t$……………………………………….(2)

Where

$H_t =$ The variance of the residual derived in equation (1)

$\beta_3 =$ Constant

H_{t-1}= the previous year's residual variance i.e. the GARCH term since today's fluctuation is influenced by yesterday's fluctuations.

μ_{t-1}^2= the previous period's squared residual derived from equation (1) i.e. the ARCH term.

GDP_t = the variance regressor as it can also influence the volatility.

$\beta_4; \beta_5; \beta_6$ are the coefficients of the ARCH , GARCH and GDP.

ε_t = the error term

Results and Discussions:

The descriptive statistics were tested at levels and the Jarque Bera (JB) results in Table 1(appendix) showed that only GDP was normally distributed. GCF and RIR were not normally distributed. The variables were tested for a random walk using Augmented Dickey Fuller (ADF) test and Akaike information criteria (AIC) with a maximum lag of 9 as captured in the table 1.1 below. The results indicate that at levels, the variables were stationary at 5% leve although they became better upon first differencing. With a null hypothesis of no stationarity at levels, the significance of the probability implied the rejection of the null hypothesis.

Table 1.1: Stationarity test:

	At levels		**At first difference**	
Variable	t-statistics	probability	t-statistics	probability
RIR	-3.51552	0.007	-3.52079	0.000
GCF	-3.52926	0.0020	-3.54033	0.0109
GDP	-3.51552	0.0001	-3.54033	0.0024

The correlation results in Table 2 (appendix) indicated that there was an insignificant weak positive association between GDP and GCF ($r = 0.189932; p = 0.2114$) and an equally insignificant weak negative association between RIR and GCF ($r = -0.066826; p = 0.6627$). insignificant weak negative association between GCF and RIR (r = -0.166545; p = 0.3390).

Cointegration was tested using the Johansen technique with a lag interval of 1:1 and both the trace test and the Maximum Eigen values all had three cointegrating equations under the assumption of a Linear deterministic trend and a comparison of the direction of the relationship between the variables was done using the normalized coefficient table and the transformed equation then became:

$$GFC = \underset{(0.53034)}{3.642518} GDP + \underset{(0.24147)}{0.488955} RIR - \underset{(0.08298)}{0.044889} TREND \text{......................} \qquad (3)$$

Under the assumption that the explanatory variables were not significant in the determination of GCF, a rule of thumb of *"half the t- statistics must be greater than the standard error"* was used and results captured in the table below indicating that the variables were significant in the determination of GCF.

Table 1.5: ***Significance table:***

Variable	Coefficient	Std. error	t- calculated	Decision rule
RIR	0.488955	0.24147	2.02490	Significant
GDP	3.642518	0.53034	6.86826	Significant
Trend	0.044889	0.08298	0.54096	Significant

With a maximum lag of 2 and a null hypothesis of no causality between GCF, RIR and GDP, granger causality test was conducted and the results in the table below indicated that there was a bi – directional causal relationship between GCF and GDP i.e. $GCF \leftrightarrow GDP$ GCF while the causality between GCF and RIR was uni-directional from RIR to GCF.

Table 1.7: ***Causality Test:***

Pairwise Granger Causality Tests			
Null Hypothesis:	Obs	F-Statistic	Prob.
GDP does not Granger Cause GCF	42	0.92066	0.4072
GCF does not Granger Cause GDP		4.49410	0.0179
RIR does not Granger Cause GCF	42	0.38203	0.6851
GCF does not Granger Cause RIR		2.51454	0.0946

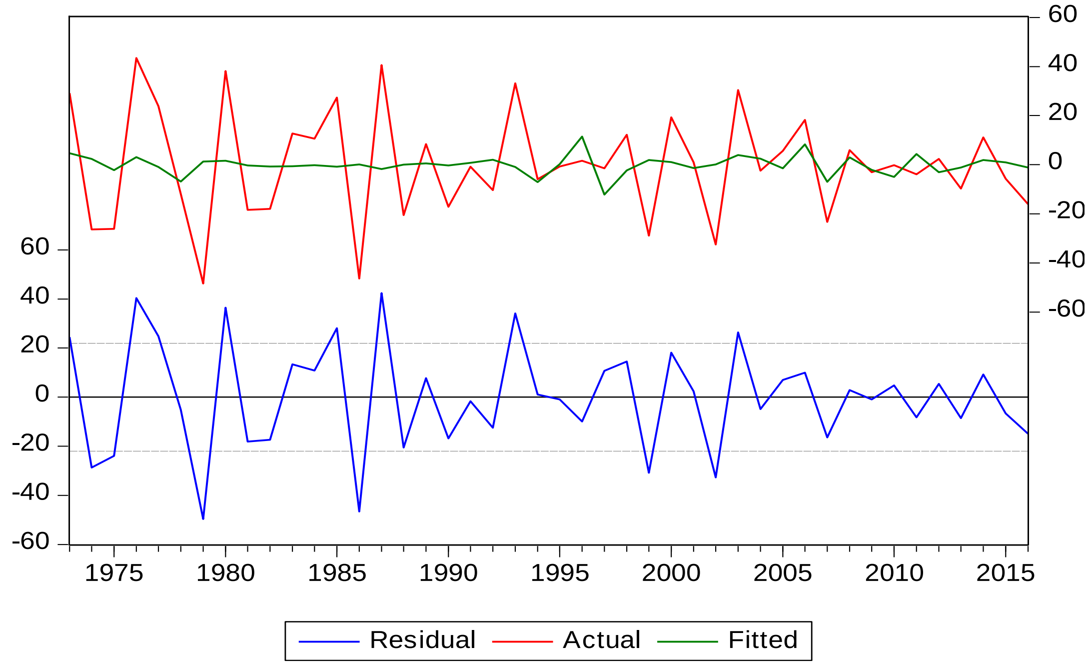
With regards to the ARCH model, the regression results were as follows;

