Determinants of Inflation in India: A Co-Integration Approach

P. R. Venugopal
Assistant Professor
Bhavan's Vivekananda College of Science, Humanities & Commerce**,** Secunderabad, India

Aayushi Aggarwal
Student of B. Com (Hons)
Bhavan's Vivekananda College of Science, Humanities & Commerce**,** Secunderabad, India

ABSTRACT

No doubt that the constant rise in the price levels of commodities and services adversely affects economic performance. The main goal of any government is to maintain relatively stable and low levels of inflation. Mild inflation can be viewed as having favorable impacts on the economy as it helps to create employment opportunities. But the uncontrollable inflation is dangerous for the economy. So, it is important to understand the factors that affect inflation rates. The main objectives of the present study are to examine the co-integration relationship between crude oil prices, gold prices, exchange rates, interest rates, and inflation, also to identify the direction of the relationship (either unidirectional or bidirectional relationship) that exists between the selected independent variables and inflation and also to study the impact of selected independent variables on Inflation (Consumer Price Index Number). The Co-integration relationship is tested using Johenson Co-integration Method has been used and the results showed that the selected independent variables have long term relation with the dependent variable Inflation. The direction of causality between the selected variables is identified using the Granger causality test and the results showed that there exists a bi-directional relationship between exchange rates and consumer price index. On the other hand, for understanding by how much percentage does the independent variables impact dependent variables a test called least square test has been performed, the results of which show that the selected variables impact inflation by 74%. 26% of the factors that are not defined under the present study can be taken into consideration for future researches.

Keywords: Inflation, Exchange Rates, Interest Rates, Crude Oil Prices, Gold Prices, Unit Root Test, Cointegrationon Test, Granger Causality test etc.

INTRODUCTION

Indian economy is a developing mixed economy. It is the world's 3rd largest by purchasing power parity and 6th largest economy by nominal GDP. The emergence of Asian economies in the world market has attracted a series of attention of policymakers. Monetary authorities announce the monetary policy measures at regular intervals to achieve the twin objectives of; 1) price stability

and 2) low unemployment through the various channels of the monetary transmission mechanism. After 1991 India achieved 6-7% average GDP growth annually.

In a country like India, the maintenance of price stability is one of the macroeconomic challenges faced by policymakers in the current scenario. The phenomenon of rising prices along with money-losing its purchasing power in real terms always had a negative impact as it increases the cost of living, cuts investment and adversely impacts economic growth. This process of rising prices is multidimensional and complex and is termed as "Inflation". Not every rise in the general price level is termed as inflation. Therefore, a rise in price level must be constant, enduring and sustained to be called inflation and this price level must affect almost every commodity and is affected by various factors of demand and supply over some time. It has been claimed by some of the economists that inflation at a moderate level is beneficial in creating employment channels, but the unanticipated and uncontrollable inflation is one of the macroeconomic problems faced by the countries majorly. Inflation in India has been determined by the multiplicity of factors that are interrelated intricately. Money in circulation is increased as a policy matter to meet the growing needs of the economy but it is mostly reflected as higher inflation due to disequilibrium with other macroeconomic variables.

Inflation is like a toothpaste; once it is out, it can hardly be back in again. Therefore, it is imperative to understand the determinants of inflation in India to control the menace of inflation in India and establish macroeconomic stability. Hence the present study is an attempt to comprehend such multifaceted relationships in Indian set up that may help the policymakers decide on different policies to control inflation.

REVIEW OF LITERATURE

A gigantic body of literature is available on inflation and its estimation which concentrates on the dynamics of inflation in India and other developing countries. Some models had employed the structural approach to inflation while others follow the monetarist's approach. The present paper reviews a few prominent studies which are as follows:

Rasool and Tarique (2017) examined the nature of co-integration between prices, lending interest rates, money supply, and real output for the period of 1970-2015 when prices are dependent variables, using autoregression distributed lag model (ARDL) based on CPI and Granger causality based on error correction method. Results reveal the existence of long-run and short-run causality running from all the explanatory variables towards the price.

