

Co-integration and Causal Relationship between Stock Prices and Macroeconomic Variables (Indian Evidence)

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Abstract

The present study tries to establish the causal relationship, degree of impact and long run relationship between stock market prices (Nifty 50) with regard to Real Gross Domestic Product and Inflation. Quarterly data from 2007 Q1 to 2017 Q3 has been used and techniques like Augmented Dickey Fuller Test, Granger Causality Test and Johansen's Cointegration Test has been used to establish the relationship and impact of Real Gross Domestic Product and Inflation on stock prices. The study found that (i) neither RGDP and Inflation Granger Cause stock prices nor stock prices Granger Cause them, (ii) RGDP and Inflation have no statistically significant relationship with the stock prices (Nifty 50) and (iii) there exhibits the presence of long run relationship between stock prices with regard to RGDP and Inflation.

Keywords: Stock prices; Inflation; RGDP; Granger causality; Johansen's co-integration

Introduction

The economics has been divided into two broad parts, microeconomics and macroeconomics. Microeconomics deals with individual units whereas macroeconomics deals with the aggregates. Macroeconomics studies the economies total output, employment, price level etc. There are number of factors that are included in it and are used to check the growth and development of an economy. Every country wants to be economically stable so as to remain at par with other countries. There are different factors that help a country to grow and prosper. One among them is stock market.

The stock market is a market in which existing securities are resold or traded. In stock exchanges, the securities issued by the Central and State government, public bodies and joint stock companies are traded. It plays an important role in allocation of scarce resources to their most productive uses. Those people who invest in the stock markets or want to invest carefully watch the performance of stock markets by observing the various indices. There are different macroeconomic factors that can affect the stock prices of a particular exchange. In the past, researchers have tried to find the impact of macroeconomic variables on stock prices but mostly in developed countries. The aim of the present study is to investigate the impact of Real Gross Domestic Product and Inflation on stock prices (Nifty-50) in India which is a developing economy.

Literature Review

The literature reveals that many studies have been conducted on this subject in different countries but mostly in developed countries that explain the relationship and impact of macroeconomic variables (GDP and Inflation) on stock prices.

Fama [1] employed regression on monthly, quarterly and annual stock returns for the period 1954-1976 and concluded statistically negative relation between stock returns and inflation rate. Geske and Roll [2] also explained the negative linkage among stock returns and inflation.

Chen, et al. [3] has explored a set of state variables as systematic influence on stock market returns and has examined their influence on asset pricing for U.S from the period Jan 1953-Nov 1983. They

empirically found that the macroeconomic variables such as industrial production, anticipated and unanticipated inflation, yield spread between the long and short term government bond were significantly affect the stock returns through their effect on future dividends and discount rates.

Gan et al. [4] investigated the relationships between New Zealand stock market index and a set of seven macroeconomic variables from January 1990 to January 2003 using co-integration and Granger causality test. The analysis revealed a long run relationship between New Zealand's stock market index and the macroeconomic variables tested. In general, the NZSE40 is determined by the interest rate, money supply and real GDP and there is no evidence that the New Zealand Stock Index is a leading indicator for changes in macroeconomic.

Ratanapakorn and Sharma [5] study investigates the long-term and short-term relationships between the US stock price index (S&P 500) and six macroeconomic variables over the period 1975-1999. They observe that the stock prices relate positively to inflation. In the Granger causality sense, every macroeconomic variable causes the stock prices in the long-run but not in the short-run.

Issahaku et al. [6] employs monthly time series data from January 1995 to December 2010. Unit root test, Vector Error Correction (VECM) and Granger Causality test is performed between macroeconomic variables and Ghana stock market. This study reveals that a significant short-run and long-run relationship exists between inflation and stock return and also unidirectional causal relationship from inflation to stock returns has been established.

Tripathi and Kumar [7] studied the relationship between macroeconomic variables (Inflation, GDP, exchange rate, interest rate,

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money supply and oil prices) and stock returns in BRICS market using quarterly data for the period 1995-2014. They found that GDP and inflation are not significantly affecting stock returns in most of BRICS markets mainly because stock returns generally tend to lead rather than GDP and inflation.

