

A Macroeconomic Relationship Between GDP, GDS And GDI: An Indian Experience

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Abstract

The present paper is an attempt to econometrically investigate the causal relationship between Gross Domestic Product at Market Price (GDP), Gross Domestic Savings (GDS) and Gross Domestic Investment (GDI) in Indian economy for the period 1971 to 2016. Secondary data has been used which is obtained from handbook on Indian economy published by Reserve Bank of India. Augmented Dickey Fuller (ADF) test has been applied to test the presence of unit root in the variables and Auto-Regressive Distributed Lag (ARDL) based co-integration technique has been used to establish the long run relationship between the variables. Lastly, Granger's causality test has been applied to check the direction of causality between the variables. The study has found a uni-directional causality running from GDP to GDS, GDP to GDI and GDS to GDI.

Key words: Gross Domestic Savings, Gross Domestic Investment, Gross Domestic Product, Co integration, Causality

Introduction

To achieve the higher rates of economic growth and development, many of the Asian and African countries started reviving their National Agendas. They started to frame such policies which majorly focused on raising the national income and per capita income. Indian economy too is not an exception and started developing and executing various short term as well as long term plans right from its independence. To achieve this core objective, Planning Commission of India, now changed to NITI Ayog, focused on raising the level of production and productivity in the economy. It is conceived that without appropriate volume of savings and net investment, this core objective cannot be achieved. The significance of saving and investment in accelerating economic growth have been comprehended by various schools of thought. But there is an on-going debate amongst various economists if it is saving or investment or both help in achieving higher rates of economic growth. This paper is also an attempt in this direction.

Review of Literature

It is conceived that these variables are inter-related but a lot of disagreement was seen amongst the researchers regarding their long-run relationship as well as direction of causality. Jangili (2011), Mehta and Rami (2014), Mishra and Jain (2012), Sekantsi and Kalebe (2015) and Katircioglu and Naraliyeva (2006) found a unidirectional causality running from saving and investment to economic growth, but the reciprocal causality was not seen. Verma (2007) found a unidirectional causality running from economic growth to savings. He also concluded that saving drives investment in both short and long period but didn't find any causality running from investment to economic growth. Bayar (2014) found mixed results i.e. a bi-directional causality was seen between GDP, GDS and GDI and also between GDS and GDI but a unidirectional causality was seen from FDI inflows to GDP, GDI, GDS. Attanasio *et. al.* (2000), found a unidirectional causality from growth to investment. Budha (2012) found that there exist a short-run bidirectional causality between investment and gross domestic product as well as between gross domestic savings and investment but no short-run causality was found between gross domestic savings and gross domestic product. It is clearly seen from the above literature review that there is no consensus amongst the researchers and hence the debate regarding the relationship among these three variables is still unresolved.

Objective of the study

The main objective of the study is to examine the co-integration and causality between saving, investment and economic growth.

Data source and Methodology

In the present analysis, secondary data for the period 1970-2016 for Indian economy is used. The data is collected from the handbook on Indian economy by Reserve Bank of India.

A three-step methodology is used to examine the relationship among these three variables i.e. Augmented Dickey Fuller test to check the presence of unit root problem in the series. ARDL model is used for examining the co-integration relationship and lastly, Granger Causality test is applied to find the direction of causality.

Relationship among GDP, GDS and GDI

The relationship among these three variables is examined with the help of three models stated below:

$$\text{Model 1: } \ln \text{RGDP}_t = \alpha + \beta_1 \ln(\text{GDS})_t + \beta_2 \ln(\text{GDI})_t + \varepsilon_t$$

$$\text{Model 2: } \ln \text{RGDS}_t = \alpha + \gamma_1 \ln(\text{GDP})_t + \gamma_2 \ln(\text{GDI})_t + \varepsilon_t$$

$$\text{Model 3: } \ln \text{RGDI}_t = \alpha + \delta_1 \ln(\text{GDP})_t + \delta_2 \ln(\text{GDS})_t + \varepsilon_t$$

Where ε_t denotes a serially uncorrected white noise error term with a mean of zero and a constant variance. GDP is Gross Domestic Product at market price, GDS and GDI are Gross Domestic Savings and Gross Domestic Investment respectively as a percentage of GDP. The variables are transformed into their natural logarithm in order to avoid the problem of heteroscedasticity in the residuals. The first and foremost step in applying co-integration model is to test the presence of unit root in the variables.

