Causality Between Determinants of Gdp & Forecasting Using Econometric Modelling – Vecm Approach

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ABSTRACT

The study examines the causality of GDP, exchange rate, inflation and index of industrial production in India over the period 2012:Q1 to 2019:Q4. The causality is examined using the Vector Error Correction Model (VECM). An open source software Gretl is used for analysis of data. The study confirms the existence of unidirectional causality from exchange rate, inflation and industrial production to GDP in the long run. There exists a bidirectional causality between gross domestic product and industrial production, and unidirectional causality between GDP and exchange rate and GDP and inflation in the short run.

KEY WORDS: GROSS DOMESTIC PRODUCT, INDEX OF INDUSTRIAL PRODUCTION, EXCHANGE RATE, CONSUMER PRICE INDEX, VECM.

INTRODUCTION

A high degree of industrialization or increase in the share of manufacturing in GDP is a key feature of modern economic growth. (Kuznets, 1973). In many studies, Index of Industrial Production (IIP) is widely used as a proxy for estimating the current state of GDP as IIP is measured on monthly basis and GDP is measured on quarterly basis in many countries (Sédillot and Pain, 2003). But in most economies, the share of services has increased significantly in GDP in recent years and hence raised the question whether the relationship between IIP and GDP is still significant (Fulop and Gyorgy, 2012) or there exists a channel of causation between them and some other variables. Gokmenoglu et al (2015), observed a long-run relationship between

industrial production, GDP, inflation and Oil price in Turkey. Joshi V. K. (2016) studied the impact of exchange rate, money supply and inflation on index of industrial production in India and found that there exists a bidirectional causality between inflation (WPI) and index of industrial production in the long run and unidirectional causality between index of industrial production and exchange rate and inflation (WPI) and exchange rate.

Razzaque et al (2017) made the empirical assessment of relationship between exchange rate and economic growth and found that depreciation in real exchange rate in Bangladesh led to rise in aggregate output. They asserted that rising inflationary pressure must also be given due consideration. Habib et al (2016) also investigated the relationship between the real exchange rate and economic growth for a panel of 150 countries using five-year average data in the post Bretton Woods period and found the significant relationship between the two in developing countries only. Thus, in the present study attempt is made to study the short run and long run causality between GDP and IIP, ExRate and CPI (inflation) in India and evaluate how IIP, ExRate and CPI impacts the GDP in India and formulate the model of estimation

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for forecasting GDP with precision. The rest of the paper is organized as below: Section 2 discusses materials and methods, Section 3 deals with results and discussion and section 4 concludes.

MATERIAL AND METHODS

The present study intends to study the causality between GDP and IIP, ExRate and CPI (inflation) and evaluate whether IIP, ExRate and CPI impacts the GDP in India. The initial model assumption made to begin with the study is given as:

$$l_GDP = \alpha_0 + \alpha_1 l_IIP_t + \alpha_2 l_ExRate_t + \alpha_3 l_CPI_t + \varepsilon_t \quad \{1\}$$

Where, GDP is the gross domestic product (NAS:2011-12), IIP is the index of industrial production (base 2011-12), ExRate is the real exchange rate, and CPI is used as proxy for inflation consumer price index (base 2012) taken from Database on Indian Economy, RBI, India. All the variables are expressed in logarithm as they are growth variables and their corresponding coefficients are the elasticity coefficients associated with them. For the present study, quarterly data from April 2012:Q1 to March 2019:Q4, i.e., 34 quarters is used as the base years were almost the same during this period. The variables, GDP, IIP, ExRate and CPI are selected due to high correlation coefficient between them. Through various literatures the other variables affecting GDP were

also identified which includes FDI, FII, money supply, exports, imports, etc. But these variables are highly correlated with some or the other variables which are incorporated in the present study and hence not included in the present study.

To test the stationarity of each series, the Augmented Dickey-Fuller (1979) unit root test is employed. The existence of non-stationarity in levels and stationarity in differences implies the chance of co-integration between the variables and possibility of the long-run relationship between the variables. To investigate the causality between the variables, Johansen's (1988) cointegration approach comprising of two likelihood ratio tests (λ_{trace} and λ_{max}) and Vector Error Correction Model (VECM) (Johansen, 1988) is used which is given as under:

$$D X_t = \sum \Gamma_i D X_{t-i} + \Pi X_{t-1} + \varepsilon_t \quad \text{-----} \\ \{2\} \quad \varepsilon_{i,t} \text{ follows } \text{distr} (0, H_t)$$

