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# Analysis of the Effect of Currency Exchange Rate, Broad Money (M3) and Oil Prices on Inflation in India

**Shikha Sharma*, Manju Dahiya**

School of Liberal Education, Galgotias University, Greater Noida, India,

*Email: shikha.sharma_phd18@galgotiasuniversity.edu.in

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**ABSTRACT**

The main goal of any government is to keep the inflation rate low and generally constant. However, the economy is threatened by unbridled inflation. Therefore, it is important to understand the factors that affect inflation rates. Information on consumer price index, inflation rate, exchange rate and money supply has been collected from secondary data sources for India. Vector autocorrelation model (VECM) is used for data analysis. In addition, Lagrange multiplier test and Jarque-Bera test were used to determine whether the relationships of the variables are normal. The results showed a short run relationship between inflation and exchange rates. In the long run, there is a poor relationship between the two. Due to the absence of one of the criteria, the VECM cannot demonstrate long-run causality between the two circumstances. The results show that none of the lagged values of broad money are interesting.

**Keywords:** Inflation, Money Supply, Broad Money, Interest Rate, Oil Prices, Exchange Rate
**JEL Classifications:** E4, E5, F2, F4

## 1. INTRODUCTION

As can be seen, the relationship between money, deficits and prices is studied empirically. The basic model is often used in emerging markets to analyse the inflationary effects of budget deficits. This underscores the importance of the fiscal system, which is common in many developing countries. As a result, fiscal inflation theory is more widely used in developing countries (e.g., Aghevli and Khan, 1978; Alesina and Drazen, 1991; Oezen, et al., 2020). Fiscal policy in advanced economies lags inflation decisions, at least in theory, because seigniorage revenues have little influence on monetary policy (Woodford, 2001). Milo (2012) uses a quantitative economic model to confirm that there is a positive relationship between government deficit financing in Albania, Bulgaria, and Romania and monetary base expansion. They also believe that fiscal imbalances are one of the main causes of money printing and inflation in these countries. From 1985 to 2012, Nguyen (2015) studied the impact of fiscal deficits and the extensive M2 monetary base and inflation in Asian countries such as Indonesia, Thailand, Bangladesh, the Philippines, Malaysia, Sri Lanka, Cambodia, Pakistan, and Vietnam, where interest rates and government spending were all sources of inflation with statistical significance.

Honohan and Lane (2003) used several regression models to describe the annual inflation gap in the euro area from 1999 to 2001. They found that changes in the nominal effective exchange rate were important in interpreting inflation. In a similar study, Honohan and Lane (2004) conclude that the exchange rate affects the inflation rate in the European Union between the strong euro (2002-2003) and the depreciating euro (1999-2001). In their 2014 study on the impact of oil price fluctuations on India's macroeconomic factors from March 1991 to January 2009.

Using annual data from 1980 to 2010, Sek, Teo, and Wong (2015) developed 2 groups of ARL models, those with a relatively high dependence value and another with a low oil dependence index.

Their results suggest that in the less oil-dependent group, both the long-term relationship between price volatility and CPI inflation and oil price fluctuations have a direct effect on local inflation, while they have an indirect effect in the more oil-dependent group.

Rondina (2017) examined the impact of changes in the real price of oil on output and inflation of the New Keynesian model using quarterly U.S. time series data covering the first quarter of 1977 to the last quarter of 2016. It finds that the New Keynesian model has different interactions between the oil price, domestic factors, and the expectation used in their study compared to the more restricted structural vector autoregressive (SVAR) model. It turned out that a good response was obtained. Emerging market monetary policy (EME) tries to find out what factors cause inflation, as non-financial factors such as frequent supply shocks drive inflation. Inflation is unpredictable and difficult to forecast. It is also argued that non-monetary factors affect inflation only in the short run.

Monetarists argue that financial factors affect inflation in the long run. Therefore, it is believed that the classical output gap model better reflects the nature of inflation in emerging markets. Using the discrete and continuous wavelet method, Tiwari et al. (2014) examined the relationship between the output gap and the output gap in France. They found that the output gap can predict short- and medium-term inflation dynamics and that there appears to be a Phillips curve. In India, where the output gap has an asymmetric impact on prices from 1996 to 2014, Mohanty and John (2015) used the time-varying structural var model to assess the main drivers of inflation. It was found to have declined in recent years. Alam and Alam (2016) studied the Indian economy between 1989 and 2013 and found that the main drivers of inflation were money supply, devaluation, and the adverse output gap.

Ramachandra (1983; 1986) was the first to present data from 1951-1971 and 1951-1980. He is aware that both prices and real income are created by money and that both prices and real income are created by prices. Gupta (1984) argues that both nominal and real income have a unilateral influence on the supply of money, which emerges from the 1954-1955-1982-1983 analysis. Money and reality were examined using quarterly data from 1960-1961 to 1981, which contradicts Nachane and Nadkarni's (1985) conclusion that currency has a linear relationship with price and is an important driver of nominal income. The link between the two volumes of output is ambiguous.