Lim & Papi (1997) examined the determinants of inflation in Turkey from 1970 to 1995 taking into consideration variables like wages, money supply, export, and import rates and domestic price

level in Turkey, using Johensen's co-integration approach. Results reveal that money supply, wages, export, and import prices have a positive influence on the domestic price level of Turkey whereas exchange rates exert a negative effect on the domestic price levels in Turkey.

Hussain and Ajmair (2016) studied the co-integration between inflation, import prices, interest rates, GDP, and money supply using. Engle-Granger co-integration and ADF test to check the stationarity of the variables. Results reveal that all the variables are stationary at 1st difference so the co-integration test was applied which showed that there is a long-run relationship among inflation, interest rates and GDP whereas the short-run relationship between inflation, import prices, and money supply exists.

Ashwani (2014) attempted to identify the key determinants of inflation in India and tries to empirically investigate the recently boasted argument that India's inflation mainly attributed to the higher purchasing power of the people. Series of data is utilized ranging from 1981 to 2011 and variables used are money supply, private and social spending and exchange rates. Statistical tools like Johansen cointegration and vector correction model, pp test and ADF test are used. Results reveal that there is a presence of long-run relationships between inflation, money supply, private and social spending and exchange rates in India. Social sector spending has not added to inflation. Moreover, the results exhibit the short-run relationship for selected variables and speed of adjustment to long-run equilibrium through a correction to the short-run disequilibrium is found very high.

Soundarapandiyan and Ganesh (2016) studied the impact of oil prices on GDP and CPI and also inter-correlation between oil prices and CPI using statistical tools such as Regression, Co linearity, and inter-correlation. The Outcome of the paper indicates that there is an inter-correlation between CPI and crude oil price and vice versa. There is a clear indication that whenever the CPI increases there is a decrease in crude oil price and vice versa. It was also found that there was a significant difference between crude oil price and GDP and no significant difference between CPI and GDP.

Tufail and Batool (2013) conducted an Analysis on the Relationship between Inflation and Gold Prices: Evidence from Pakistan (2013), examined the relationship between gold and stock prices and inflation in Pakistan, Using time-series data for the period 1960–2010, co-integration and vector error correction techniques to assess the long-run relationship between inflation and the assets mentioned above. The same techniques are applied to examine the inflation-hedging properties of these assets. Results reveal that gold prices are positively related to inflation; the study widens its analysis to examine the hedging properties of assets in the capital market against expected and unexpected inflation. The total returns on gold, stock exchange securities, real estate, and foreign currency are taken as dependent variables. The results suggest that all these assets, except foreign currency, provide a hedge against inflation (either expected and/or unexpected). Gold provides a complete hedge against unexpected inflation but not against expected inflation.

Real estate provides a significantly more-than-complete hedge against expected inflation, but not against unexpected inflation where the relationship is negative and insignificant.

RESEARCH GAP

For any country's macroeconomic policy high and sustainable economic growth and low inflation are the two important targets. Whereas, when the inflation is too high, it will reduce the value of money, unless interest rates are higher than inflation and the higher inflation gets the less chance there is that saver will see any real return on their money.

So, the need for doing this study is to know what the various determinants of inflation are and how they are causing fluctuations in inflation rates. From the review of the literature, it is observed that there is consistency in the inconsistency of the usage of the variables. So, the present study focuses on using CPI, crude oil prices, interest rates, exchange rates, gold price variables which were not part of the review of literature variables. Hence, this study is unique in the usage of variables.

SCOPE OF THE STUDY

This study takes into consideration exchange rates, crude oil prices, gold prices, interest rates, and inflation rates i.e. CPI concerning India. For the present study, the monthly data from January 2005 to May 2017 (149 observations) is taken into consideration.