Dependent Variable: GCF

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.060380	3.314269	-0.018218	0.9856
RIR	-0.534907	0.457656	-1.168798	0.2491

R-squared	.031501	Mean dependent var	-0.062780
Adjusted R-squared	0.008442	S.D. dependent var	22.07775
S.E. of regression	21.98437	Akaike info criterion	9.062929
Sum squared resid	20299.12	Schwarz criterion	9.144029
Log likelihood	-197.3844	Hannan-Quinn criter.	9.093005
F-statistic	1.366089	Durbin-Watson stat	2.836292
Prob(F-statistic)	0.249076		

From this, the results indicated there was a negative and insignificant relationship between RIR and GCF and any increase in RIR by a unit resulted into GCF declining by 0.534907%. From this regression, the annual residuals were calculated and their trends shown in the graph below:



From this figure, higher volatility in 1976 caused another higher volatility for a very long time up to 1987 and a smaller volatility in 1987 caused another smaller volatility up to 1992. However, another bigger/higher volatility in 1993 also caused a bigger/higher volatility up to 2003 followed by a lower/smaller volatility in 2004 with another smaller volatility to date.

With regards to the GARCH model and assuming a normal distribution, GDP was added to the GARCH as given by equation (2) and the results were as follows;

Dependent Variable: GCF
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 06/27/18 Time: 12:25
Sample: 1 44
Pre sample variance: back cast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) + C(6)*GDP

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-1.040725	2.546168	-0.408742	0.6827
RIR	-0.580393	0.432290	-1.342601	0.1794
	Variance Equation			
C	-1.731958	19.12185	-0.090575	0.9278
RESID(-1)^2	-0.134864	0.048309	-2.791713	0.0052
GARCH(-1)	1.114372	0.000703	1586.001	0.0000
GDP	-9.458093	20.02948	-0.472209	0.6368
R-squared	0.029255	Mean dependent var		-0.062780
Adjusted R-squared	0.006142	S.D. dependent var		22.07775
S.E. of regression	22.00985	Akaike info criterion		8.864741
Sum squared resid	20346.20	Schwarz criterion		9.108040
Log likelihood	-189.0243	Hannan-Quinn criter.		8.954968
Durbin-Watson stat	2.829824			

From this result, the mean equation (1) indicated that RIR was insignificant but negative in the determination of GCF and an increase in the levels of interest rate by a unit percentage resulted into GCF declining by 0.580393%. The variance equation (2) or the volatility of GCF / the variance of the residual indicated that the ARCH term (μ_{t-1}^2) was significant but negatively affected the volatility of GCF i.e. an increase in it led to a decline in volatility of GCF by 0.134864 %. The GARCH term (H_{t-1}) in equation (2) was significant and positive and a unit increase in it led the volatility of GCF increasing by 1.114372% while GDP is insignificant in the determination of GCF volatility (p=0.6368) and its percentage unit increase led to decline in GCF by 9.958093.

Summary and conclusion:

The main objective of this study was to extract the determinants of volatility in Gross capital formation in Kenya by specifically Establishing the relationship between Real Interest Rate (RIR) and Gross Capital Formation in Kenya; determining the ARCH effect upon the Gross Capital Formation in Kenya; determining the GARCH effect upon the Gross Capital Formation in Kenya; Determine the effect of GDP on Gross Capital Formation in Kenya.

The results indicated that RIR has an insignificant effect on GCF, the ARCH term and GARCH term had a significant effect on GCF volatility while GDP had no significant effect on GCF volatility. Because of the significance of both the ARCH and the GARCH term, it was concluded that the internal shocks in RIR causes the volatility in GCF.