Where X_t is the 4 x 1 vector of l_GDP , l_IIP , l_ExRate and l_CPI respectively, D is the first difference operator, ε_t is a 4 x 1 residual vector indicating ($\varepsilon_{GDP,t}$, $\varepsilon_{IIP,t}$, $\varepsilon_{ExRate,t}$, $\varepsilon_{CPI,t}$) that follows an unspecified conditional distribution with mean zero and time-varying covariance matrix, H_t . The VECM measurement comprises of an adjustment to changes in X_t in both the short and long-run using the expected parameters Γ_i and Π , respectively. The VECM description of the above Equation (2), may be given as follows:

$$D(l_GDP_t) = \sum a_{l_GDP,i} D(l_GDP_{t-i}) + \sum b_{l_GDP,i} D(l_IIP_{t-i}) + \sum c_{l_GDP,i} D(l_ExRate_{t-i}) + \sum d_{l_GDP,i} D(l_CPI_{t-i}) \\ + a_{l_GDP} Z_{t-1} + \varepsilon_{l_GDP,t} \quad \text{-----} \quad (3)$$

$$D(l_IIP_t) = \sum a_{l_IIP,i} D(l_IIP_{t-i}) + \sum b_{l_IIP,i} D(l_GDP_{t-i}) + \sum c_{l_IIP,i} D(l_ExRate_{t-i}) + \sum d_{l_IIP,i} D(l_CPI_{t-i}) \\ + a_{l_IIP} Z_{t-1} + \varepsilon_{l_IIP,t} \quad \text{-----} \quad (4)$$

$$D(l_ExRate_t) = \sum a_{l_ExRate,i} D(l_ExRate_{t-i}) + \sum b_{l_ExRate,i} D(l_GDP_{t-i}) + \sum c_{l_ExRate,i} D(l_IIP_{t-i}) \\ + \sum d_{l_ExRate,i} D(l_CPI_{t-i}) + a_{l_ExRate} Z_{t-1} + \varepsilon_{l_ExRate,t} \quad \text{-----} \quad (5)$$

$$D(l_CPI_t) = \sum a_{l_CPI,i} D(l_CPI_{t-i}) + \sum b_{l_CPI,i} D(l_GDP_{t-i}) + \sum c_{l_CPI,i} D(l_IIP_{t-i}) + \sum d_{l_CPI,i} D(l_CPI_{t-i}) \\ + a_{l_CPI} Z_{t-1} + \varepsilon_{l_CPI,t} \quad \text{-----} \quad (6)$$

where a's, b's, c's and d's are the coefficients in the short-run, $z_{t-1} = \beta' X_{t-1}$ is the error- correction term that captures the impact of deviations of the previous period on the dependent variable from long-run equilibrium perspective in equation (2), and ε 's indicates the residuals. The Wald test is used to test the hypothesis of short term causality on the joint significance of the lagged estimated coefficients of $D(l_GDP_{t-i})$, $D(l_IIP_{t-i})$, $D(l_ExRate_{t-i})$, and $D(l_CPI_{t-i})$.

RESULTS AND DISCUSSIONS

1. Correlation Estimates: The correlation between the variables taken for the study is shown below in table 1:

It can be seen that there exists a high and positive correlation between the gross domestic production and other selected variables. Also, there exists high and positive correlation between other variables. The correlation between GDP and IIP is 0.9723, between GDP and ExRate is 0.8955, between GDP and CPI is 0.9777,

between IIP and ExRate is 0.8682, between IIP and CPI is 0.9370 and between ExRate and CPI it is 0.9398.

Table 1. Correlation Matrix

	l_GDP	l_IIP	l_ExRate	l_CPI
l_GDP	1.0000	0.9723	0.8955	0.9777
l_IIP		1.0000	0.8681	0.9370
l_ExRate			1.0000	0.9398
l_CPI				1.0000

Source: Author's computation using Gretl – an open source software.

2. Test for Stationarity: The Augmented Dickey-Fuller test (ADF) is used to test the stationarity of the GDP, IIP, ExRate, and CPI. The Table 2 below shows the results of unit root test for stationarity:

Table 2. Unit Root Test

Series	Augmented Dickey-Fuller test statistic (with constant & 2 lags)			
	Level	p-value	1st Difference	p-value
l_GDP	-1.42985	0.5692	-6.23969	3.108e-008
l_IIP	-1.33907	0.6135	-8.76135	2.597e-015
l_ExRate	-1.75821	0.3933	-4.8963	3.312e-005
l_CPI	-3.28589	0.01555	--	--

Source: Author's computation using Gretl – an open source software.

It can be seen that the variables GDP, IIP and ExRate becomes stationary for the first difference and the variable CPI is stationary at level. Hence it is concluded that all the series LogGDP, LogIIP, LogExRate except LogCPI are non-stationary indicating the chances of cointegration between them. This implies that some or all the variables are either integrated with order one I(1) or order two I(2).