Ray [8] explored the impact of macroeconomic variables on stock prices in India from the period 1990-2011. Multiple regression result indicates that GDP has positive influence whereas inflation rate do not have significant effect on Indian stock prices.

Reddy [9] explained the impact of inflation and GDP on stock market returns in India for the period ranging from 1997-2009. He found that reduction in inflation rate lead to increase in stock prices whereas RGDP has a positive impact on stock prices.

While going through the relevant literature it was found in many cases that there is a relationship and impact of GDP and Inflation on stock prices.

Objectives

1. To study the causal relationship between Stock market prices (Nifty 50) with regard to Real Gross Domestic Product and Inflation.
2. To examine the degree of impact of Real Gross Domestic Product and Inflation on Stock market prices (Nifty 50).
3. To study the long run relationship between Stock market prices (Nifty 50) with regard to Real Gross Domestic Product and Inflation.

Hypothesis

H_{01} : There is no statistically significant causal relationship between stock market prices with regard to RGDP and Inflation.

H_1 : There is a statistically significant causal relationship between stock market prices with regard to RGDP and Inflation.

H_{02} : There is no statistically significant impact of RGDP and Inflation on stock market prices.

H_2 : There is a statistically significant impact of RGDP and Inflation on stock market prices.

H_{03} : There is no statistically significant long run relationship between Stock market prices with regard to RGDP and Inflation.

H_3 : There is a statistically significant long run relationship between Stock market prices with regard to RGDP and Inflation.

Methodology

Data description and data type

To achieve the above mentioned objectives time series Quarterly data from April, 2007 (Q1) to December, 2017 (Q3) have been used. Data has been collected from various sources for this study mentioned below in the table.

Dependent variable

Stock prices: The Stock price is simply the number that a willing seller is ready to pay and a willing buyer is ready to accept. The stock prices of Nifty 50 are used in this study.

Independent variables

Gross domestic product at constant prices or real GDP: GDP represents the monetary value of all goods and services produced within a nation's geographic borders over a specified period of time. Real gross domestic product (GDP) is an inflation-adjusted measure that reflects the value of all goods and services produced by an economy in a given year, expressed in base-year prices, and is often referred to as "constant-price," "inflation-corrected" GDP or "constant dollar GDP." Real GDP is an accurate gauge of changes in the output level of an economy.

Inflation (CPI): Inflation is a sustained increase in the general price level of goods and services in an economy over a period of time. A comprehensive measure used for estimation of price changes in a basket of goods and services representative of consumption expenditure in an economy is called consumer price index.

Tool and techniques

In this study, Time series data has been used. Time series refer to the data accumulated at regular intervals. For instance, height of ocean tides, daily closing prices of stock markets etc. Many financial time series contain a unit root, means the series is non-stationary and it is generally acknowledged that stock prices and macroeconomic variables (here RGDP and Inflation) might not be an exception. A series is said to be stationary if its mean and variance are constant over a period of time and a series is said to be non-stationary if its mean and variance are not constant. Non-stationary series possess units' root that can cause problems for drawing meaningful inferences in time series analysis. Various tests are available to test the unit root in a time series like Augmented Dickey Fuller (ADF), Philips Perrontest (PP), Kwiatkowski Phillips Schmidt Shin (KPSS) test, Elliott-Rothenberg Stock Test, Zivot Andrews Test, etc. ADF test has been used in the study because it is commonly used test.

Augmented Dickey Fuller (ADF)

Dickey and Fuller developed the ADF test for testing unit root in a series and it is mostly used test. An Augmented Dickey-Fuller test (ADF) tests the null hypothesis that a series has unit root and the alternative hypothesis is that series has no unit root. If the critical value is more than the ADF test-statistic (in absolute value), the null hypothesis cannot be rejected, means the series is non-stationary at the level. The ADF test has been applied to test the stationary status of the data using E-Views 10 software.

The ADF test used to test the existence of unit root can be applied on three cases; with intercept, trend and intercept or none. The following model has been used in this study for ADF test.