INDEPENDENT VARIABLES: Exchange rates, interest rates (interest rate from government securities and interest rate from treasury bills), crude oil prices, gold prices.

DEPENDENT VARIABLE: Inflation (CPI)

MATERIALS AND METHOD

DATA COLLECTION SOURCE: Data has been collected from secondary sources like Newspapers, articles, magazines, and websites such as www.rbi.org.in, Inflation.eu, www.indexmundi.com, World gold council, investing.com, Federal Reserve Bank of St Louis

STATISTICAL TOOLS: In the course of analysis of the present study, econometric tools include a unit root test (Augmented Dickey-Fuller), Johansen's system co-integration test has been used.

Model Specification

- **Unit root test**

A unit root test is conducted in statistics, to test whether time series variables are non-stationary and possesses a unit root or not. Null hypothesis (H0) is generally defined as the presence of a unit root whereas alternative hypothesis (H1) is either stationarity, explosive or trend stationarity root depending upon the type of test used.

A time series is stationary or not (include unit root or not) for which Augmented Dickey- fuller 1979 (ADF) has been used in the present study. ADF test is considered as an appropriate tool to check the stationarity of time series data. The data is non-stationary if the critical value is lower than the calculated value, subsequently, the null hypothesis is rejected and the series is decided to be stationary.

H0: time series is stationary.
H1: time series is non–stationary.

If the set of data is found I (1) non-stationary, and if the regression produces a I(0) error term, the equation is said to be co-integrated. On the other hand, if there are two variables, (xt and yt), which are both nonstationary in levels but stationary in first differences, then the variables would become integrated of order one, I(1), and their linear combination should have the form as given:

$Z_t = x_t - b\ (y_t)$

However, if there is a I (0) such that zt is also integrated of order zero, I(0), the linear combination of xt and yt is said to be stationary and the selected variables are also to be co-integrated. If the two variables are co-integrated, there will be an underlying long-run relationship between them. For determining the presence of unit roots, an extension of the dickey and fuller method has been applied. This test uses a regression of the first difference of the series against the lagged difference terms, and the series lagged once with optional constant and time trend. If the test on the level series fails to reject the null hypothesis, the ADF conclusion is that the series is integrated of order one, I (1). One limitation of the dickey-fuller test is its assumption that the errors are statistically independent and they have constant variance.

- **Granger causality test**

  To determine whether a one-time series is useful in forecasting another, a statistical technique called Granger causality test is used.

- **Johansen co-integration test**

  To test the co-integration relationship between various time series Johansen test is used. The Co-integration test provides a means to determine whether a set of endogenous variables share a long-run stochastic trend. The Findings of co-integration test indicates the interdependence of the endogenous variables, which may be the result of economic linkages between the exchange activity between the markets and the investors. The hypothesis to be examined with this test to be applied to the present study has been presented below:

  H0: there is no co-integration relationship between the variables.
  H1: there is the co-integration relationship between the variables.
  The Johansen approach of testing for co-integration relies on the relationship between the rank of a matrix and its characteristic roots, or eigenvalues.

- **Least square method test**

  To test the impact of independent variables on the dependent variable a test called least square method test is performed in the present study. A least-square method is a form of mathematical regression analysis that represents the strength of the relationship between the known independent variables and unknown dependent variables.

  Model

  Inflation = f (Exchange rates, interest rates, crude oil prices, gold prices)

EMPIRICAL RESULTS AND ANALYSIS

A) UNIT ROOT TEST RESULTS

Johansen co-integration analysis is needed where there is any co-integration existing between the selected variables that can be tested. (ie inflation, exchange rates, gold prices, crude oil prices, the interest rate on government bonds and the interest rate on treasury bills), .co-integration analysis is possible only if the series is stationary.

