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Money Supply, Oil Prices And Inflation In India : Cointegration And Causality Analysis

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Abstract
With the recent episodes of inflation breaching RBI's benchmark rate, the question of whether money supply effects inflation is pertinent. Furthermore, rising commodity prices in particular, oil prices could have been one of the reason influencing inflation. The purpose of this research is to examine the relationship between the money supply, oil prices, and inflation rate in India. The study uses secondary time series data for the period January 2013 to July 2023. ARDL bounds test approach is used to find out the long-term relationship between these variables. Further Granger Causality tests whether the relationship between variables is uni-directional or bi-directional. The study finds that there is indeed a long run relationship between money supply, general price level and oil prices. Paradoxically, the study finds no discernible causation among money supply, general price level and oil prices. The findings support classical view of one-on-one relationship between money supply and price level. Furthermore, oil prices do not reflect in general price level in India for the study period.

Keywords: *money supply, inflation, oil prices, ARDL, cointegration, causality*

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I. Introduction

Macroeconomic stability and growth momentum of a developing country depends on the stability of inflation rate in the country. IMF estimates India to be one of the top two fast-growing significant economies in 2022 (Economic Survey 2022-23). The survey further delivers that India faced the challenge of reining inflation that the European strife accentuated which tightened global commodity prices particularly oil prices.

The level of money supply has a huge impact on inflation in any country. An increase in money supply usually leads to rise in purchasing power of the households. They demand goods and services with this increase in nominal money supply however the economic activity responds only with lag/s. This leads to a rise in the general price level in the economy. From 2013 to mid-June 2023 broad money supply has grown yearly. In June 2023 it stood at about 3 times of the amount in Jan 2013.

Another factor influencing general inflation is fuel price inflation. India is a net importer of crude oil and fulfils as much as 85 per cent of its energy requirements through imports. (Mint 2023). The continuous rise in oil prices tends to reduce aggregate demand by households and firms as they have less disposable income to spend on non-energy goods. The oil prices have fluctuated throughout the period of sample starting from $186/barrel to reaching as high as $261/barrel in June 2022.

The relationship between money supply, inflation rate, and oil prices has acquired a lot of attention over the periods. This paper is an attempt to find the empirical evidence between these three variables, i.e. money supply, inflation rate, and oil prices in India. For framing the policies, the direction of causality between money supply, inflation rate, and oil prices is important.

Therefore, the present study made an attempt to estimate the impact of consumer price index and oil prices on money supply in India during Jan 2013 to July 2023 using Auto-Regressive Distributed Lag (ARDL) Bounds Testing of Cointegration propounded by (Pesaran& Shin, 1999). It is with this backdrop, the rest of the paper is structured as follows: Section 2 reviews the related literature; Section 3 discusses the data and methodology of the study; Section 4 makes the empirical analysis; and Section 5 concludes.

II. Review Of Literature

The nexus of money supply, inflation rate, and oil prices have always been a question of interest of researchers and policymakers. Quantity theorists proposed there is a strong and positive correlation between money supply and general price level. They concluded that changes in inflation is brought about by exogenous changes in money supply. Later in the 1930s, 40s and 50s, the role of money as a determining factor to explain price movements fell in the list of variables considered important in economic analysis(Phillip Cagan, 1989). In the 1960s a new era of monetary theorists started taking shape in the purview of Milton Friedman and *Schwartz's*