The intercausal relationship between money and price is also illustrated by Singh (1989) using monthly data from 1970 to 1971 to 1986 to 1987, 1962 to 1980, and 1957 to 1986. According to Jadhav (1994), money leads to an increase in both prices and output in 1955, 1956, 1987, and 1988. Consequently, the results of earlier studies are contradictory. In India, numerous studies have been published on the consequences of government deficits, money supply and inflation. Sarma (1982), following Aghevli and Khan (1978), found a process in which deficits usually generate inflation and inflation causes India's imbalances. Jadhav (1994) found a self-perpetuating trend in government deficits and inflation in the macroeconomic framework from 1970-1971 to 1986-1987. Until the 1990s, government debt was the main cause of inflation in India, according to the theory of Rangarajan and Mohanty (1998). In contrast, neither the government nor M3 has been shown to have a long-run relationship with the fiscal deficit or the net financing of the Reserve Bank of India (RBI) to the government. Thus, they challenge the notion that stabilisation can be achieved by reducing the fiscal deficit.

According to Bhattacharya et al. (2008), from 1997 to 2007, the effects of fluctuations in the nominal exchange rate on India's wholesale price index (WPI) and consumer price index were (CPI) were studied. They found that their relationship was cointegrative and that the Exchange Rate Pass Through (ERPT) was important but incomplete. Khundrakpam and Goyal (2008), on the other hand, use more recent data to perform a cointegration analysis using the Autoregressive Distributed Lag (ARDL) approach. In this situation, it is crucial for the government to run a deficit in order to promote the accumulation of additional resources and the increase in money supply, both of which cause inflation. The long-run equilibrium between the volatility of the Indian exchange rate and inflation was demonstrated by Raj et al. (2008) using the VECM. Khundrakpam and Pattnaik (2010) examined the empirical relationship between fiscal deficits and inflation between 1953 and 2005, before Fiscal Responsibility and Budget Management (FRBM), and between 1953 and 2009, after FRBM. Their results suggest a cointegration relationship between the price level and deficit spending, on the one hand, and budget deficits and the price level, on the other. According to Mohanty (2010), rising inflation in India in 2008 and 2009 raised concerns among policymakers because of its cost. In his view, addressing structural supply constraints, particularly in agriculture, is critical to the success of monetary policy in containing inflation.

AK Tiwari and Tiwari (2011) examined the correlation between inflation and India's fiscal deficit, considering all potential explanatory factors. They found that inflation is not responsible for the fiscal deficit. Meanwhile, public spending and money supply emerged as key indicators of rising debt burden. However, Tiwari and Co (2012), examining the same data set using the VECM approach, Granger causality, and the Wald test, discovered that fluctuations in the money supply, budget deficit, or government spending are not really caused by inflation. Nor was a deficit in the budget associated with it by Granger.

To identify long- and short-term relationships among inflation, money supply, personal and social spending, and exchange rates in India, Ashwani (2014) examined data from 1981 to 2011, and the time-varying SVAR model was used by Mohanty and John (2015) to identify the main factors influencing prices in India from 1996 to 2014. The output gap has a disproportionately large impact on inflation. However, its importance has declined in recent years. From 2009 to 2011, crude oil prices were the most important factor affecting inflation, but from 2011 to 2012, the fiscal deficit was the most important factor.

As a result, the literature covers a wide range of inflation variables in many economies. Among the most important influences on inflation are the monetary base, exchange rates, fiscal variables, and supply shocks. Because the material is so contradictory, empirical research on the relationship between inflation and fiscal deficits has failed to reach agreement. The RBI's Financial Working Board (RBI, 1998) examined this and found that inflation in India can be explained quite well by the expansion of the money supply over time.

Interest rates have been shown to be unhelpful in producing economic stability (Svensson, 2011), so achieving price stability should not be the only objective. Current research focuses on the path of money supply rather than interest rate strategies to assess inflation trends in India. Exchange rates and crude oil prices are based on the theory that exchange rate fluctuations not only directly affect the prices of imported products, but also indirectly affect the prices of locally produced products that compete with imported products. It is treated individually as a variable affecting inflation.

In addition, crude oil prices are an important supply-side factor that makes our model incomplete. Changes in oil prices have many effects on the macroeconomic performance of the economy. Rising oil prices directly affect travel costs, leading to higher bills and prices for oil-dependent products. The redistribution of capital and labour between the energy-intensive and non-energy-intensive segments of the economy is the result of oil price fluctuations. This article identifies interest rates, monetary policy, exchange rates, and oil prices as important components in determining inflation in India.

The empirical literature often uses regression or VAR models to assess how prices and interest rates respond to oil price shocks. The magnitude and potential asymmetries of the impact of oil prices on output have been discussed in a number of studies in this area (Cavallo and Wu, 2012; Hamilton, 1996; 2003; 2009a; 2011; Kilian, 2008a; Kilian and Barsky, 2002).

The consequences of oil price shocks can be assessed from three perspectives, namely the source of the shocks, the transmission mechanism of oil shocks, and the structure of energy flows, as detailed in Lamazoshvili (2014). Some studies distinguish between the effects of oil supply and oil demand shocks. Kilian (2014) explained in detail the need to understand the causes or origins of the oil shock. The consequences of oil prices can be felt through a number of channels. One of the channels is the inflation or supply channel. Higher oil prices lead to inflationary pressures and higher final product prices.

This paper examines how the exchange rate, aggregate money supply, and oil prices affect inflation. These elements have been examined separately in previous articles. We have also examined both short-run and long-run relationships. Our main focus is on India. The information analysed includes all recent global developments that have affected the economy in recent years.

## 2. METHODOLOGY

This research is quantitative and analytical. Most of the data analysis is done using statistical and econometric techniques of Vector Error Correction Model. The annual data for the time frame of the study ranges from 1990 to 2021.

