Commodity and Oil Price Fluctuations, Macroeconomic Performance and Challenges for an Emerging Economy: The Indian Experience

by

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Abstract

Commodity and oil price fluctuations have significant bearing on domestic macroeconomic performance and challenges macroeconomic policy making of an emerging economy. The paper explores the impact of non-energy commodity and oil price fluctuations on domestic macroeconomic variables such as, output, inflation and real exchange rate in India; being a natural candidate for whom commodity and oil constitutes sizeable imports. The empirical analysis carried out through Vector-Error Correction Model (VECM) for the post-liberalisation period 1991-2014 clearly points out that commodity and oil price shocks have a significant impact on the variation of output and prices accounting for real exchange rate adjustment as well as the role of a developed financial market (private credit). The real exchange rate adjusts to commodity and oil price shocks accounting for foreign exchange reserves and financial markets (private credit). The impulse response functions indicate that one standard deviation shock in commodity and oil prices persists for over three to eight quarters over domestic prices and output. While these results points out for lessening the commodity and oil imports through a series of medium- and long-term structural-cum-policy reform measures, in the immediate it also lends for a role of intervention by monetary authority (central bank) in pursuit of inflation targeting. Conjointly, pursuance of countercyclical fiscal policy to stabilize domestic output and prices in short run are called for.

Keywords: Commodity prices, oil price, output variation, real exchange rate, vector-error correction model, impulse response function, central bank intervention

JEL Classification: E30, E63, E41

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I. Introduction

Global commodity and oil price fluctuations have increased over the years. UNCTAD Handbook of Statistics (2009) data shows that commodity price volatility has increased by 175 per cent over the last two decades. Fluctuations in global commodity and oil prices impact domestic macroeconomic performance of emerging economies. While global oil and commodity price booms may significantly benefit commodity- and oil- exporting countries, but a sharp fall in commodity and oil prices equally increases macroeconomic vulnerability; wiping out real incomes and welfare. Similarly, large commodity- and oil- importing countries face significant macroeconomic stress with rising commodity prices with resultant output fluctuation, inflation and fiscal duress. Thus the governments are bound to implement measures first to cope with commodity and oil price volatility, and then, to maintain production and price incentives to stabilise the economy. India, as a large oil and commodity importing emerging economy is no exception to this.

Figure 1 to Figure 4, plots quarterly rates of change in global commodity and oil prices with rates of change in domestic output (industrial production) and inflation. A cursory glance through Figure 1 to Figure 2 suggsts that, in general, global commodity and oil price movements have a lead-lag inverse relationship with industrail production. The swings in industrial output appears to be more pronounced than the rate of change in commodity and oil prices. It is discernible from Figure 3 and Figure 4 that the rate of doemstic wholsale price inflation is closely associated with commodity and oil price movements and swings in domestic inflation rate is larger than commodity and oil price movements. Moreover, since 2008, quarterly fluctuations in domestic inflation rate appears to be following more closely to commodity and oil price movements. Given these cursory observations, we briefly review underlying open-economy macroeconomic interrelationships among commodity and oil prices and output, inflation and exchange rate. This is to set the research agenda at the end of Section II.