At level:

Intercept is used

$$D(X)=\alpha+\beta X(-1)+\epsilon$$

Trend and Intercept are used

$$D(X)=\alpha+\beta X(-1)+\theta+\epsilon$$

None is used

$$D(X)=\beta X(-1)$$

At 1st difference:

Intercept is used.

$$D(X,2)=\alpha+D(\beta X(-1))+\varepsilon$$

Trend and Intercept is used.

$$D(X,2)=\alpha+D(\beta X(-1))+\theta+\varepsilon$$

None is used.

$$D(X,2)=D(\beta X(-1))+\varepsilon$$

At 2nd difference:

Intercept is used.

$$D(X,3)=\alpha+D(\beta X(-1),2)+\varepsilon$$

Trend and Intercept is used.

$$D(X,3)=\alpha+D(\beta X(-1),2)+\theta+\varepsilon$$

None is used.

$$D(X,3)=D(\beta X(-1),2)+\varepsilon$$

Here,

D =Difference

X =Variable

α =Intercept or Constant

β =Coefficient of variable

θ =Trend

ε =Error term.

Granger causality test

Engle-Granger was the one who used the concept of causality in economics. Granger causality test is always applied on a stationary series. Granger causality test is a tool that helps to determine whether one time series is significant enough to forecast the another series and is also used to know whether the past values of a variable are able to give explanation of another one. In this study, it is used to test the causality between the stock market prices with regard to RGDP and Inflation. Granger defined the causality relationship based on the two principles:

1. The cause happens prior to its effect
2. The cause has unique information about the future values of its effect.

In this study the test is based on following two regression equations:

$$X=\beta_1 * X_{t-i} + \beta_2 * Y_{t-j} + \varepsilon_1$$

$$Y=\beta_3 * X_{t-i} + \beta_4 * Y_{t-j} + \varepsilon_2$$

Here,

X and Y =variables

β =coefficient of variables at lag

ε =residual.

The null hypothesis that $\beta=0$ can be tested by using the standard F-test. For Granger causality test, E-views 10 software has been used.

Suppose there are two variables A and B and after applying Granger causality test on them four outcomes of cause and effect are possible:

1. From A to B there is a unidirectional causality that means A causes B.

2. From B to A there is a unidirectional causality that means B causes A.

3. When both A and B causes each other that means there is a bilateral causality between them.

4. When none cause each other independence is suggested.

In Granger Causality test lag length is very important. There are many lag length selection criteria such as Akaike Information Criterion, Schwarz Information Criterion, Hannan-Quinn Criterion and Final Prediction Error. On the basis of Akaike Information Criterion lag length is determined.

Regression

In this study, linear regression is used to measure the degree of impact of RGDP and Inflation on stock market prices. It is the most commonly used statistical technique to determine the strength of the relationship between dependent variable and independent variable.

$$Y=a+b_1 * X_1 + \varepsilon.$$

Here,

Y =Dependent variable

a =Constant

b =Coefficient of an independent variable

X =Independent variables

ε =Residual.

The below models are used in the study:

$$STPC=\alpha+\beta_1 * RGDP+\varepsilon$$

$$STPC=\alpha+\beta_2 * RGDP+\varepsilon$$

Here,

$STPC$ =Stock prices

α =Constant

β =Coefficient of independent variable

ε =Residual.

Johansen's co integrating test

The Johansen's test is used in this study that was introduced by Johansen and Johansen and Juselius because it is the superior test for co integration. Co-integration test has been applied on non-stationary series to examine whether the long run relationship exists between variables or not. Two time series cannot wander off in opposite directions for very long when they are co-integrated. This test is based on two test statistics, viz., Trace statistic, and Maximum Eigen value statistic to identify the number of co-integrating relations among variables. Trace statistic tests the r co-integrating relations in the null hypothesis against k cointegrating relations in the alternative hypothesis, where k is the number of variables used in the test whereas Max-Eigen statistic tests the r cointegrating relations in null hypothesis against the $r+1$ cointegrating relations in alternative hypothesis.