To do stationarity analysis, the unit root test of Augmented Dickey-Fuller is conducted with the levels and first differences of each series only on the condition that the null hypothesis is non-stationary, so rejection of the unit root hypothesis supports the stationarity. Table 2 and Table 3shows the results of the unit root test. In table 1, data at level i.e. original data's probability value in all the variables except in case of interest rate on government bonds is more than 5%, hence we fail to reject the null hypothesis i.e. data is at the unit root (non-stationary).

So, the first difference was applied (table 2) using augmented dickey fuller (ADF) test then the probability values resulted in less than 5%. Therefore, we reject the null hypothesis and attained stationarity at first difference.

Table 1: Result of the Augmented Dickey-Fuller test at the level:

VARIABLES	TEST STATISTICS	CRITICAL VALUE 5%	PROBABILITY VALUE	RESULT
CPI	-1.68	-2.8826	0.4403	NON-STATIONARY
ER	-0.29	-2.8825	0.9227	NON-STATIONARY
GP	-1.8238	-2.8811	0.3678	NON-STATIONARY
COP	-2.5501	-2.8811	0.1059	NON-STATIONARY
IRG	-2.9760	-2.8815	0.0396	STATIONARY
IRT	-2.4010	-2.8821	0.1433	NON-STATIONARY

TABLE 2: Result of Augmented Dickey Fuller test at first difference:

VARIABLES	TEST STATISTICS	CRITICAL VALUE 5%	PROBABILITY	RESULT
CPI	-6.8313	-2.88307	0.0000	STATIONARY
ER	-4.0586	-2.8826	0.0016	STATIONARY
GP	-10.17776	-2.8811	0.0000	STATIONARY
COP	-7.3718	-2.8811	0.0000	STATIONARY
IRG	-------	-------	------	--------
IRT	-3.1020	-2.8818	0.0286	STATIONARY

B) JOHANSEN CO-INTEGRATION TEST RESULTS

Johansen co-integration test is used to determine the number of co-integrating relationships, that is, whether there is co-integration as well as whether there is co-integration relationships between inflation, exchange rate, gold prices, crude oil prices, interest rates existing or not. Two tests are used, the Trace test and the Maximum Eigenvalue test, to determine the number of co-integrating vectors. The estimation for each series assumes a linear deterministic trend unrestricted with intercepts and no trends. A lag of 1 to 13 (in first difference) is used for each series, based on the Akaike info criterion (AIC).

Sample (adjusted): 2005M07 2017M05.

Included observations: 143 after adjustments

Trend assumption: linear deterministic trend.

Series: CPI, ER, COP, GP, IRT.

Exogenous series: CPI

Warning: critical value assumes no exogenous series

Lags interval (in first difference):

Table 3: Johansen co-integration test result

UNRESTRICTED CO-INTEGRATION RANK TEST (TRACE)

HYPOTHESIZED NO. OF CE(s)	EIGEN VALUE	TRACE STATISTICS	0.05 CRITICAL VALUE	PROBABILITY**
NONE*	1.000000	4945.959	66.81889	0.0000
ALMOST 1	0.213475	89.08688	47.85613	0.0000
ALMOST 2	0.178197	54.74809	29.79707	0.0000
ALMOST 3	0.112131	26.68367	15.49471	0.0007
ALMOST 4	0.065430	9.576555	3.841466	0.0019

The Trace test indicates 5 co-integrating eqn(s) at the 0.05 level of Significance.
(*) sign denotes rejection of the hypothesis at the 0.05 level of significance.
** MacKinnon-Haug-Michelis (1999) p-values.

UNRESTRICTED CO-INTEGRATION RANK TEST (MAXIMUM EIGENVALUE)

HYPOTHESIZED NO. OF CE(s)	EIGENVALUE	MAX-EIGEN STATISTICS	0.05 CRITICAL VALUE	PROBABILITY**
NONE*	1.000000	48.56882	33.87687	0.0000
ALMOST 1*	0.213475	34.33878	27.58434	0.0058
ALMOST 2*	0.178197	28.06442	21.13162	0.0045
ALMOST 3*	0.112131	17.00711	14.26460	0.0180
ALMOST 4*	0.065430	9.576555	3.841456	0.0019

Max-Eigen value test indicates 5 co-integrating equation (s) at the 0.05 level.
(*) sign denotes rejection of the hypothesis at the 0.05 level of significance.
** MacKinnon-Haug-Michelis (1999) p-values.