Figure 1: Global Commodity Price Movements and Industrial Output Fluctuation

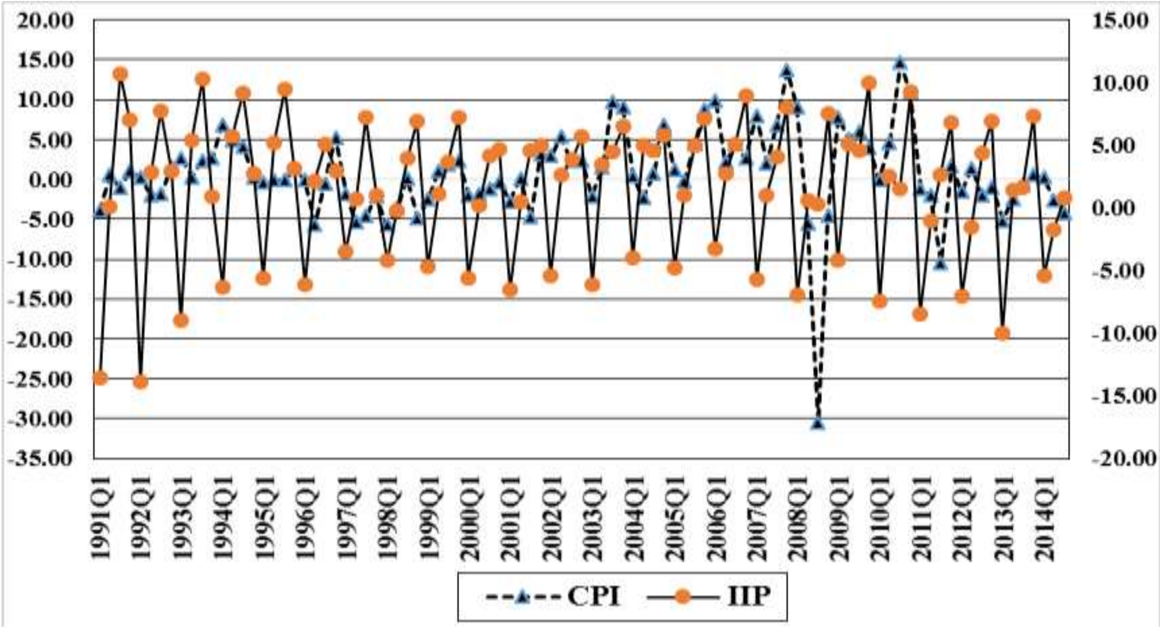


Figure 2: Global Crude Oil Price Movements and Industrial Output Fluctuation