### 2.1. Sources of Data

Secondary data sources were used to collect information on Indian crude oil prices, consumer price index, exchange rate, and money supply. Information collected from secondary data sources include Central Statistical Organisation of Indian Economy data, Indian Economic Survey reports, Petroleum Planning and Analysis Cell data, monthly monetary and financial statistics, reports, and websites.

### 2.2. Objective of the Study

- To determine whether the exchange rate has a significant impact on inflation in India.
- To determine whether money supply has a significant impact on inflation in India.
- To determine whether oil prices have a significant impact on inflation in India.

### 2.3. Definition of Variables for the Study

Independent variable: Inflation.

Dependent variable: Crude Oil Prices, Broad Money and exchange rate.

### 2.4. Econometric Model for Hypothesis

This study is quantitative and analytical. Most of the data analysis is done using statistical and econometric techniques. The first step in our analysis was to determine the lags between variables. Once the lags were determined, we performed Johansen tests for cointegration and used the vector autocorrelation model for data analysis (VECM). Besides, we also used Lagrange multiplier test to check autocorrelation and Jarque-Bera test to check normality between variables. The short- and long-term relationships of the variables are examined.

Considering a VAR with p lags, yt = v + A1yt-1 + A2yt-2 + - - - + Apyt-p + εt, where yt is a K × 1 vector of parametersand v is a K × 1 parameter vector,

K × K parameter matrices form A1 - Ap.

where εt is a vector of perturbations with K × 1. εt has a covariance matrix with a mean of 0 and becomes gradually normal.

Each VAR (p) can be rewritten as VECM. We can rewrite the expression in VECM form as

Δ yt = v + Π yt-1 + Σ Γi Δ yt-1 + εt where Π = j=p j=1 Aj - Ik and Γi = j=p j=i+1 Aj.

In both equations, v and εt are identical.

## 3. THEORETICAL BACKGROUND

### 3.1. Inflation and the Exchange Rate

The exchange rate regime is crucial to a country's economic performance. The exchange rate measures a country's monetary competitiveness at the global level. A country's exchange rate has a direct impact on its exports and imports. Currency appreciation hurts exports, while currency depreciation makes imports more expensive. Central bank inflation targets are affected by exchange rate volatility. The exchange rate regime and economic growth are closely related. Although it is difficult to establish a direct or indirect relationship between the exchange rate and overall economic growth, the exchange rate is linked to both growth and inflation. The change in the exchange rate has the greatest impact.

There is a strong link between crude oil and many currency pairs for three reasons. First, because the contract is denominated in dollars, price changes immediately affect the associated currency pairs. Second, a country that is heavily dependent on crude oil exports is more vulnerable to upward and downward trends in energy markets. Third, falling crude oil prices lead to corresponding declines in industrial commodities, increasing the risk of global deflation and forcing currency pairs to reassess their linkages.

### 3.2. Inflation and Broad Money (M3)

The amount of money available in a country is called the money supply. Domestic credit is one of the elements that cause money to circulate. The volume of domestic credit and the country's net foreign assets are used to determine the money supply. There are two forms of money supply: narrow money and quasi-money. The money supply is defined differently in different countries. The reason for this is that the total money supply is determined by the money creation of each country Sinah (2017).

Inflation is one of the problems associated with an expansion of the money supply. According to Vaish (2002), inflation is a rapid increase in the total money supply that leads to a long-term increase in the general price level. People will demand more goods when the money supply increases because they have more money to spend. This leads to demand-side inflation. For this reason, central banks must tightly control the money supply to avoid being trapped in periods of high inflation. At the same time, a country must avoid falling into deflation or experiencing zero inflation. Both circumstances are detrimental to a country's health.

The amount of money in circulation is called the money supply. It includes cash, coins, and deposits in banks. There would be more money in the economy if the government printed more money. With more money available, households would have a greater demand for products and services. We want to buy more products with more money. However, if the quantity of goods available for purchase remained the same, businesses would see a significant increase in demand for this limited supply and therefore increase prices to meet the higher demand. Therefore, inflation occurs when the money supply increases faster than real output growth. This is caused by more money being spent to buy the same number of things. As a result, businesses raise their prices in response to the increase in financial demand.

Expansionary monetary policy may encourage excessive investment in crude oil locally, which in turn could increase speculation in the futures market, upsetting the balance between spot and futures prices. This could threaten the stability of the financial system and the economy. The amount of oil produced and consumed could also change, affecting environmental sustainability. suggests an unusual policy recommendation. Instead of trying to minimise the negative impact of financial markets on the actual economy, it recommends finding ways to use financial market systems to achieve better outcomes.

### 3.3. Inflation and Oil Prices

Fluctuations in crude oil prices are a worldwide phenomenon that affects every country in the world. The impact of oil prices is particularly significant in defining developing countries because they lack financial stability and are vulnerable to external shocks. Inflation and price fluctuations are significantly affected by changes in the price of oil. Fluctuations in inflation or price levels can lead to additional economic changes that affect the overall health of the economy. Therefore, the inflation rate is considered the most important economic indicator for assessing the health of the economy. Therefore, price stability and low inflation are the most important goals of policymakers.

The value of the currency decreases as a result of inflation, which also increases the cost of consumer goods and services. Consequently, the higher cost of living for consumers could adversely affect consumer discretionary spending and economic growth.

Higher oil prices are statistically associated with inflation. When oil prices rise, the prices of things that depend on oil also rise. For example, the cost of products made from petroleum-based materials, such as plastics, or goods such as fruits and vegetables, which are typically transported to markets by trains and trucks with gasoline or diesel engines, may rise. At both the microeconomic and macroeconomic levels, changes in the price of oil can affect the economy.