TESTING OF UNIT ROOT: AUGMENTED DICKEY-FULLER TEST

To analyse whether the variables are co integrated or not, stationarity of data is checked by using Augmented-dickey Fuller (ADF) test. The application of ADF test carries null hypothesis of non-stationarity of time series against the stationary alternative. The rejection of null hypothesis will be done by following the three guidelines: 1. p-value should be significant at 5%. 2. The value of trace-statistics in absolute terms should be greater than its critical values. 3. For acceptance of the model, value of coefficient should be negative. Table 1 displays ADF test statistics results for GDP, GDS and GDI.

Table: 1 Unit Root Table : Augmented Dickey-Fuller Test (Schwarz Info Criterion)					
Variables	At level (Trend and Intercept)		First difference (Intercept)		Order Of Integration
	p-value	ADF- statistics	p-value	ADF- statistics	
GDP	0.353	-0.183	0.0000	-0.678	I(1)
GDI	0.0231	-0.5569	-	-	I(0)
GDS	0.333	-0.293	0.000	-1.107	I(1)
Note: 1. The results have been computed by using ADF test using evIEWS software 9					
Source: Author's Calculations					

It is clear from the above table that all the three variables are stationary at different order of integration. In case of GDP and GDS, the data is stationary at first order of difference i.e. at I(1)

where p-value is significant at zero. Whereas, GDI is stationary at level i.e. $I(0)$ using both intercept and trend. Since the order of integration is not same therefore, ARDL approach to test co-integration relationship is used in the succeeding section.

Auto-Regressive Distributed Lag (ARDL): A Co-integration Approach

Since the variables are stationary at mixed order of integration i.e. either of $I(0)$ or at $I(1)$ but none of them are stationary at $I(2)$ therefore, we can successfully run ARDL approach (also known as Bound test) to examine the long run relationship between the variables. Before applying ARDL model to test the existence of equilibrium relationship between the variables, it is mandatory to determine optimum lag structure for the model which depends upon minimum values of AIC and SIC criterions shown in table 2:

Table: 2: Lag length selection for co-integration analysis using VAR						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	11.42157	NA	0.000132	-0.421079	-0.294413	-0.375280
1	202.0755	343.1771*	1.50e-08	-9.503777*	-8.997113*	-9.320584*
2	211.6162	15.74207	1.47e-08*	-9.530810	-8.644148	-9.210221
3	213.9418	3.488414	2.10e-08	-9.197090	-7.930431	-8.739106
4	221.4739	10.16839	2.36e-08	-9.123697	-7.477039	-8.528318
5	229.3492	9.450276	2.67e-08	-9.067458	-7.040803	-8.334684
6	239.0773	10.21458	2.86e-08	-9.103867	-6.697214	-8.233697
Notes: * Indicates lag order selected by the criterion.						
Source: Author's calculations						

It is clearly seen in the above table that the values in both criterions are minimum at 1-1 lag-length. Hence, the optimum lag structure is 1-1 for all the models. Following are the ARDL models for all the three variables:

$$\Delta \ln(\text{GDP}) = \alpha_0 + \sum_{j=1}^n b_j \Delta \ln(\text{GDP})_{t-j} + \sum_{j=0}^n c_j \Delta \ln(\text{GDS})_{t-j} + \sum_{j=0}^n d_j \Delta \ln(\text{GDI})_{t-j} + \delta_1 \ln \text{GDP}_{t-1} + \delta_2 \ln \text{GDS}_{t-1} + \delta_3 \ln \text{GDI}_{t-1} + e_{1t}$$

$$\Delta \ln(\text{GDS}) = \beta_0 + \sum_{j=1}^n e_j \Delta \ln(\text{GDS})_{t-j} + \sum_{j=0}^n f_j \Delta \ln(\text{GDP})_{t-j} + \sum_{j=0}^n g_j \Delta \ln(\text{GDI})_{t-j} + \delta_4 \ln \text{GDS}_{t-1} + \delta_5 \ln \text{GDP}_{t-1} + \delta_6 \ln \text{GDI}_{t-1} + e_{2t}$$

$$\Delta \ln(\text{GDI}) = \gamma_0 + \sum_{j=1}^n h_j \Delta \ln(\text{GDI})_{t-j} + \sum_{j=0}^n i_j \Delta \ln(\text{GDP})_{t-j} + \sum_{j=0}^n j_j \Delta \ln(\text{GDS})_{t-j} + \delta_7 \ln \text{GDI}_{t-1} + \delta_8 \ln \text{GDP}_{t-1} + \delta_9 \ln \text{GDS}_{t-1} + e_{3t}$$