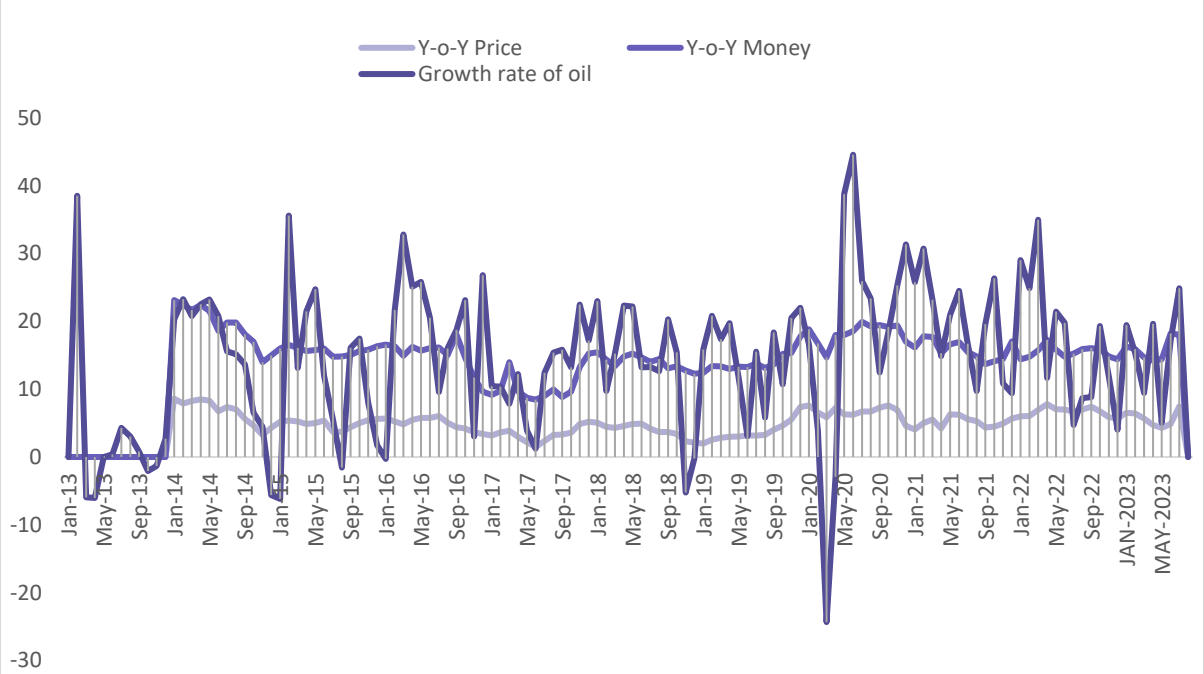
A Monetary History of the United States, 1867-1960 (1963) leading the way, an outpouring of studies put new life into the traditional view of money as paramount. (Phillip Cagan, 1989)

A minority `structuralist' view holds that in developing countries inflation evolves from pressures arising in economic growth in economies with institutional rigidities, particularly in agriculture and international transactions. Monetary and fiscal authorities choose to expand the money supply, ratifying the inflationary pressures, rather than face unemployment or disruptions in consumption and investment. Underdeveloped financial markets and a weakly independent central bank can contribute to the likelihood of money supply growth. Under this view, money supply expansion is a consequence of, and therefore caused by, structural inflation ((Pinga & Nelson, 2001)).

With the groundbreaking work of (Hamilton, 1983), there has been a growing and concentrated literature probing the link between oil price shocks and various macroeconomic indicators such as inflation (e.g., (BACHMEIER & CHA, 2011); (Barsky & Kilian, 2001); (Kilian, 2008)), monetary policy (e.g., (Bernanke et al., 1997); (Hamilton & Herrera, 2004)). However, despite the large share of existing literature assessing the impacts of oil price shocks on various economies across the globe, there is still much less research focusing on the Indian economy. Indeed, the literature analysing the consequences of oil price swings on the Indian economy is very scarce.

Figure 1 depicts the movements of the consumer price inflation, broad money supply (M3) which has been taken as year-on-year growth rate, and oil prices which has been taken as growth in Brent index the period from January 2013 to July 2023. In the early period of the study a high inflation rate at 8 % is observed. In the successive years, the rate has reduced, primarily due to RBI Monetary policy stance being one of inflation targeting. Later on we see that inflation has breached the mark of targeted inflation starting from the month of Dec 2019 which was controlled in subsequent months by calibrated monetary policy stance. World crude oil prices of which Brent index is taken a proxy of has been nothing short of unpredictable beginning from the sample period. This could be because of protectionist policies of the U.S. and European Union. In the third quarter of 2018, growth rate of crude oil prices turned negative attributed to United States' trade war with China. ((*Why Oil Prices Rose And Crashed In 2018 | OilPrice.Com*, n.d.)) and end of the sample period unpredictability could be linked to Russia-Ukraine war. Year on Year money supply growth was faster in the first half of the sample period than the second half.