As noted earlier, rising oil prices can make it significantly more expensive for businesses to produce, transport, and provide services. Rising oil prices can also indirectly increase the cost of transportation, heating, and production for businesses, thereby increasing the cost of production. Producers may then decide to pass these costs on to customers. At the microeconomic level, however, increased costs at the pump and in stores may reduce discretionary spending that might otherwise be used to buy new appliances, clothes, or a holiday, something many consumers are well aware of. Long-term price increases in consumer goods and services can reduce demand and lead to sluggish or even negative economic growth.

## 4. FINDINGS AND RESULTS

### 4.1. Inflation and Exchange Rates

*4.1.1. Test for cointegration*

Even if and are nonstationary processes, in a bivariate model with variables yt and xt, there is one such that yt-xt is I (0). Even if the two variables are separately stochastic, they are cointegrated or have a fixed long-run association. The concept of VAR can be used to begin the study of such processes.

The tests of FPE, AIC, HQIC, SBIC, and LR all chose four lags as shown in Table 1. This suggests that four lags will explain

**Table 1: Lag determination of VECM of inflation and currency exchange rate**

| Selection order criteria | | | | | Number of observations: 30 | | | |
|---|---|---|---|---|---|---|---|---|
| Lag | LL | LR | df | p | FPE | AIC | HQIC | SBIC |
| 0 | –103.911 | | | | 884.126 | 12.4601 | 12.4698 | 12.5581 |
| 1 | –72.2625 | 63.296 | 4 | 0.000 | 34.4348 | 9.20735 | 9.23659 | 9.50143 |
| 2 | –66.261 | 12.003 | 4 | 0.017 | 27.9923 | 8.97188 | 9.0206 | 9.46201 |
| 3 | –63.1429 | 6.2362 | 4 | 0.182 | 33.2402 | 9.07564 | 9.14384 | 9.76181 |
| 4 | –52.6768 | 20.932* | 4 | 0.000 | 17.7934* | 8.31492* | 8.40262* | 9.19715* |

Endogenous: Inflation rate currency exchange rate. Exogeneous: _cons

**Table 2: Johansen tests for cointegration**

| Johansen tests for cointegration | | | | | |
|---|---|---|---|---|---|
| Trend: Constant | | | Number of Obs.=30 Lags=4 | | |
| Maximum rank | Parms | LL | Eigen value | Trace statistic | 5% critical value |
| 0 | 14 | –61.969845 | | 18.5860 | 15.41 |
| 1 | 17 | –55.468166 | 0.53462 | 5.5827 | 3.76 |
| 2 | 18 | –52.676825 | 0.27922 | | |
| Johansen tests for Cointegration | | | | | |
| Trend: Constant | | | Number of Obs.=30 Lags=4 | | |
| Maximum rank | Parms | LL | Eigen value | Max statistic | 5% critical value |
| 0 | 14 | –61.969845 | | 13.0034 | 14.07 |
| 1 | 17 | –55.468166 | 0.53462 | 5.5827 | 3.76 |
| 2 | 18 | –52.676825 | 0.27922 | | |

**Table 3: Vector error correction model**

| Vector error correction model | | | Number of obs.=30 | | |
|---|---|---|---|---|---|
| Log likelihood = –55.46817 | | | AIC=8.525667 | | |
| Det (sigma_ml) = 2.339442 | | | HQIC=8.60849 | | |
| | | | SBIC=9.35888 | | |
| Equation | Parms | RMSE | R-square | Chi-square | P>Chi-square |
| D_Inflation rate | 8 | 1.17164 | 0.8057 | 37.31257 | 0.0000 |
| D_Currency Exchange | 8 | 2.99857 | 0.5634 | 11.61556 | 0.1692 |

**Table 4: Vector error correction model**

| | Coef. | Std. Err. | z | P>IzI | 95% Conf. Interval | |
|---|---|---|---|---|---|---|
| D_Inflation rate | | | | | | |
| _ce1 | | | | | | |
| l1 | –0.3810325 | 0.2033723 | –1.87 | 0.061 | –0.7796349 | 0.0175698 |
| Inflation rate | | | | | | |
| Ld | –0.3290106 | 0.2141839 | –1.54 | 0.125 | –0.7488034 | 0.0907822 |
| L2d | 0.087453 | 0.2320983 | 0.38 | 0.706 | –3.674513 | 0.5423573 |
| l3d | 0.3942337 | 0.2386909 | 1.65 | 0.099 | –0.0735919 | 0.8620594 |
| Currency exchange | | | | | | |
| Ld | 0.1172129 | 0.1487989 | 0.79 | 0.431 | –0.1744275 | 0.4088533 |
| l2d | –0.1650228 | 0.1436931 | –1.15 | 0.251 | –0.4466561 | 0.1166105 |
| l3d | –0.4764607 | 0.1263627 | –3.77 | 0.000 | –0.724127 | –0.2287945 |
| _cons | 1.638336 | 0.427005 | 3.84 | 0.000 | 0.8014215 | 2.47525 |

**Table 5: Cointegrating equations**

| Equations | Parms | Chi-square | P>Chi-square |
|---|---|---|---|
| _ce1 | 1 | 0.4037417 | 0.5252 |

our bivariate model of inflation and currency exchange. After determining the number of lags, our next step is to look for cointegration between the variables.