The parameters δ_i where $i = 1, 2, 3, \dots, 9$, are corresponding long-run multipliers, while the parameters $b_j, c_j, d_j, e_j, \dots, j_j$ are the short-term dynamic coefficients of ARDL model.

The null hypotheses of the model exhibits no co-integration (i.e. $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = \delta_9 = 0$) against existence of co-integration as an alternate hypotheses (i.e. $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = \delta_9 \neq 0$). Results of ARDL model shows that r-square value of the model is 37% (when GDP is DV), 50% (when GDS is DV) and 58% (when GDI is DV). These values shows that almost 50% variations in the model is unexplained by endogenous variables. The value f-statistic is zero in all the three cases, which means the model is statistically fitted well. Further, Bounds test approach is applied to know if the variables are co-integrated in the long run. The null hypothesis of the Bounds test approach states that there does not exist any long run relationship whereas, alternate hypothesis favours existence of long run relationship. The criterion guideline says that if the f-value is below $I(0)$ bound, we cannot reject null hypothesis and if the f-value is higher than the $I(1)$ bound, we

can reject null hypothesis of no co-integration. The values of f-statistics and Bound range for different dependent variables are displayed in table 3.

Table: 3 ARDL Bound Testing Model: Among GDP, GDS and GDI		
Equation	F-statistics	Degree of freedom
GDP as Dependent Variable	7.944575	2
GDS as Dependent Variable	20.46739	2
GDI as Dependent Variable	33.92665	2
Notes: i)The values of I(0) 3.17*, 3.79** and 5.15*** and the values of I(1) 4.14*, 4.85** and 6.36*** represents significance at 10%, 5% and 1% levels of significance, respectively using Schwarz Criterion.		
Source: Author's calculations		

Table 3 shows that there is existence of long run relationship among these three variables, as the value of f-statistics in all the three cases is greater than I(1) bound at 1%, 5% and 10% levels of significance. Thus, we reject the null hypothesis of existence of no co-integration. In the next step, Error Correction Model is applied to know if any disequilibrium occurs then how much time the Error Correction Term (ECT) will take to restore to equilibrium position

Estimation Long-run Coefficients of the Models

Since the variables are co-integrated in the long run, ECT is inserted in the ARDL model and the modified equations are stated below:

$$\Delta \ln GDP_t = \alpha_0 + \sum_{i=1}^p a_{1i} \Delta \ln(GDP)_{t-i} + \sum_{i=1}^q a_{2i} \Delta \ln(GDS)_{t-i} + \sum_{i=1}^q a_{3i} \Delta \ln(GDI)_{t-i} + \lambda ECT_{t-1} + e_{1t}$$

$$\Delta \ln GDS_t = \alpha_0 + \sum_{i=1}^p b_{1i} \Delta \ln(GDS)_{t-i} + \sum_{i=1}^q b_{2i} \Delta \ln(GDP)_{t-i} + \sum_{i=1}^q c_{3i} \Delta \ln(GDI)_{t-i} + \lambda ECT_{t-1} + e_{1t}$$

$$\Delta \ln GDI_t = \alpha_0 + \sum_{i=1}^p c_{1i} \Delta \ln(GDI)_{t-i} + \sum_{i=1}^q c_{2i} \Delta \ln(GDP)_{t-i} + \sum_{i=1}^q c_{3i} \Delta \ln(GDS)_{t-i} + \lambda ECT_{t-1} + e_{1t}$$

In the above equations, λ = speed of adjustment parameter with a negative sign i.e. $(1 - \sum_{i=1}^q \delta_i)$, ECT = extracted residuals from the regression of the long run-run equation i.e. $(\ln DV_{t-1} - \theta X_t)$, DV is the Dependent Variable, $\theta = \sum_{i=1}^q \beta_i / \alpha$ is a long run parameter, e_{1t} = is the white noise term.