Table 3 demonstrates the Johansen co-integration test results. It assures the existence of Co-integration among the selected variables or not. The result obtained shows that the series is co-integrated, under both the trace and maximum Eigenvalue tests reject the null hypothesis of no co-integrating, suggesting that there are five common stochastic trends, indicating a degree of market integration. Therefore, it may conclude that there exists a stationary, long term relationship among the variables, as stated in (Haroon Rasool; 2017).

C) PAIRWISE GRANGER CAUSALITY TESTS RESULTS

The Granger causality test is a statistical proposition test for determining whether a one-time series is helpful in forecasting another. In the present study, in search of the direction of causation among the selected financial variables, the Pairwise Granger causality test has been performed.

Table-4 reveals that there exists no causality at 95% confidence level between:

a) Consumer price index and crude oil prices
b) Consumer price index and gold prices
c) Consumer price index and the interest rate on government securities
d) Consumer price index and the interest rate on treasury bills

Bi-directional causality exists between:

a) Exchange rate and consumer price index
b) Consumer price index and exchange rate.

Uni-directional causality exists between:

a) Crude oil prices and consumer price index
b) Gold prices and consumer price index
c) Interest rate on government securities and consumer price index
d) The interest rate on treasury bills and consumer price index.

It is important to note that the pronouncement of causality between the selected variables does not mean the movement in one variable causes movement in other variables. To a certain extent, causality entails in order of movements in the time series.

TABLE 4

Pairwise Granger Causality Tests
Date: 04/05/19 Time: 15:26
Sample: 1 149
Lags:2

Pairwise Granger Causality Test Result

Null hypothesis	**Obs.**	**F-statistics**	**Prob.**	**Decision**	**Type of causality**
COP does not Granger cause CPI	147	3.37840	0.0369	Reject Ho	Uni-directional
CPI does not Granger cause COP	147	0.29843	0.7424	DNR Ho	No causality
ER does not Granger cause CPI	147	1.62325	0.0009	Reject Ho	Bi-directional
CPI does not Granger cause ER	147	6.10433	0.0029	Reject Ho	Bi-directional
GP does not Granger cause CPI	147	0.98274	0.0018	Reject Ho	Uni-directional
CPI does not Granger cause GP	147	0.73326	0.4822	DNR Ho	No causality
IRG does not Granger cause CPI	147	0.18037	0.0011	Reject Ho	Uni-directional
CPI does not Granger cause IRG	147	1.87685	0.1568	DNR Ho	No causality
IRT does not Granger cause CPI	147	0.38164	0.0034	Reject Ho	Uni-directional
CPI does not Granger cause IRT	147	0.49531	0.6104	DNR Ho	No causality

Note: Decision rule: reject Ho if probability-value<0.05, DNR= do not reject.

D) LEAST SQUARE METHOD

It is a regression analysis that finds the line of best fit (which is nothing but a scatter plot of data points that best expresses the relationship between those points) for the set of data, providing a visual demonstration of the relationship between the data points. Each data point is representative of the relationship between the known independent variable and an unknown dependent variable.

Table 5 represents that crude oil prices, exchange rates, gold prices and interest on government securities have an impact on inflation (CPI) as the probability values are less than 0.05%. On the other hand, the probability value in case of interest rate from treasury bill is more than 0.05% so it does not have an impact on inflation.