The largest eigenvalue statistic method, the Johansen static approach, and finally the choice of r as the lowest information criterion are the three methods that the cointegration test uses to determine the rank of the model (Table 2). The header row contains a list of the summed values, the directional prediction, and the total number of lags used. The main table contains a row for each possible r-value, i.e., the frequency of the cointegrating equations.

The null hypothesis that there are no cointegrating relationships is rejected because the trace statistic at r=0 is larger than the critical value of 15.41 in Table 2 above, where the value is 18.5860. Since the essential value of 3.76 at 5% is exceeded by the trace statistic at r=1 of 5.5827, the null hypothesis that there is only one

**Table 6: Johansen normalisation restriction imposed**

| Beta | Coef. | Std. Err. | z | P>IzI | 95% Conf. Interval | |
|---|---|---|---|---|---|---|
| _ce1 | | | | | | |
| Inflation rate | 1 | | | | | |
| Currency exchange | 0.0414023 | 0.0651588 | 0.64 | 0.525 | –0.0863065 | 0.1691111 |
| _cons | −6.724441 | | | | | |

**Table 7: Lagrange multiplier test**

| Lags | Chi-square | Df | P>Chi-square |
|---|---|---|---|
| 1 | 2.7177 | 4 | 0.60612 |
| 2 | 1.3619 | 4 | 0.85080 |

H0: No autocorrelation at lag order

**Table 8: Jarque bera test**

| Equations | Chi-square | df | P>Chi-square |
|---|---|---|---|
| D_Inflation rate | 0.648 | 2 | 0.72333 |
| D_Currency exchange. | 0.847 | 2 | 0.65469 |
| All | 1.495 | 4 | 0.82753 |

cointegrating relationship between inflation and foreign exchange is rejected.

Another alternative is to use the maximum eigenvalue test statistic. This is shown in the second section of the table. At the 5% level, the above result also shows that the number of ranks of the model is 0. At rank 0, the max statistic is smaller than the critical value at 5%, so we accept the null hypothesis that there is no cointegration. The next step is to calculate the VECM estimates.

Table 3 contains all the information about the variables. Along with the information, the R-squared value is also given along with the P-values. According to the R-squared value of the two variables, inflation justifies causality more than foreign exchange and the P-value of inflation is significant.

Table 4 shows the regression equations using the inflation rate as the dependent variable and the lagged value of the exchange rate as the independent variable. The results can be interpreted as follows:

1. Ce1 represents the cointegrating equation. To establish long-run causality between inflation and the exchange rate, Ce1 must have a negative coefficient and a significant P-value. As you can see in the table above, the equation does have a negative coefficient, but the P-value is not significant enough. Since one of the two conditions is not met, the VECM does not show long-term causality between the two.
2. To examine short-term causality, we look at the lagged coefficient and P-value for each independent variable. This part explains the lagged values of currency exchange for inflation. As the results show, only the third lag is significant, as its P-value is 0.000. This means that only the third lag of the currency exchange has a short-run causality with inflation (Table 5).

Inflation is considered as a dependent variable. When the long-run situation is considered, the signs of the coefficients reverse. This means that the exchange rate has a negative impact on inflation in the long run. The coefficients are not statistically significant because the P-value is high, as shown in Table 6.

The null hypothesis states that there is no autocorrelation on the lag order. The P-values are not significant for either lag. This means that the VECM model is free of the autocorrelation problem (Table 7).

The null hypothesis states that the residuals of the variables are normally distributed. The P-values of all variables are not significant, which means that the null hypothesis is accepted (Table 8). Therefore, the residuals of the variables are normally distributed. Therefore, there is no problem with normality in the VECM.

## 4.2. Inflation and Broad Money Supply (M3)

### *4.2.1. Test for cointegration*

Even if and are non-stationary processes, in a bivariate model with variables yt and xt, one exists such that yt-xt equals I. (0). Even if the two variables are independently stochastic, they are cointegrated or have a fixed long-run relationship. The concept VAR can be used to start studying such processes.

As can be seen from the results in Table 9, the tests of FPE, AIC, HQIC, SBIC, and LR all chose four lags. This means that our bivariate model of inflation and broad money is explained by four lags. The next step is to look for cointegration among the variables after calculating the number of lags (Table 10).

The three techniques used in the cointegration test to determine the rank of the model are the highest eigenvalue analytical technique, the Johansen static technique, and finally the selection of r as the lowest information criterion. The total number of lags used, the predicted direction, and a list of cumulative values are included in the header. Each potential r value or frequency of cointegrating equations is given its own row in the main table.

The null hypothesis of no cointegrating equations is rejected because the trace values at r=0 are greater than the critical value of 15.41 in Table 10. This number is 29.4679, and since these trace statistics at r=1 of 1.8767 do not exceed the critical value of 3.76 at 5% the null hypothesis that there is only one cointegrating relationship between inflation and broad money is accepted.

Another option is to use the statistics from the maximum eigenvalue test. The second section of the table shows this. The above result also shows that the number of ranks of the model at the 5% level is 1. Since the maximum statistics at rank 1 are below the crucial threshold of 5%, we accept the null hypothesis that there is only one cointegration. Thus, we have obtained the same result in both cases.