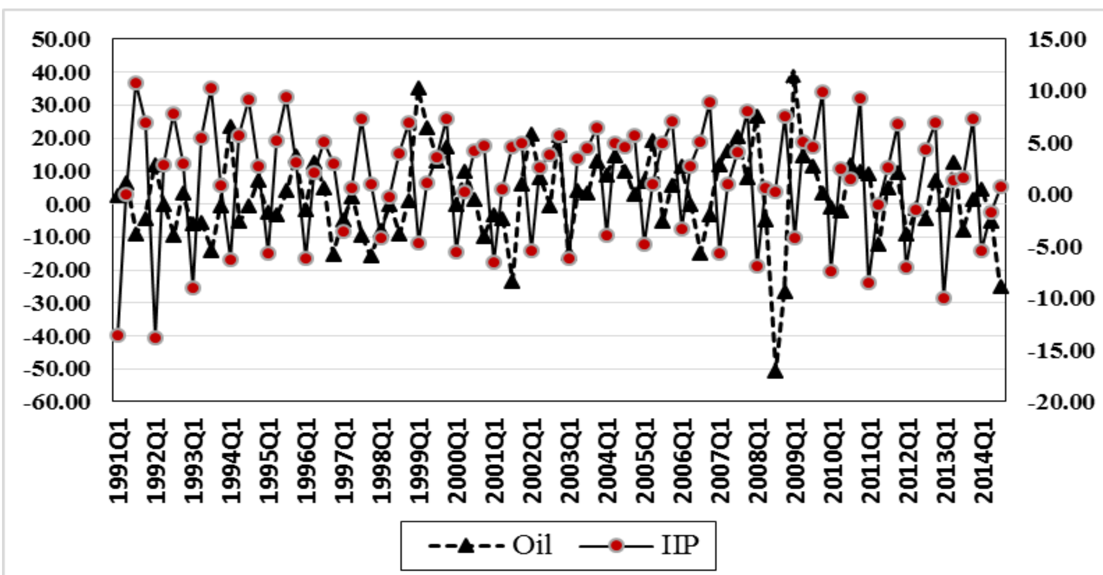


Figure 3: Global Commodity Price Movements and Wholesale Price Inflation

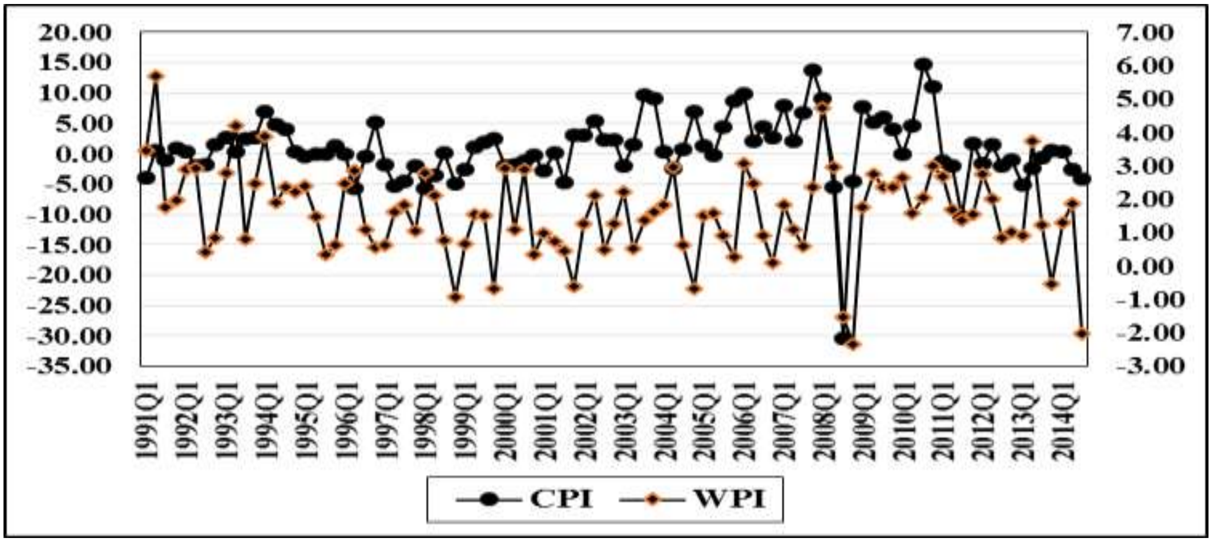
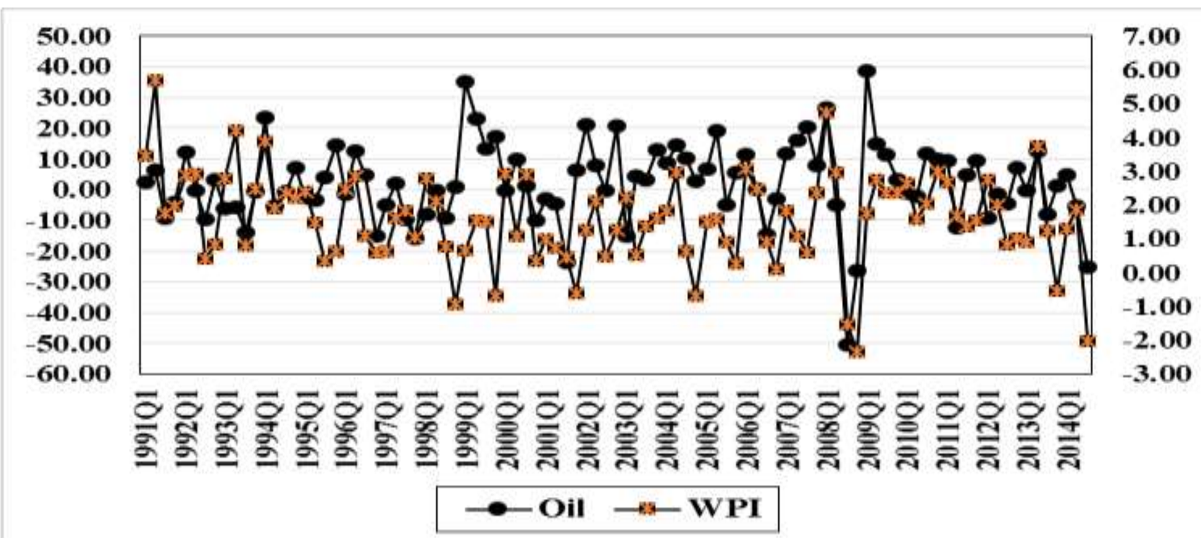