Table 4: ARDL Estimation of Long-run Coefficients, GDP, GDS and GDI								
lnGDP (DV)			lnGDS (DV)			lnGDI (DV)		
GDS (-1)	GDI(-1)	ECT(-1)	GDP (-1)	GDI(-1)	ECT(-1)	GDP (-1)	GDS(-1)	ECT(-1)
0.1292 (0.146825) [1.549196]	0.4814 (-0.047541) [-0.710616]	0.03111 (-0.077450) [-1.025803]	0.1089 (0.567344) [1.593511]	0.1007 (-0.239991) [-1.680369]	0.0485 (-0.103098) [-0.712108]	0.0018 (1.493937) [3.337334]	0.1467 (0.302296) [1.480164]	0.0005 (-0.623433) [-3.787978]
Source: Author's calculations								

Table 4 exhibits the long-run coefficients of the model. It is calculated that the value of coefficient is statistically significant in case of GDS and GDI at 10% and 5% levels of significance respectively on GDP when both the variables are dependent variables, which clearly indicates that GDP has long-run positive effect on both GDS and GDI. Whereas, other way long-run causality is not found. The study also found the existence of long-run unidirectional causality runs from GDI to GDS. The coefficient of ECT (stated in brackets) is negative in all the three cases and its p-value is statistically

significant for all the three variables thus, satisfying the principle of adjustment of short-run imbalances to long run equilibrium. However, the speed of adjustment can be calculated by using the formula $1/ECT_{t-1}$ where, 1 depicts yearly data. As per the formula, long run equilibrium will be restored in 12.91 years, when GDP is a DV and 9.69 years when GDS is a DV. Lastly, the ECT will take 1.60 years to restore to equilibrium position, when GDI is a DV.

For checking the reliability of the model, residual diagnostic tests are performed. ARDL model is based on the assumptions of absence of serial correlation and stability in the model. Table 5 displays the results for serial correlation. The null hypothesis of presence of serial correlation will be accepted at 5% level of significance.

Table 5: Testing of Serial Correlation

Dependent Variables	Serial Correlation			
	Test Statistic		LM version	
	f-statistic	p-value	Chi-square	p-value
GDP	2.876478	0.0683	5.656165	0.0601
GDS	1.138066	0.2926	1.247566	0.2640
GDI	0.002983	0.9567	0.003365	0.9537
Source : Author's calculations				

It is clearly seen from the above table that there is no problem of serial correlation in the above models as p-value is statistically insignificant therefore, we cannot accept null hypothesis of presence of serial correlation in all the three variables. For stability diagnostic of the model, CUSUM Test and CUMUM Square test is performed and the results are displayed in the form of figures presented below.