Table 11 shows all the information about the variables. Along with the information, the R-squared value is also given along with the

**Table 9: Lag determination of VECM of inflation and currency exchange rate**

| Selection order criteria | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Number of observations: 30 | | | | | | | | |
| Lag | LL | LR | df | P | FPE | AIC | HQIC | SBIC |
| 0 | –102.509 | | | | 10452.5 | 14.9299 | 14.9214 | 15.0212 |
| 1 | –44.6517 | 115.71 | 4 | 0.000 | 4.82446 | 7.23596 | 7.21061 | 7.50984 |
| 2 | –43.1494 | 3.0046 | 4 | 0.557 | 7.2636 | 7.59277 | 7.55052 | 8.04924 |
| 3 | –38.7269 | 8.845 | 4 | 0.065 | 7.79815 | 7.53242 | 7.47326 | 8.17147 |
| 4 | –25.6501 | 26.154* | 4 | 0.000 | 2.83108* | 6.23573* | 6.15967* | 7.05737* |

Endogenous: Inflation rate BroadMoneyM3. Exogeneous: _cons

**Table 10: Johansen tests for cointegration**

| Johansen tests for Cointegration | | | | | |
|---|---|---|---|---|---|
| Trend: Constant | | | | Number of Obs. = 30 | |
| Lags=4 | | | | | |
| Maximum Rank | Parms | LL | Eigen value | Trace statistic | 5% critical value |
| 0 | 14 | –40.384037 | | 29.4679 | 15.41 |
| 1 | 17 | –26.588487 | 0.86065 | 1.8767 | 3.76 |
| 2 | 18 | –25.650106 | 0.12545 | | |
| Johansen tests for cointegration | | | | | |
| Trend: Constant | | | | Number of Obs. = 30 | |
| Lags=4 | | | | | |
| Maximum rank | Parms | LL | Eigen value | Max statistic | 5% critical value |
| 0 | 14 | –40.384037 | | 27.5912 | 14.07 |
| 1 | 17 | –26.588487 | 0.86065 | 1.8767 | 3.76 |
| 2 | 18 | –25.650106 | 0.12545 | | |

**Table 11: Vector error correction model**

| Vector error correction model | | | | | |
|---|---|---|---|---|---|
| Number of obs. = 30 | | | | AIC=6.226922 | |
| Log likelihood = –26.58846 | | | | HQIC=6.15509 | |
| Det (sigma_ml) = 0.1529869 | | | | SBIC=7.002921 | |
| Equation | Parms | RMSE | R-square | Chi-square | P>Chi-square |
| D_Inflation rate | 8 | 1.83086 | 0.6216 | 9.85812 | 0.2751 |
| D_BroadMoneyM3 | 8 | 0.575984 | 0.9979 | 2856.415 | 0.0000 |

**Table 12: Vector error correction model**

| | Coef. | Std. Err. | z | P>IzI | 95% Conf. interval | |
|---|---|---|---|---|---|---|
| D_Inflation rate. | | | | | | |
| _ce1 | | | | | | |
| l1 | –0.8518713 | 1.000315 | –0.85 | 0.394 | –2.812453 | 1.10871 |
| Inflation rate | | | | | | |
| Ld | –0.1494774 | 0.355848 | –0.42 | 0.674 | –0.8469267 | 0.547972 |
| L2d | –0.0704203 | 0.38742 | –0.18 | 0.856 | –0.8297496 | 0.688909 |
| l3d | –0.380983 | 0.5582025 | –0.68 | 0.495 | –1.47504 | 0.7130738 |
| Broad Money m3 | | | | | | |
| ld | –0.3934855 | 0.5805711 | –0.68 | 0.498 | –1.531384 | 0.7444129 |
| l2d | 3.449486 | 2.435126 | 1.42 | 0.157 | –1.323273 | 8.222245 |
| l3d | –0.6226087 | 1.780516 | –0.35 | 0.727 | –4.112356 | 2.867139 |
| _cons | 2.686049 | 1.74133 | 1.54 | 0.123 | –0.7268945 | 6.098992 |

**Table 13: Cointegrating equations**

| Equations | Parms | Chi-square | P>Chi-square |
|---|---|---|---|
| _ce1 | 1 | 160.4172 | 0.0000 |

P-values. According to the R-squared value of the two variables, the justification of broad money is greater than that of inflation and the P-value of inflation is insignificant as it is >0.05.

The regression equations with the inflation rate as the dependent variable and the lagged value of broad money as the independent variable are shown in Table 12. The conclusions are as follows:

1. The cointegrating equation is represented by Ce1. Ce1 must have a negative coefficient and a large P-value to demonstrate long-run causality between inflation and

**Table 14: Johansen normalisation restriction imposed**

| Beta | Coef. | Std. Err. | z | P>IzI | 95% Conf. Interval | |
|---|---|---|---|---|---|---|
| _ce1 | | | | | | |
| Inflation rate | 1 | | | | | |
| Broad Money M3 | 0.3037657 | 0.0239835 | 12.67 | 0.000 | –0.2567588 | 0.3507725 |
| _cons | –3.058803 | | | | | |

**Table 15: Lagrange multiplier test**

| Lags | Chi-square | Df | P>Chi-square |
|---|---|---|---|
| 1 | 5.4120 | 4 | 0.24758 |
| 2 | 4.5368 | 4 | 0.33820 |

**Table 16: Jarque bera test**

| Equations | Chi-square | df | P>Chi-square |
|---|---|---|---|
| D_Inflation rate | 0.408 | 2 | 0.81532 |
| D_Broad Money M3. | 1.190 | 2 | 0.55156 |
| All | 1.598 | 4 | 0.80909 |

money supply. Although the equation has a negative coefficient, the P-value is not significant enough, as shown in the table above. The VECM does not show long-run causality between the two conditions because one of the two conditions is missing.