Table 3. Johansen Co-integration Test – r is the number of Cointegrating Vectors

Null	Alternativer	λ - Trace	p-value	λ - max	p-value
None *	1	74.651	0.0163	38.894	0.0006
At most 1	2	35.757	0.0722	20.610	0.0578
At most 2	3	15.147	0.1079	14.920	0.0373
At most 3	4	0.22742	0.6710	0.22742	0.6335

* denotes rejection of the hypothesis at the 0.05 level.

Source: Author's computation using Gretl – an open source software.

3. Testing for Co-integration: To determine the order of cointegration, the Johansen's cointegration test is applied. The Table 3 below shows the results of λ_{trace} and λ_{max} :

It can be seen that λ_{trace} and λ_{max} (eigen statistics) are significant at 5% level of significance, hence the null hypothesis of no cointegration (none) is rejected. This implies that all the four variables are cointegrated with order 1, which also indicates the possibility of long term causality between them. Thus, a certain variable can be targeted to bring about the desired changes in the other variables in the structure as a policy matter.

4. Vector Error Correction Model Approximation: The existence of cointegration between the variables compels one to use a valid error correction model to capture the short run and long run causality between the variables. (Granger Representation Theorem). The table 4 below

gives the summary output of Vector Error Correction Model (VECM):

As seen in table 4, the error correction terms have correct sign in equation 3, 4 and 5, but only first equation's EC term is significant at 1% level of significance. Thus, the index of industrial production (IIP), exchange rate (ExRate) and inflation (CPI) cause gross domestic product (GDP) in the long run. As error correction terms of other equations are not significant, the channel of causation in the long run cannot be determined. Thus, in the long run, IIP, ExRate and CPI (inflation) cause GDP. To study the direction of causality in the short run Wald test of causality is performed and is shown below in table 5. As seen in table 5, the index of industrial production exchange rate and inflation cause gross domestic product in the short run in the equation of GDP. In the short run, the GDP cause IIP, but the exchange rate and inflation does not cause IIP.

Table 4. Estimated VECM with 4 lags

Equation	D(l_GDP))	D(l_IIP)	D(l_ExRate)	D(l_CPI)
EC	-0.139145***	-0.00788852	-0.00292710	0.0344160
	[-5.005]	[-0.07905]	[-0.02672]	[0.6144]
	(0.0002)	(0.9381)	(0.9791)	(0.5488)
C	1.39878***	0.0458866	0.0201588	-0.332395
	[5.053]	[0.04618]	[0.01848]	[-0.5960]
	(0.0002)	(0.9638)	(0.9855)	(0.5607)
D(l_GDP(-1))	-0.249929	1.70828**	-0.815937	-0.419838
	[-1.454]	[0.617203]	[-1.204]	[-1.212]
	(0.1681)	(0.0151)	(0.2485)	(0.2456)
D(l_GDP(-2))	-0.540413***	-0.0707112	0.962512**	0.158903
	[-5.098]	[-0.1858]	[2.304]	[0.7439]
	(0.0002)	(0.8553)	(0.0371)	(0.4692)
D(l_GDP(-3))	0.00309917	1.40301***	0.249705	0.0697622
	[0.02695]	[3.399]	[0.5510]	[0.3011]
	(0.9789)	(0.0043)	(0.5903)	(0.7678)
D(l_IIP(-1))	0.475580***	-0.449858	-0.0700679	-0.0483200
	[6.581]	[-1.734]	[-0.2460]	[-0.3319]
	(1.23e-05)	(0.1048)	(0.8092)	(0.7449)
D(l_IIP(-2))	0.202831**	-0.760343**	0.300739	0.140295
	[2.351]	[-2.456]	[0.8846]	[0.8072]
	(0.0339)	(0.0277)	(0.3913)	(0.4331)
D(l_IIP(-3))	0.132972**	-0.307204*	0.00844564	0.0504368
	[2.763]	[-1.778]	[0.04453]	[0.5202]
	(0.0152)	(0.0970)	(0.9651)	(0.6111)
D(l_ExRate(-1))	0.148963***	0.0512926	0.183883	-0.0500705
	[3.150]	[0.3022]	[0.9867]	[-0.5255]
	(0.0071)	(0.7670)	(0.3406)	(0.6075)
D(l_ExRate(-2))	-0.00529211	-0.0536639	0.315503	0.0141766
	[-0.1104]	[-0.3118]	[1.670]	[0.1467]
	(0.9137)	(0.7598)	(0.1172)	(0.8854)
D(l_ExRate(-3))	0.0677562	0.146576	-0.527285***	-0.0448219
	[1.534]	[0.9245]	[-3.029]	[-0.5036]
	(0.1473)	(0.3709)	(0.0090)	(0.6224)
D(l_CPI(-1))	-0.197480**	-0.243529	0.396637	0.301474
	[-2.249]	[-0.7726]	[1.146]	[1.704]
	(0.0412)	(0.4526)	(0.2710)	(0.1105)
D(l_CPI(-2))	-0.127645	0.796092**	0.423831	-0.0911207
	[-1.293]	[2.246]	[1.089]	[-0.4579]
	(0.2171)	(0.0414)	(0.2945)	(0.6540)
D(l_CPI(-3))	-0.196716*	-0.412177	-0.151381	0.347744
	[-1.789]	[-1.044]	[-0.3493]	[1.569]
	(0.0953)	(0.3141)	(0.7321)	(0.1389)
R2	0.950139	0.863042	0.797860	0.726765
Durbin-Watson	1.794869	1.500998	2.352640	1.691355

[] – indicates t –ratio. () – indicates p – value.