Figure 4: Global Crude Oil Price Movements and Wholesale Price Inflation



II. Open-Economy Macroeconomic Analytics

While the extent of impact of commodity and oil price shocks depends on country-specific structural characteristics, countries that are typically adversely affected by are usually countries with high net imports of commodity and oil per GDP. The spikes in crude oil price significantly increases the energy costs of countries. For all those domestic industries using commodity and oil as inputs, rising input and wage prices result in cost-push inflation. Whereas, in markets with nominal price and wage rigidities, a delayed price adjustments can even create a bigger output shock in the long run. During the times of sharp worsening terms of trade, macroeconomic performance is contingent on the degree of flexibility in exchange rate management given the state of external balance sheet and fiscal excesses. A steep fall in current account and consequent worsening of fiscal deficit, in turn, is reflected in saving and investment imbalances and economic crises. Macroeconomic transmission of terms of trade shocks are generally through significant variance in output. Nominal wage and price rigidities increase output volatility and unemployment. In a flexible exchange rate, nominal exchange rate immediately adjusts itself insulating the economy from the external shock and stabilizing output. Whereas, in a fixed exchange rate, terms of trade shocks are amplified with asymmetric response of output, i.e., larger output response to negative than to positive shock (UNCTAD 2012). In case of an output gap, the shocks will have an adverse impact on growth mainly through inflation and fall in real income. Further, an excessive volatility that creates uncertainty over future price levels discourages long-term planning and investment; for that producers and consumers of commodities underinvest in physical assets that derails growth and disrupts government budgets (Cespedes and Velasco 2012).

Commodity and oil price booms and busts, therefore, pose a challenge for macroeconomic policy warranting deft policy maneuvering. While countries with managed exchange rates combined with capital controls could avoid potential cyclicality from capital flows, others have been successful in insulating the economy from terms of trade shocks through inflation-targeting combined with floating exchange rates. In managed exchange rate coupled with capital controls central bank intervention with varying foreign exchange reserves could avoid potential risks of transmitting commodity price shocks to real exchange rate (Aizenman, Edwards and Riera-Crichton, 2011). Therefore, rather than raising interest rates, anchoring inflationary expectations turns out to be the key monetary policy objective wherein the headline inflation being the target and core inflation being the guidepost. On the other hand, countercyclical fiscal policy may complement monetary policy objective of containing commodity price shocks especially under an inflation targeting regime.

Bruno (1982) finds empirical evidence that oil price shocks lead to an increase in wages and prices, and decrease in real output. The same conclusion was substantiated by Hamilton (1983) using the Vector Auto Regression (VAR) technique. Burbidge and Harrison (1984) found that the impact was different across different countries in spite of the fact that all were developed countries. On the other hand, Hooker (1996) found that the causal relationship between oil prices and macroeconomic variables weakened post-1973 and were not able to capture the dynamics of business. Whereas Christini (1998) observed a very strong correlation between macroeconomic variables and oil prices. Analysing the periods of commodity booms and busts for commodity exporting countries, Cespedes and Velasco (2012) find that commodity price booms are positively associated with heightened economic activity. Further, commodity terms of trade has a significant impact on real exchange rate but reserve accumulation contains the impact. More flexible exchange rate regime countries are associated with more moderate variation in output.

In the Indian context, most of the earlier studies [Rangarajan et al., (1981) and Sastry (1982)] estimate the cost-push effect of oil price hike using input output analysis. This method is not useful in estimating the oil price shocks over a longer period of time given its static nature. In February 1999, from an all-time low of $11 per barrel and oil prices increased to a peak of $35 in the first week of September 2000. From its peak of $147 during 2008 it has fallen to less than $50 at present. India imports more than 100 million tons of crude oil and other petroleum products, in turn, spends large amounts of foreign exchange. The increasing quantum of imports of petroleum products has a significant impact on the Indian economy in times of soaring crude oil prices. It is estimated that for every unit dollar increase in crude oil price, wholesale price inflation rises by 30 basis points (RBI 2005). These developments provide a motivation to understand the mechanisms through which commodity and oil price fluctuations are transmitted to the macroeconomy.

Against these developments, we explore the oil and non-energy commodity price fluctuations and their impact on Indian macroeconomy. We provide the responses of different macroeconomic variables to oil and non-energy commodity price changes - different channels through which oil and commodity price changes affect open-economy macroeconomy. Our objective is to find out the output response to oil and non-energy commodity price fluctuations. As outlined above, in flexible exchange rate, exchange rate adjustment or in a managed exchange rate variation foreign exchange reserves (as a measure for degree of foreign exchange intervention) stabilizes output response and hence output variation would be smaller. Since India follows managed exchange rate wherein central bank actively intervened in the past in foreign exchange market to contain excess volatility in exchange rate, we also examine the exchange rate adjustment to a commodity shock along with variation in foreign exchange reserves. This is in order to examine whether variation in foreign exchange reserves contains exchange rate volatility in the wake of oil and non-oil energy commodity price shocks. Also, since well-developed financial markets reduce the impact of commodity and price shocks on credit and investment, we also examine the role of financial market (private credit as a percentage of GDP) in mitigating price shocks.