2. The lagged coefficient and P-value for each independent variable are used to examine short-term causality. The lagged values of currency exchange for inflation are explained in this section. The results show that none of the lagged values of broad money are remarkable. This suggests that none of the lagged values are related to inflation in the short run (Table 13).

The dependent variable here is inflation. The signs of the coefficients reverse when the long-run is examined. This suggests that broad money has a negative impact on inflation over time. Since the P=0.000, the coefficients are statistically significant, as shown in Table 14.

H0: No autocorrelation at lag order.

The null hypothesis states that there is no autocorrelation in the lag (Table 15). For both lags, the P-values are negligible. This eliminates the problem of autocorrelation in the VECM model.

The null hypothesis states that the residuals of the variables have a normal distribution (Table 16). The null hypothesis is accepted because the P-values of all variables are insignificant. Consequently, the residuals of the variables are regularly distributed. Consequently, there is no normality problem with the VECM.

## 4.3. Inflation and Oil Prices

### *4.3.1. Testing for cointegration*

Even if and are non-stationary processes, in a bivariate model with variables yt and xt, there is one such that yt-xt is I (0). Even if the two variables are separately stochastic, they are cointegrated or have a fixed long-run association. The concept of VAR can be used to begin the study of such processes.

The tests of FPE, AIC, HQIC, SBIC, and LR all chose two lags, as shown in the results in Table 17. This suggests that two lags will explain our bivariate model of inflation and oil prices. Having determined the number of lags, our next step is to look for cointegration between the variables.

The three techniques used in the cointegration test to determine the rank of the model are the analytical technique with the highest eigenvalue, the Johansen static technique, and finally the selection of r as the lowest information criterion. The total number of lags used, the predicted direction, and a list of cumulative values are included in the header. Each potential r value or frequency of cointegrating equations is given its own row in the main table (Table 18).

Since the trace values at r=0 are higher than the significant value of 15.41, the null hypothesis that there are no cointegrating equations is rejected. Since the trace values at r=1 of 6.5441 exceed the threshold of 3.76 at 5%, the null hypothesis that there is only a cointegrating link between inflation and broad money is rejected.

Use the maximum eigenvalue test statistics as another alternative. This is shown in the second part of the table. The above result also shows that the number of ranks of the model at the 5% level is zero. We accept the null hypothesis that there is no cointegration since the maximum statistic at rank 0 is below the critical threshold of 5%.

The information on the variables is given in Table 19. The R-squared value and P-values are also provided along with the information. The R-squared value of the two variables shows that inflation is more likely to justify causality than oil prices, and the P-value of oil prices is significant.

The regression equations are shown in Table 20, using the inflation rate as the dependent variable and the lagged value of the exchange rate as the independent variable. An interpretation of the results follows:

1. The cointegrating equation is represented by Ce1. Ce1 must have a negative coefficient and a significant P-value to establish long-run causality between inflation and oil prices. Although the equation has a negative coefficient, the P-value is not significant enough, as shown in the table above. The VECM does not show long-run causality between the two conditions because one of the two conditions is missing.
2. The lagged coefficient and P-value for each independent variable are used to examine short-run causality. The lagged values of oil prices for inflation are explained in this section.

**Table 17: Lag determination of VECM of inflation and oil prices**

| Selection order criteria<br>Number of observations: 30 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Lag** | **LL** | **LR** | **df** | **p** | **FPE** | **AIC** | **HQIC** | **SBIC** |
| 0 | –113.55 | | | | 2747.87 | 13.5941 | 13.6038 | 13.6921 |
| 1 | –100.48 | 26.14 | 4 | 0.000 | 952.154 | 12.527 | 12.5562 | 12.8211 |
| 2 | –90.5055 | 19.948* | 4 | 0.001 | 485.035* | 11.8242* | 11.8729* | 12.3143* |
| 3 | –89.6437 | 1.7236 | 4 | 0.786 | 751.071 | 12.1934 | 12.2616 | 12.8796 |
| 4 | –87.2051 | 4.8772 | 4 | 0.300 | 1033.78 | 12.3771 | 12.4648 | 13.2593 |

Endogenous: Inflation rate oil prices. Exogeneous: _cons

**Table 18: Johansen tests for cointegration**

| Johansen tests for cointegration | | | | | |
|---|---|---|---|---|---|
| **Trend: Constant** | | | | **Number of Obs. = 30** | |
| **Lags=2** | | | | | |
| **Maximum Rank** | **Parms** | **LL** | **Eigen value** | **Trace statistic** | **5% critical value** |
| 0 | 6 | –112.53958 | | 18.1082 | 15.41 |
| 1 | 9 | –106.75757 | 0.45591 | 6.5441 | 3.76 |
| 2 | 10 | –103.4855 | 0.29137 | | |
| **Johansen tests for cointegration** | | | | | |
| **Trend: Constant** | | | | **Number of Obs. = 30** | |
| **Lags=2** | | | | | |
| **Maximum rank** | **Parms** | **LL** | **Eigen value** | **Max statistic** | **5% critical value** |
| 0 | 6 | –112.53958 | | 11.5640 | 14.07 |
| 1 | 9 | –106.75757 | 0.45591 | 6.5441 | 3.76 |
| 2 | 10 | –103.4855 | 0.29137 | | |