TABLE 5 Dependent Variable: INFLATION
Method: Least Squares
Date: 04/05/19 Time: 15:13
Sample: 1 149
Included observations: 149

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.597587	0.569807	0.773606	0.0104
CRUDEOIL	2.616545	0.694005	0.482032	0.0205
EXCHANGE_RATE	-0.158191	0.236112	-1.703792	0.0061
GOLD_PRICES	-1.564656	0.656406	-0.485269	0.0032
INTEREST_RATE	0.361242	0.111663	0.746956	0.0023
THEASURY_BILLS	-0.251024	0.567707	-1.448606	0.1496

R-squared	0.774563	Mean dependent variable	0.366100
Adjusted R-squared	0.742205	S.D. dependent variable	0.188076
S.E. of regression	0.367903	Akaike info criterion	-6.803612
Sum squared resid	0.188932	Schwarz criterion	-6.682648
Log-likelihood	512.8691	Hannan-Quinn criteria.	-6.754466
F-statistic	2.304329	Durbin-Watson stat	1.601360
Probability (F-statistic)	0.036629		

FINDINGS AND CONCLUSION

This project aims at exploring the relationship between crude oil price, gold prices, interest rate, exchange rates, and CPI in India. The principal conclusion of the empirical results is that the selected time series exhibit that:

1) At level, the probability values for the original data are more than 5% (except for interest from government securities), which means the data is at unit root that is non-stationary data. Therefore, we fail to reject Ho.

2) ADF test was performed to check the Stationarity. As a result of the test, the Stationarity was obtained at the first difference. Therefore, we reject Ho.

3) To identify the co-integration relationship between the selected variables and CPI, the Johansen co-integration test was performed which showed that there exists long term relationship between the variables and CPI.

4) To analyze the causal relationship between the selected variables and CPI, at test called pairwise Granger causality test was performed which showed that there exists a bi-directional relationship between exchange rates and consumer price index. Whereas, uni-directional relationship exists crude oil prices and CPI, gold prices and CPI, the interest rate on government securities and CPI and interest on treasury bills and CPI.

5) The least-square test was performed to analyze the impact of selected variables on CPI. It showed that all the variables except interest rate on treasury bills have an impact on CPI, as the probability values are less than 5%.

SUGGESTIONS

In the present study, variables (such as crude oil prices, gold prices, interest rates, exchange rates) are taken into consideration as the determinants of inflation. This study has explained that 74 % impacted the inflation from the variables selected for this study. This study could not explain 26% impact on inflation. Thus, there is necessitate to do further research to get more clarity on the determinants of inflation by considering other macro-economic factors and financial market indicators (such as money supply, housing prices, and stocks) to arrive at robust empirical analysis. In India this could be a possible area of research in future.

REFERENCES

1) Rasool and Tarique (2017), "Determinants of Inflation: Evidence from India using Autoregressive Distributed Lagged Approach", Asian Journal of Research in Banking and Finance, Vol.8, No.1, January 2018, pp.1-17, ISSN 2249-7323.
2) Lim and Papi (1997). "Än Econometric Analysis of the Determinants of Inflation in Turkey", International Monetary Fund, European 1 Department, WP/97/170.
3) Hussain and Ajmair (2016),' Determinants of Inflation in India", International Journal of Scientific & Engineering Research, Vol 7, Issue 2, ISSN 2229-5518.
4) Ashwini, Dr.,2014, Determinants of inflation in India: A Cointegration Approach, International Journal of Multidisciplinary Consortium, Vol-1, No1, June.
5) Soundarapandiyan and Ganesh (2016), "An Analytical View of Crude Oil Prices and Its Impact on Indian Economy", IOSR Journal of Business and Management (IOSR-JBM) e-ISSN: 2278-487X, p-ISSN: 2319-7668 PP 23-28.
6) Tufail and Batool (2013). "An Analysis of the Relationship between Inflation and Gold Prices: Evidence from Pakistan," Lahore Journal of Economics, Department of Economics, The Lahore School of Economics, vol. 18(2), pages 1-35, July-Dec.
7) Modern Economic Theory (Theory and Policy) KK Dewett & M H Navalur: S. Chand Publications.