Figure1: Y-o-Y growth rate of prices, and money supply and growth rate of oil (Jan 2013-July 2023)



Source: Author's Compilation

III. Data And Methodology

Definition of Variables

This paper utilises a sample time series data set consisting of 127 observations of inflation rate, oil prices and money supply in India from January 2013 to July 2023. The data for consumer price index (proxy for inflation rate) and broad money supply (M3) is extracted from Centralised information management system directory of

RBI. Consumer Price Inflation (CPI) (Base 2012 = 100) is used as a general index for inflation as this is the targeted variable of the India's Central Bank. Broad money supply is chosen as a proxy for money supply as it contains both narrow money and time deposits. Brent crude which is an index is taken up as a proxy for oil prices. Brent crude index is taken up from International Financial Statistics published by International Monetary Fund (IMF). Data for money supply is transformed into natural logarithm scale prior to analysis.

The descriptive statistics of all the raw variables used in the study are reported in Table 1.

Table 1: Descriptive Statistics

Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
M3	14580205	13981647	23423360	8115795	4261442	0.361402	1.957798
Oil	158.1842	145.957	261.0806	59.55898	51.68467	0.381846	2.115755
CPI	140.5457	137.6	186.3	104.6	20.79813	0.313299	2.112703

Note: CPI and oil (Brent crude) is in index form

Methodology

In order to delve into finding cointegration between money supply, consumer price index, and oil prices in India for the study period jan 2013 to July 2023, the paper uses ARDL approach envisaged by – (Pesaran & Shin, 1999),(Pesaran et al., 2001). An Autoregressive Distributive Lag(ARDL) model uses lags of the dependent variable and both contemporaneous and lagged values of the independent variables. The model can directly estimate the short-run impacts and indirectly infer the long run equilibrium relationship. removing problems associated with omitted variables and autocorrelation. One of the benefits of ARDL bounds tests procedure is that it can be employed regardless of whether the underlying variables are stationary i.e., I(0), integrated of order one i.e., I(1) or a mix of both.

The functional form of our model is:
lm = f(p,oil)
where,
lm = natural log of money supply
p = consumer price index
oil = brent crude index

The ARDL technique envisaged for our analysis involves estimating the following unrestricted error correction model :

$$\Delta lm_t = \alpha_{0lm}+\sum^{p}_{i=1}\beta_{1lm}\Delta lm_{t-i}+\sum^{p}_{i=1}\beta_{2p}\Delta p_{t-i}+\sum^{p}_{i=1}\beta_{3oil}\Delta oil_{t-i}+\delta_{1lm}lm_{t-1}+\delta_{2p}p_{t-1}+\delta_{3oil}oil_{t-1}+\mu_{1t} \ldots(1)$$

$$\Delta p_t = \alpha_{0p}+\sum^{p}_{i=1}\beta_{1p}\Delta p_{t-i}+\sum^{p}_{i=1}\beta_{2lm}\Delta lm_{t-i}+\sum^{p}_{i=1}\beta_{3oil}\Delta oil_{t-i}+\delta_{1p}p_{t-1}+\delta_{2lm}lm_{t-1}+\delta_{3oil}oil_{t-1}+\mu_{2t} \ldots(2)$$

$$\Delta oil_t = \alpha_{0oil}+\sum^{p}_{i=1}\beta_{1oil}\Delta oil_{t-i}+\sum^{p}_{i=1}\beta_{2lm}\Delta lm_{t-i}+\sum^{p}_{i=1}\beta_{3p}\Delta p_{t-i}+\delta_{1oil}oil_{t-1}+\delta_{2lm}lm_{t-1}+\delta_{3p}p_{t-1}+\mu_{3t} \ldots(3)$$

Where, p is the number of lags, Δ represents the first difference operator, α_{0lm}, $\alpha_{0p,}$ α_{0oil} are the drift component, and μ_{1t} , μ_{2t} , μ_{3t} represents the residuals for equations (1), (2) and (3) respectively. . Furthermore, money supply is the dependent variable, while the independent variables are consumer price index(p) and brent crude oil (oil). Moreover, the coefficients β's are used to depict the short-run relationship and coefficients δ's represent the long-run relationship among the variables.
The null hypothesis of no cointegration among the variables in Eq. (1) is

$H_0 = \delta_{1lm} = \delta_{2p} = \delta_{3oil} = 0$
against $H_1 = \delta_{1lm} \neq \delta_{2p} \neq \delta_{3oil} \neq 0$

which is denoted as F_{lm} (lm|p,oil)

Similarly we can compute null hypothesis for equation (2) and equation (3).