III. Data Source, Data Structure and Methodology

Fluctuations in crude oil prices impact the economy through various channels. We examine the response of industrial output to the episodic change in commodity and oil prices. We empirically establish different channels through which shocks to commodity and oil prices affect the domestic macroeconomy. We restrict in this study in analysing the direct impact of oil and non-energy commodity prices on industrial output and domestic inflation, and thereby, on the growth of output. Finally, we provide an empirical account of the role played by the development of financial markets (private credit). Moreover, we analyse the impact of oil and non-energy commodity price fluctuations on real exchange rate (REER) adjustment while accounting for variations in foreign exchange reserves.

We use quarterly data for the post-reform period spanning over 1991 to 2014. In the absence of high-frequency quarterly data of GDP for the entire period, we use industrial output as a proxy for domestic output and we make use of Index of Industrial Production (IIP) to measure the variation in industrial output. The data for IIP has been sourced from the Ministry of Statistics and Programme Implementation, Government of India (GoI). For measuring domestic inflation rate we make use of Wholesale Price Index (WPI) and the WPI data has been obtained from the Minstry of Finance, GoI. As an indicator of financial market development of the economy, the share of credit to private sector of the total credit has been considered. The data related to credit to private sector has been taken from World Bank Economic Database. The data on real exchange rate represented by real effective exchange rate (REER) and data on foreign exchange reserves has been obtained from Database of Indian Economy managed by RBI.

To measure commodity price movements, the data on Commodity Price Index (CPI) has been obtained from the World Bank Economic Database. CPI includes non-energy commodities only which includes agriculture (beverages, food and raw materials), fertilizers and metals & minerals (base metals). The composition of CPI is presented in Figure 5.

Fig. 5: Composition of Commodity Price Index

Non-energy												
	Agriculture									Fertilizers	Metals & Minerals	
		Beverages	Food				Raw Materials					Base Metals (ex. iron ore)
				Oils & Meals	Grains	Other Food		Timber	Other Raw Mat.			

The crude oil price has been obtained from Economic Research Department of Federal Reserve Bank of St. Louis. Since we have observed seasonality in the quarterly data of IIP and WPI, we have deseasonalised IIP and WPI before carrying out empirical estimation.