Figure 1: GDP as DV

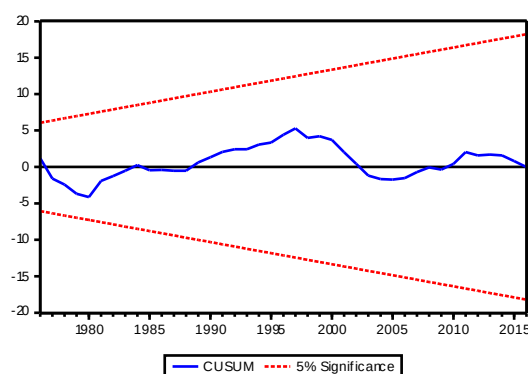


Figure 3: GDS as DV

Figure 2: GDP as DV

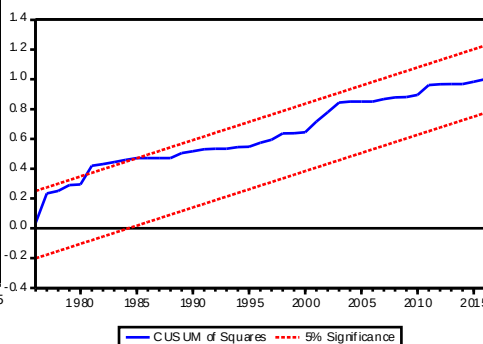


Figure 4: GDS as DV

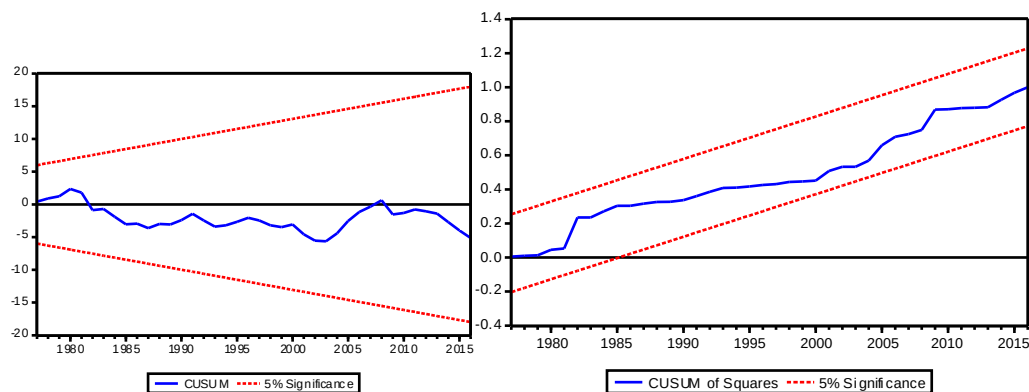
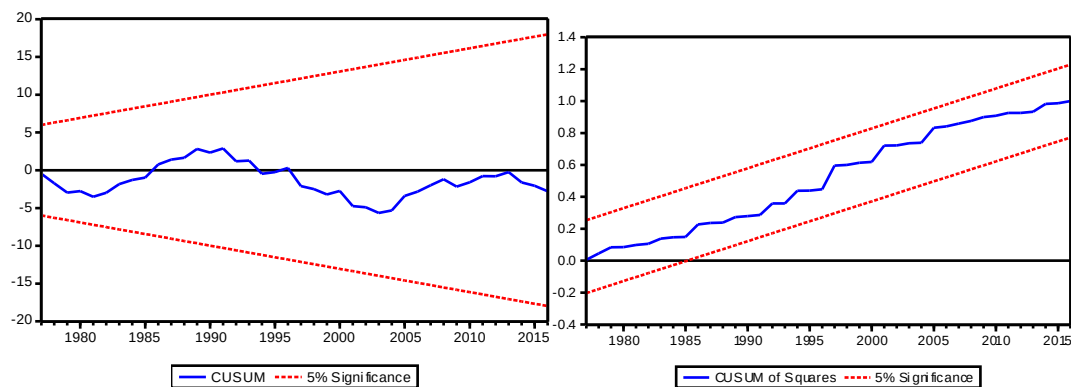


Figure 5: GDI as DV

Figure 6: GDI as DV



The above figures shows that the model is stable as the blue line falls between the two red lines using CUSUM test and CUSUM of squares, which means it is falling in the region of 95% level of significance, depicting the stability of the model.

6.3.4 Granger's Causality Test

The Short-run causal relationship among the variables has been extracted through Granger's Causality test. The null hypotheses depicts presence of causal relationship between the variables against non-existence of causal relationship as an alternate hypotheses. The null hypotheses will be accepted at 1%, 5% or 10% levels of significance. The results of Granger's Causality test is shown in the table 6.

Table: 6. Short run Causality: Granger's Causality Test

Null Hypothesis:	F-Statistic	Prob.
GDS does not Granger Cause GDP	0.55365	0.4610
GDP does not Granger Cause GDS	2.63081	0.1023
GCF does not Granger Cause GDP	1.52727	0.2234
GDP does not Granger Cause GDI	5.40641	0.0250
GDI does not Granger Cause GDS	0.15373	0.6970
GDS does not Granger Cause GDI	7.28383	0.0100
Source: Author's Calculations		

The results of Granger's Causality test shows that there is a uni-directional causality running from GDP to GDS and GDP to GDI at 10% and 5% levels of significance which means to boost GDS and GDI in the economy, the government should make measures to boost GDP. It is also seen in the above

table that GDS granger cause GDI at 1% level of significance but other way causality is not seen thus, confirming Lewis (1955) hypotheses of higher savings leads to higher investment.

Summary and conclusions

The major objective of the paper is to examine the causal relationship between GDP, GDS and GDI over the period 1970-2016 by using ARDL model and Granger causality test. The study found a long-run unidirectional running from GDP to GDI, GDP to GDS and GDI to GDS. Granger causality test also found a short-run unidirectional causality running from GDP to GDS, GDP to GDI and also from GDS to GDI.

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