Empirical analysis and discussion

The study undertaken to examine the statistically significant causal relationship, impact and long run relationship between Stock prices with regard to Real Gross Domestic Product and Inflation. In order

to accomplish the objectives of the study various techniques have been used to derive the results. The results are shown below:

Augmented Dickey-Fuller test

The Augmented Dickey Fuller Test has been applied to check whether the time series data used in the study has a unit root or not. It has been applied on all the three variables namely Stock prices (STPC), Real Gross Domestic Product (RGDP) and Inflation (INF) using E-views 10 software each having 43 observations of quarterly data ranging from 2007 to 2017.

The hypotheses for the test are:

H_0 : Variable has a unit root

H_1 : Variable has no unit root.

The ADF test is used to test the stationary of the time series data in order to apply further tests in the study like Granger causality test and regression analysis so the results obtained are not spurious. Before applying this test on the data, the test type of the time series is verified, graph has been drawn. Software used the Schwarz information criterion (SIC) (i.e., by default) to choose the lag values for the test. On level and first difference variables are tested. To test the hypothesis 5% level of significance is used in the study. The results are shown in Tables 1a and 1b.

It is evident for the Table 1a that the calculated ADF test-statistics of variables RGDP is greater than the critical value (5% level of significance) and also P value (i.e., probability value) is less than 0.05,

S. No.	Variables	Symbol	Source
1.	Stock prices	STPC	NSE
2.	Real Gross Domestic Product	RGDP	FRED
3.	Inflation	INF	OECD

Table 1: Data collected from various sources.

Variables	Test type	t-statistic	Critical value	P value	Outcome
STPC	Trend and Intercept	-2.000289	-3.520787	0.5842	Non-stationary
RGDP	Trend and Intercept	-5.140454	-3.529758	0.0008	Stationary
INF	Intercept	-1.399676	-2.943427	0.5720	Non-stationary

Table 1a: Augmented Dickey-Fuller test: level form.

Variables	Test type	t-statistic	Critical value	P value	Outcome
STPC	Trend and Intercept	-4.764129	-3.523623	0.0022	Stationary
INF	Intercept	-3.125378	-2.948404	0.0337	Stationary

Table 1b: Augmented Dickey-Fuller Test: 1st differenced form.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-444.4139	NA	3383779.	23.54810	23.67738	23.59410
1	-414.5568	53.42853	1131520.	22.45036	22.96749*	22.63435*
2	-406.1946	13.64352	1182401.	22.48393	23.38891	22.80591
3	-403.3278	4.224826	1674683.	22.80672	24.09955	23.26670
4	-308.2510	30.36408*	837713.4*	22.06584*	23.74653	22.66382

Endogenous Variables: DSTPC GDP DINF.

*indicates lag order selected by the criterion.

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final Prediction error.

AIC: Akaike Information Criterion

SC: Schwarz information Criterion.

HQ: Hannan-Quinn information criterion.

AIC has been used to select the optimal length of lag for the test. AIC chooses the lag with least value i.e., lag 4.

Table 2: VAR lag order selection criteria.

therefore the null hypothesis is rejected. For other two variables i.e., STPC and INF null hypothesis cannot be rejected because the ADF test-statistics is less than critical value and p value is greater than 0.05. It is clear that these variables are non-stationary on level, and the data has been converted into 1st difference to make them stationary.

It is apparent from Table 1b that all the three variables have ADF test-statistics greater than critical value (5% level of significance) and also the P value is less than 0.05. In Table 1b the variables become stationary 1st difference. Now the Granger Causality Test and Regression Analysis can be easily applied for the study.

Granger causality test

Before applying Granger causality test optimal level of lag is selected. The lag means that the data is differenced at 1 i.e., t-1. For selecting the lag, VAR selection criteria has been used in the study. Result of the VAR lag selection criterion has been depicted by the Table 2 below:

To examine the first objective of the study i.e., to study the causal relationship between Stock market prices (Nifty 50) with regard to Real Gross Domestic Product and Inflation the Granger causality test has been used. The hypotheses for the test are:

H_{01} : RGDP do not Granger cause stock prices

Stock prices do not Granger cause RGDP

H_{11} : RGDP do Granger cause stock prices

Stock prices do Granger cause RGDP

H_{02} : INF does not Granger cause stock prices

Stock prices do not Granger cause INF

H_{12} : INF does Granger cause stock prices

Stock prices do Granger cause INF.