**Table 19: Vector error correction model**

| Vector error correction model | | | | | |
|---|---|---|---|---|---|
| Number of obs. = 30 | | | | | |
| Log likelihood = –106.7576 | | | | AIC=12.18501 | |
| Det (sigma_ml) = 260.3129 | | | | HQIC=12.26072 | |
| | | | | SBIC=12.63237 | |
| **Equation** | **Parms** | **RMSE** | **R-Square** | **Chi-square** | **P>Chi-square** |
| D_Inflation rate | 4 | 1.67091 | 0.3438 | 7.857559 | 0.0969 |
| D_Oil prices | 4 | 12.5783 | 0.5182 | 16.13581 | 0.0028 |

**Table 20: Vector error correction model**

| | **Coef.** | **Std. Err.** | **z** | **P>IzI** | **95% Conf. Interval** | |
|---|---|---|---|---|---|---|
| D_Inflation rate | | | | | | |
| _ce1 | | | | | | |
| l1 | –0.0079923 | 0.1619714 | –0.05 | 0.961 | –0.3254505 | 0.3094658 |
| Inflation rate | | | | | | |
| Ld | –0.0108398 | 0.2532541 | –0.04 | 0.966 | –0.5072087 | 0.4855291 |
| Oil prices | | | | | | |
| Ld | 0.0719824 | 0.0267107 | 2.69 | 0.007 | 0.0196304 | 0.1243344 |
| _cons | –0.011618 | 0.3932856 | –0.03 | 0.976 | 0.7824435 | 0.7592076 |

**Table 21: Cointegrating equations**

| **Equations** | **Parms** | **Chi-square** | **P>Chi-square** |
|---|---|---|---|
| _ce1 | 1 | 33.00507 | 0.0000 |

According to the results, none of the lags is significant as the P-value is greater than 0.05 (Table 21).

Inflation is the dependent variable here. In the long-run analysis, the signs of the coefficients reverse (Table 22). This indicates that oil prices have a favourable effect on inflation in the long run. The coefficients are statistically significant, as the P-value is 0.000.

The null hypothesis states that there is no autocorrelation at the lag stage. The P-values are insignificant at both lags. Thus, the autocorrelation problem of the VECM model is solved, as shown in Table 23.

The null hypothesis states that the residuals of the variables follow a normal distribution (Table 24). Since the P-values of all variables are negligible, the null hypothesis is accepted.

**Table 22: Johansen normalisation restriction imposed**

| Beta | Coef. | Std. Err. | z | P>IzI | 95% Conf. Interval | |
|---|---|---|---|---|---|---|
| _ce1 | | | | | | |
| Inflation rate | 1 | | | | | |
| Oil prices | –0.1494348 | 0.0260113 | –5.75 | 0.000 | –0.200416 | –0.0984537 |
| _cons | 3.685568 | | | | | |

**Table 23: Lagrange multiplier test**

| Lags | Chi-square | Df | P>Chi-square |
|---|---|---|---|
| 1 | 3.9225 | 4 | 0.41660 |
| 2 | 8.1137 | 4 | 0.08750 |

**Table 24: Jarque bera test**

| Equations | Chi-square | df | P>Chi-square |
|---|---|---|---|
| D_ Inflation rate | 3.350 | 2 | 0.18728 |
| D_ Oil Prices | 0.402 | 2 | 0.81796 |
| All | 3.752 | 4 | 0.44058 |

Consequently, the residuals of the variables are uniformly distributed. Consequently, the VECM is free from the normality problem.

## 5. CONCLUSION

In our study, we have examined the impact of exchange rates, broader money supply (M3) and oil prices on inflation in India. The influence of the above variables was examined using the VECM model. We considered both short-run and long-run effects. The results showed that inflation and exchange rates have a short run relationship. In the long run, inflation and exchange rates have a negative relationship. To prove causality between the variables, the two criteria must be satisfied. The equation has a negative coefficient, but the P-value is not significant enough. Since one of the two conditions is not met, the VECM does not show long-term causality between the two variables. According to the results, only the third lag is significant because its P-value is 0.000. This means that only the third lag of the exchange rate shows short-run causality with inflation. Our results are consistent with those found in the literature we reviewed, such as those of Honohan and Lane (2003; 2004), Bhattacharya et al.

In the long run, the other relationship between inflation and broad money is also negative. Although the equation has a negative coefficient, the P-value is not significant enough. The VECM does not show long-run causality between the two conditions because one of them is missing. The results show that none of the lagged values of broad money are noteworthy. This suggests that none of the lagged values are related to short-run inflation. Comparing our study with previous studies, such as those by Ghosh and Kanjilal, Sek, Teo, and Wong (2015), we find that it leads to the same results in terms of correlation between variables.

Looking at inflation and oil prices, we find that they are positively related, which means that as oil prices increase, inflation also increases. Although the equation has a negative coefficient, the P-value is not significant enough, as shown in the table above. The VECM does not show long-run causality between the two conditions because one of them is missing. The lagged values of oil prices for inflation are explained in this section. According to the results, none of the lags is significant as the P-value is greater than 0.05. When we examine previous research, we find that our study is comparable to them in terms of the relationship between the variables, such as Alam and Alam (2016), Ramachandra (1983; 1986), Nachane and Nadkarni (1985).

Governments, central banks, and other government agencies must work together to design and formulate various policies that will help the country achieve significant growth. Consequently, policymakers should consider how oil prices, the real exchange rate, and exporters' production costs would affect domestic inflation. These are important variables that can affect the stability of prices and the financial market. Many experts have hypothesised that monetary policy could be a useful tool to limit the excess impact of these shocks on domestic inflation.

There are other aspects that could be studied and researched that affect inflation. GDP, stock market, and foreign direct investment are among the variables that can be studied. Moreover, only India is the subject of our study, so the other countries can also be considered.

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