* signifies 10 % level of significance. ** signifies 5 % level of significance.

*** signifies 1 % level of significance.

Source: Author's computation using Gretl – an open source software.

Table 5. Wald Test F-Statistics with 4 lags

	D(I_GDP) ↓	D(I_IIP) ↓	D(I_ExchangeRate) ↓	D(I_CPI) ↓
D(I_GDP)	--	3.6014		
[0.0412]	2.3201			
[0.1216]	2.0462			
[0.1570]				
D(I_IIP)	8.9879 [0.0018]	--	0.37486	
[0.8219]	1.2227			
[0.3561]				
D(I_ExchangeRate)	2.7111 [0.0857]	1.0233		
[0.4374]	--	0.11300 [0.9753]		
D(I_CPI)	3.4123 [0.0478]	2.0785		
[0.1523]	0.74807			
[0.5794]	--			

[] – indicates p – value.

Source: Author's computation using Gretl – an open source software.

Year/ Quarter	L_GDP	Forecast	Quarter Year/	L_GDP	Forecast	
2016:2	14.842266	14.842525	2019:1	15.011766	15.012587	
2016:3	14.857769	14.857037	2019:2	15.002788	15.004303	
2016:4	14.880894	14.881234	2019:3	15.014939	15.016519	
2017:1	14.898060	14.903365	2019:4	15.038418	15.043095	
2017:2	14.901575	14.892017		Forecast	Std Error	95% Interval
2017:3	14.926110	14.920203	2020:1	15.056696	0.003356	15.050119 - 15.063273
2017:4	14.954449	14.950215	2020:2	15.071127	0.005449	15.060448 - 15.081806
2018:1	14.965249	14.968539	2020:3	15.091744	0.006363	15.079272 - 15.104215
2018:2	14.960379	14.961627	2020:4	15.117697	0.008750	15.100547 - 15.134847
2018:3	14.980823	14.983265	2021:1	15.135309	0.010554	15.114623 - 15.155994
2018:4	15.008465	15.005310	2021:2	15.146562	0.012155	15.122737 - 15.170386

Source: Author's computation using Gretl – an open source software.

Thus, in the short run, it seems that there exists bidirectional causality between GDP and IIP. The exchange rate equation shows that, the GDP, IIP and inflation doesn't cause exchange rate in the short run. Similarly, in the last equation of inflation, no variable (the GDP, index of industrial production and exchange rate) cause inflation in the short run. Thus, there exists a bidirectional causality between GDP and IIP, and

unidirectional causality between CPI & GDP and ExRate & GDP. Thus, CPI causes GDP and ExRate causes GDP in the short run and is summarized as below:

To validate the model, the predicted values are obtained for the some sample data values and out of the sample period. The results are presented as below: From the above table, it can be seen that VECM predicts the GDP

with very low deviation and out of sample forecasts also seems to be reliable as the standard error is very low. Thus, under the conditions of non-stationary and cointegrating series, VECM is considered as the most appropriate model which not only predicts, but shows the causality effect as well.

CONCLUSION

The study shows the existence of long run unidirectional causality between exchange rate, industrial production and inflation towards gross domestic production and short run bidirectional causality between industrial production and gross domestic product and unidirectional causality between exchange rate and GDP & inflation and GDP towards GDP in India. This confirms with the study by Mlambo, 2020 according to which exchange rate and inflation significantly impacts manufacturing sector in SACU (South African Custom Union) countries. The present study shows the bidirectional causality between industrial production and GDP in the short run in India. Also the VECM model effectively captured the long run causality of industrial production, exchange rate and inflation for forecasting GDP in India.

From the policy perspective, the monetary policy of India is inflation-targeting rather than growth targeting. But the short run and long run economic growth perspective cannot be ignored. Looking at the present state of economic growth it is the need of an hour to look towards economic growth targets so that economic development becomes more prominent. The exchange rate volatility directly affects the exports and imports of the country and inflation determines the buying capacity of the market, and hence are very important from the perspective of industrial output and aggregate output of the market. Thus, at planned level of inflation and exchange rate, VECM model can give the direction of

GDP achievable in near future to the policy makers.

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