The null hypothesis has been rejected or selected on the basis of p-value of f-statistic. The results of Granger Causality Test are depicted in below Table 3.

From the above Table 3 it is apparent that the probability value in both the cases are higher than 0.05, hence on the basis of above results it is concluded that the Null Hypotheses are accepted. There exists no relationship between them; neither Real Gross Domestic Product and Inflation Granger cause Stock prices nor stock prices Granger cause them.

Regression analysis

Linear regression analysis has been used to examine the impact

of Real Gross Domestic Product and Inflation on stock prices. The hypotheses of the test are:

H_{10} : RGDP has no impact on stock prices

H_{11} : RGDP has an impact on stock prices

H_{20} : INF has no impact on stock prices

H_{21} : INF has an impact on stock prices.

The models below have been used for the study:

$$DSTPC = \alpha + \beta_1 * RGDP + \epsilon$$

$$DSTPC = \alpha + \beta_2 * INF + \epsilon$$

In the model, DSTPC is dependent variable whereas Real Gross Domestic Product and Inflation are independent variables. The results are depicted in Tables 4a and 4b.

The result of the Regression Analysis Table 4a exhibit that RGDP has an R^2 value of 5.27% which means only 5.27% of impact is caused by RGDP and the rest i.e., 94.73% is caused by the external variables not included in the model. The result also shows that RGDP is not statistically significant at 5% level of significance, since the p-value exceeds 0.05. That means Real Gross Domestic Product is not capable of individually influencing stock prices (Nifty 50) and also indicates that there is insufficient evidence in the data to conclude that a relationship exists between RGDP and stock prices. The f-statistics shows a probability of 0.143357 indicating that RGDP has statistically no significant relationship with stock prices, means it cannot influence stock prices. On the bases of above results, null hypothesis cannot be rejected.

Table 4b shows that Inflation has an R^2 value of 0.39% which means only 0.39% of impact is caused by inflation and the rest i.e., 99.61% is caused by the external variables not included in the model. Since the p-value exceeds 0.05, it shows that inflation is not statistically significant at 5% level of significance. That means neither inflation is capable of individually influencing stock prices (Nifty 50) and nor there is insufficient evidence in the data to conclude that a relationship exists between inflation and stock prices. The probability of f-statistics shows the value of 0.693737 indicating that inflation has statistically no significant relationship with stock prices, means it cannot influence stock prices. From the results of the Table 4b, null hypothesis is accepted.

Johansen's cointegration test

To investigate the long run relationship between stock prices with regard to RGDP and INF Johansen Co integration Test has been used on the non-stationary variables in the study. In order to carry out the test, it is necessary to make the assumption regarding the trend underlying the data. In this study, variables have some sort of trend, therefore, Intercept (no trend) in CE and VAR has been selected from different options present under Deterministic Trend Specification. It means the level data have trend but the co integrating equations have only intercept. The number of lags have been selected by the Akaike Information Criterion i.e., lag 4. As is concluded by unit root test above in Table 1a, that all the variables considered except the RGDP are I(1), while the RGDP is I(0). So for the testing of cointegration among the variables, the RGDP is dropped from the further analysis because it is

Null Hypothesis	Obs	F-statistic	Prob.	Relationship
RGDP does not Granger Cause DSTPC	38	0.78511	0.5442	No relationship
DSTPC does not Granger Cause RGDP		1.19970	0.3321	
DINF does not Granger Cause DSTPC	38	1.88889	0.1392	No relationship
DSTPC does not Granger Cause DINF		1.30003	0.2932	

Table 3: Granger Causality test.