Two sets of critical F-values have been provided by (Pesaran et al., 2001) for large samples, (Narayan, 2005) for sample size ranging from 30 to 80 and (Turner, 2006) for response surface analysis, where one set assumes that all variables in ARDL model are I (1) and another assumes that all variables are I (0) in nature. If the calculated F-statistic falls outside of the band then we can conclude that cointegrating relationship among variables exist irrespective of the knowledge of underlying variables being *I(0)* or *I(1)*. If the computed F-statics falls within the critical band, inference remains inconclusive.

IV. Empirical Findings

Stationarity Tests

Firstly, we check for the order of integration of the variables undertaken in our analysis. Although it is not imperative to check for the order of integration for bounds tests of cointegration, (Ouattara, 2004) argued that the computed F-statistics provided by (Pesaran et al., 2001)are not valid in the presence of I(2) variables. The study uses Augmented- Dickey Fuller (ADF) test (Dickey & Fuller, 1979) to check for stationarity at levels and first difference.

Table2: Results of ADF unit root test

Variables	ADF Statistic at level with trend and intercept	p-value	ADF Statistic at 1st difference with trend and intercept	p-value
Lm	-4.354	0.003	-4.613	0.001
P	1.218	1.000	-6.277	0.000
oil	-2.318	0.420	-10.287	0.000

Source: Author's Compilation

Variables p (CPI) and oil (Brent crude index) are found to be stationary at first difference i.e they are integrated of order one. Money supply denoted by lm was found to be stationary at level i.e. it is integrated of order zero.

Serial Correlation LM Test

The probability value of Chi-square is 0.280, which is more than 0.05. This shows that there is no presence of auto correlation. Hence the model is free from auto-correlation.

Table3: Serial Correlation LM test: Breusch-Godfrey

F-statistic	1.213	Prob. F(2,117)	0.301
Obs*R-squared	2.539	Prob. Chi-Square (2)	0.280

Source: Author's compilation

Heteroskedasticity Test

The probability value of Chi-square is 0.54, which is more than 0.05. This shows that the model is free from heteroskedasticity and hence the size of the error term does not vary across the values of independent variables.

Table4: Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.880	Prob. F(5,119)	0.551
Obs*R-squared	4.065	Prob. Chi-Square (5)	0.540
Scaled explained SS	7.170	Prob. Chi-Square (5)	0.208

Source: Author's compilation

Lag selection

To begin with ARDL bound testing it is important to ascertain the optimal lag order.The optimal number of lags for cointegration test is chosen using Schwarz-Bayesian (SBC) information criteria and Akaike Information Criterion (AIC) as suggested by (Pesaran et al., 2001).

ARDL (1,2,0) emerged the most appropriate model based on AIC criteria as shown in figure 2 (see appendix). This result is further corroborated by the absence of serial correlation in the model. Hence, the analysis proceeds keeping this model into consideration.

Test for cointegration

Given the variables are a mix of I(0) and I(1), the ARDL Bounds Test approach to cointegration has been used in our analysis. Further, F-test is used to test the significance of long run cointegration between the variables.

Table 5: Results of Bounds Co-integration Test

F-statistic	19.93	
Significance Bound	I(0)	I(1)
10%	2.63	3.35
5%	3.1	3.87

Source: Author's compilation

Here, F-test statistics is 19.93, which exceeds all the upper bound critical values at 5 as well as 10 percent level of significance. This gives evidence on the existence of long-run relationship among the variables as the null hypothesis stating that there is no long-run relationship/co-integration among the variables is rejected. This signifies that a long run relationship exists among money supply, Consumer price index and crude oil prices in India.