Recommendation:

The clamor for more investments can only be possible with a stable and reliable level of interest rates. Hence, a stable interest rates regime is a consideration the policy makers in Kenya must assure, or else effort to woo investments is an exercise in futility.

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Appendices:

Appendix 1: Raw data

year	GDP	GFCF	RIR
1980	5.591976	-1.49188	0.942589
1981	3.773544	4.863311	1.410506
1982	1.506478	-20.1736	2.605412
1983	1.30905	-9.91748	3.572394
1984	1.755217	-1.85675	3.83512
1985	4.300562	-2.89628	5.257538
1986	7.177555	13.96069	4.864495
1987	5.937107	9.525607	8.15739
1988	6.203184	-1.144	8.026232
1989	4.690349	4.583638	6.815212
1990	4.192051	0.839888	7.332797
1991	1.438347	3.086991	5.745513
1992	-0.79949	-10.1876	1.825329
1993	0.353197	9.324409	3.413472
1994	2.632785	10.21404	16.42811
1995	4.406217	8.442338	15.80165
1996	4.146839	6.24556	-5.77659

1997	0.474902	3.120004	16.87957
1998	3.290214	8.091536	21.09633
1999	2.305389	-0.75699	17.45405
2000	0.599695	8.26101	15.32743
2001	3.779906	12.38174	17.8125
2002	0.54686	-6.12087	17.35814
2003	2.932476	-7.95221	9.770511
2004	5.1043	7.335058	5.045258
2005	5.906666	27.79861	7.609988
2006	6.472494	31.74717	-8.00987
2007	6.85073	2.197836	4.819091
2008	0.232283	12.85354	-0.985
2009	3.30694	9.968914	2.837078
2010	8.402277	13.85266	12.0259
2011	6.111613	4.752576	3.840676
2012	4.5632	12.35737	9.456607
2013	5.879764	2.117032	11.54773
2014	5.35184	14.20236	7.815634
2015	5.713383	6.698605	5.896232
2016	5.848665	-9.32635	7.899352

Table 1 ***Descriptive statistics:***

	GCF	GDP	RIR
Mean	4.556972	4.363353	6.056174
Std. Dev.	15.18512	3.121389	7.106249
Skewness	-0.372036	1.346113	0.045250
Kurtosis	2.760919	7.301234	2.641537
Jarque-Bera	1.145255	48.27880	0.256286
Probability	0.564041	0.000000	0.879727

Table 2 ***Correlation:***

Covariance Analysis: Ordinary

Included observations: 45

Correlation			
Probability	GCF	GDP	RIR
GCF	1.000000		

GDP	0.189932	1.000000	
	(0.2114)	-----	
RIR	-0.066826	-0.092773	1.000000
	(0.6627)	(0.5444)	-----

Table 3 ***cointegration:***

Date: 07/04/18 Time: 17:00
Sample (adjusted): 1975 2016
Included observations: 42 after adjustments
Trend assumption: Linear deterministic trend (restricted)
Series: GCF GDP RIR
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace):

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.745950	130.2867	42.91525	0.0000
At most 1 *	0.649410	72.73722	25.87211	0.0000
At most 2 *	0.495254	28.71543	12.51798	0.0000

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized		**Max-Eigen**	**0.05**	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
None *	0.745950	57.54944	25.82321	0.0000
At most 1 *	0.649410	44.02179	19.38704	0.0000
At most 2 *	0.495254	28.71543	12.51798	0.0000

Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

GCF	**GDP**	**RIR**	**@TREND(74)**	
-0.097657	0.355718	0.047750	-0.004384	
-0.045483	0.266569	-0.248556	-0.009321	
0.022432	0.448655	0.000934	-0.002442	

Unrestricted Adjustment Coefficients (alpha):

D(GCF)	17.85713	7.099070	-12.15829
D(GDP)	-0.726018	-0.615607	-2.089971
D(RIR)	-5.536671	6.158182	-0.654923
1 Cointegratin Equation(s):		Log likelihood	-432.8305

Normalized cointegrating coefficients (standard error in parentheses)

GCF	GDP	RIR	@TREND(74)
1.000000	-3.642518	-0.488955	0.044889
	(0.53034)	(0.24147)	(0.08298)

Table 4: ***OLS***

Dependent Variable: GCF

Included observations: 44

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.060380	3.314269	-0.018218	0.9856
RIR	-0.534907	0.457656	-1.168798	0.2491

R-squared	0.031501	Mean dependent var	-0.062780
Adjusted R-squared	0.008442	S.D. dependent var	22.07775
S.E. of regression	21.98437	Akaike info criterion	9.062929
Sum squared resid	20299.12	Schwarz criterion	9.144029
Log likelihood	-197.3844	Hannan-Quinn criter.	9.093005
F-statistic	1.366089	Durbin-Watson stat	2.836292
Prob(F-statistic)	0.249076		