Variable	Coefficient	Std. Error	t-statistic	Prob.
C	-217.7457	253.9044	-0.857589	0.3962
RGDP	50.48967	33.82397	1.492719	0.1434

R-squared	0.052766	Mean dependent var	142.6905
Adjusted R-squared	0.029085	S.D. dependent var	516.3393
S.E. of regression	508.7751	Akaike info criterion	15.34834
Sum squared resid	10354082	Schwarz criterion	15.43108
Log Likelihood	-320.3151	Hannan-Quinn criter.	15.37867
F-Statistic	2.228209	Durbin-Watson stat	1.414190
Prob.(F-Statistic)	0.143357		

Table 4a: Regression analysis.

Variable	Coefficient	Std. Error	t-statistic	Prob.
C	142.1372	80.51657	1.765315	0.0851
DINF	-21.32074	53.75260	-0.396646	0.6937

R-squared	0.003918	Mean dependent var	142.6905
Adjusted R-squared	-0.020984	S.D. dependent var	516.3393
S.E. of regression	521.7287	Akaike info criterion	15.39862
Sum squared resid	10888034	Schwarz criterion	15.48137
Log Likelihood	-321.3710	Hannan-Quinn criter.	15.42895
F-Statistic	0.157328	Durbin-Watson stat	1.470508
Prob.(F-Statistic)	0.693737		

Table 4b: Regression analysis.

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical value	Prob.**
None*	16.99734	15.49471	0.0295
At most 1	0.169342	3.841466	0.6807

Trace test indicates 1 co integrating equation(s) at the 0.05 level
 *denotes rejection of the hypothesis at the 0.05 level
 **Mackinnon-Hang-Michelis (1991) P-values.
 Unrestricted Cointegration Rank Test (Trace).

Hypothesized No. of CE(s)	Max-Eigen Statistic	0.05 Critical value	Prob.**
None*	16.82799	14.26460	0.0192
At most 1	0.169342	3.841466	0.6807

Max-Eigen value test indicates 1 cointegrating equation(s) at the 0.05 level
 *denotes rejection of the hypothesis at the 0.05 level
 **Mackinnon-Hang-Michelis (1991) P-value.
 Unrestricted Cointegration Rank Test (Maximum-Eigen value).
 Series: STPC INF.

Table 5: Johansen's cointegration Test.

already stationary means it already has a long run relationship with STPC. With the help of two likelihood tests i.e., trace test and Maximum Eigen value test, the Johansen's cointegration test investigates the presence of cointegrating vectors or relations in a non-stationary time series. Thus, if two variables are found co integrated, it implies some relationship in the long-run. Trace statistic tests the null hypothesis of r co-integrating relations against the alternative of k cointegrating relations, where k is the number of variables used in the test.

$$H_0: r=0$$

$$H_1: r \leq k.$$

Max-Eigen statistic tests the null hypothesis of r cointegrating relations against the alternative of $r+1$ cointegrating relations

$$H_0: r=0$$

$$H_1: r=r+1.$$

Result from the above analysis indicates that stock prices are cointegrated with inflation in the long run. From Table 5, it is concluded that null hypothesis in both Trace Test and Max-Eigen Value Test can be rejected because the probability of co-integrating vector at none is less than 0.05. That means there is a long run relationship between STPC and INF and both the variables does not move in opposite direction for a long period of time.

Conclusion

The study examined the casual relationship and impact and long run relationship of Stock prices of Nifty 50 with regard to RGDP and Inflation and found that stock prices and inflation except RGDP are not stationary at levels but at first difference.

The Granger Causality test is also used to study the causal relationship and it was concluded that neither RGDP and Inflation Granger cause stock prices nor stock prices Granger cause them. That means there exists no relationship between the variables under study.

Regression Analysis has been applied to test the impact of RGDP and Inflation on stock prices and it was concluded that neither RGDP nor Inflation are capable of individually influencing Stock prices of Nifty 50, therefore, null hypotheses of the model have been accepted because the f-statistic shows that the RGDP and Inflation have no statistically significant relationship with stock prices (Nifty 50).

In order to Study the long run relationship between stock prices and Inflation, Johansen Co integration Test has been used and this test exhibits the presence of long run relationship between stock prices and inflation.

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