Short run and Long run Analysis

After cointegration among the variables is established we proceed to examine the long run relationship and short run dynamic behaviour of the variable around its equilibrium level via Error correction mechanism (ECM) model. The findings of long run relationship are reported in Table6. It denotes that where prices(CPI) has a positive impact on money supply, oil prices have a negative impact on money supply in India for the period Jan 2013 – July 2023. . Further, a one unit increase in prices lead to a 1.39% increase in money supply keeping other variables constant. This shows a one-on-one relation between money supply and prices (CPI). Further, a unit increase in oil prices lead to reduction in money supply by .04%. Both the independent variables have significant impact on money supply.

Table6: Long- run Estimates

Variable	Coefficient	Std. error	t-statistic	prob.
P	0.0139	0.001	90.530	0.000
Oil	-0.0004	0.000	-7.411	0.000
C	14.564	0.024	594.20	0.000

The result of short run dynamics are reported in table 7 which reflects the parsimonious ARDL(1, 2 ,0) model thus chosen. In short run prices effects money supply negatively both contemporaneously and with one lag. Further, the coefficients of prices contemporaneous and lag are insignificant.

Table7: Error Correction Representation for the Selected ARDL (1, 2, 0) Model

Variable	Dependent Variable Δlm			
	Coefficient	Std.error	T-statisctic	P-value
Δp	-0.000361	0.0009	-0.393	0.695
Δp_{t-1}	-0.00156	0.0010	-1.491	0.138
ect_{t-1}	-0.0316	0.0035	-9.040	0.000

Error correction term tells us that around 3.16% of departures from long run equilibrium is corrected at each period. The coefficient of error correction term(ect) shows a negative sign and is significant at 1 percent level of significance. Negative sign of ect and statistically significant value denotes that the model is self-correcting in long run and the speed of adjustment is 3.16% each month.

Granger Causality Results

To examine whether there is unidirectional and/or bidirectional causality among the variables Granger Causality Test is applied. Granger developed by (Granger, 1969) is implemented. The basic intuition behind this test is that the past changes in values of one of the bivariate variables helps in predicting the current changes of the other variable. The results of Granger causality test are presented in table 8.

Table8: Pairwise Granger Causality Test

Null Hypothesis	**Obs**	**F-statistic**	**Prob.**
Δp does not Granger cause lm	124	1.545	0.217
lm does not Granger cause Δp	124	1.664	0.193
Δoil does not Granger cause lm	124	0.056	0.945
lm does not Granger cause Δoil	124	2.448	0.090
Δoil does not Granger cause Δp	124	0.523	0.594
Δp does not Granger cause Δoil	124	0.579	0.561

From the above causality result it can be inferred that there is a lack of a causal relationship between general prices(CPI), oil price(brent crude index) and the money supply. It could be due to several factors. First of all, oil prices do not form a major share of consumer price inflation in rural as well as urban areas in India and therefore, the transmission could be absent. Furthermore, India being oil importer definitely can't effect the global oil prices as they are strictly exogenous.

Monetary authorities respond to inflation rate with only with a lag, and because India still largely being an informal economy, the transmission mechanism remains incomplete. Furthermore, there are no feedback effects from CPI to money supply and vice versa thus refuting the classical quantity theory of money.

The lack of a discernible causal relationship between oil prices and the money supply may be evidence of the successful prudent and stable fiscal and monetary policy on the part of Indian government and RBI respectively.

V. Conclusion

The analysis is an attempt towards studying the effects of general price level and oil prices on money supply in India for the period Jan 2013 to July 2023. Evidence from ARDL bounds test ascertains that there is a one-on-one relation between money supply and prices in the long run, however these dynamics are absent in the short run. The oil prices do not impact Indian money supply in long as well as short run as is evident from insignificant coefficients. Furthermore, Granger Causality test observes no transmission among money supply, prices and oil prices. It could be because India is largely an oil importing nation and thus cannot impact world oil prices. Moreover, the causality between money supply and prices seems to be absent. It could be because of exogenous changes in prices brought about by geo-political factors. Monetary authorities and policy makers are required to devise prudential norms so as to manipulate the money supply to have price stability in the long-run which in turn would contribute to accelerated development of the country. Moreover, the rise in oil prices seems to make little to no dent on consumer price index in India. Accordingly, the monetary authority could make appropriate policies along with fiscal policies so the price stability remains in the long run.