Fig. 6: Index of Industrial Production

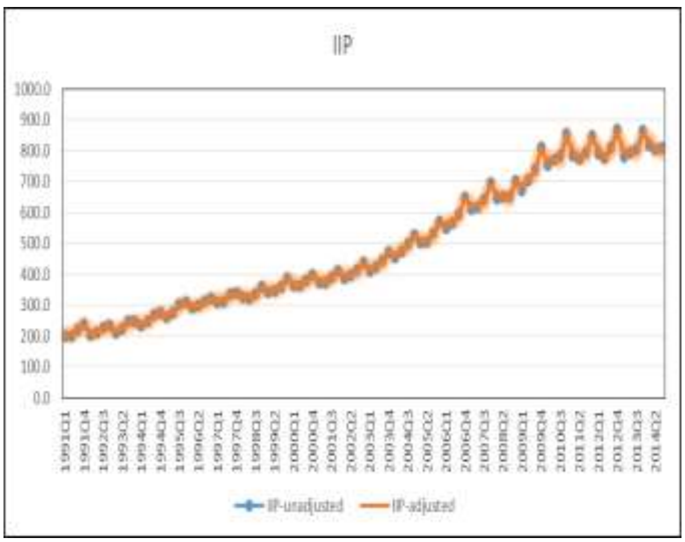


Fig. 7: Commodity Price Index

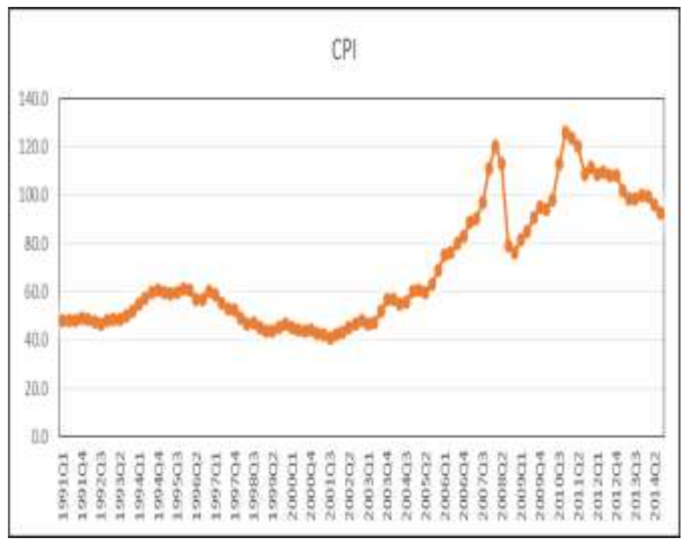
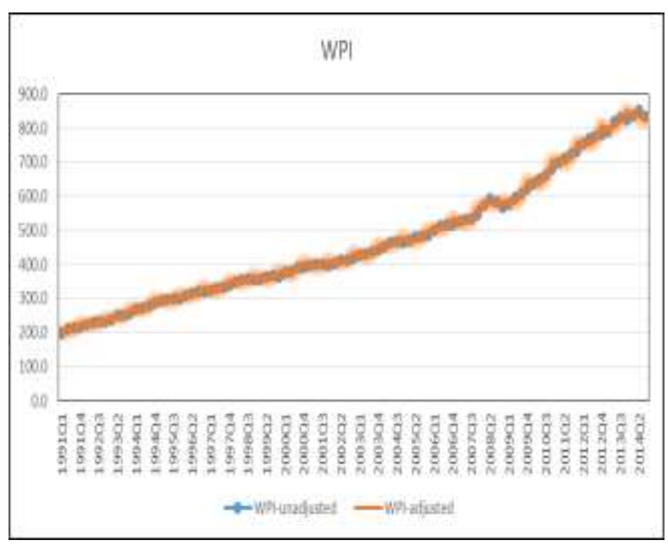


Fig. 8: Oil Prices

Fig. 9: Wholesale Price Index



IV.i. Empirical Estimation Method

Following diagnosing standard time series properties of macroeconomic variables, unit roots test are carried out for all the variables and it was found that all the variables are non-stationary at levels but becomes stationary in their first differences. Vector error correction (VECM) models are more appropriate for analyzing such multivariate time series data as they are extremely useful in analyzing the dynamic behavior of economic and financial time series. Also, VECM models are superior over other causal time series models. Moreover, since we analyse the impact of commodity and oil price fluctuations on domestic macroeconomic variables of output, inflation and exchange rate, VECM models are amenable to derive macroeconomic policy implications from the empirical findings. VECM is a multi-equation system where all the variables are treated as endogenous. The k- variable VAR model is given as:

$$Y_t – \alpha + \beta_1\gamma_{t-1} + \beta_2\gamma_{t-2} + \ldots\ldots\ldots\ldots.. + \beta_k\gamma_{s-k} + \varepsilon_t$$

where

$$Y_t = (y_{1t}, y_{2t}, \ldots\ldots y_m)$$

is an (nx1) vector of time series variables.

$\beta_i(i = 1,2,\ldots.k)$ are n x n coefficient matrices The right hand side of each equation includes lagged values of all dependent variables in the system.

ε_t is the error term which is a nx1 matrix.

Although Granger-causal relationship can also be established between the variables considered, however VECM is preferred over the former. The testable hypothesis proposed here are the following:

1. There is a significant relationship between change in output, credit to private sector and crude oil price.
2. There is a significant relationship between change in output, credit to private sector and non-energy commodity price.
3. There is a significant relationship between change in REER, crude oil price, foreign exchange reserves and credit to private sector.
4. There is a significant relationship between change in REER, commodity price, foreign exchange reserves and credit to private sector.

ii. Empirical Results

a. The Schwarz Information Criterion (SIC) is the least for a lag of five therefore indicating that a lag of five period is the optimal. Further, both trace and maximum eigenvalue test indicate one co-integrating equation. The high value of Adjusted-R-squared for Δ(IIP) and other variables indicates a good fit between these variables. The F-statistics also indicates a significant relationship. Therefore, we may infer that there exists a significant relationship between the IIP, crude oil price and credit to private sector as evident from Table 1.

Table 1: VECM of Oil Prices, Credit, WPI and IIP

Cointegrating Equation:	Cointegrating Equation 1			
IIP(-1)	1.000000			
OIL(-1)	-0.962819 (2.70528) [-0.35590]			
WPI(-1)	-2.479277 (0.48956) [-5.06434]			
CREDIT(-1)	30.92398 (12.7514) [2.42515]			
C	-359.8611			
Error Correction:	Δ(IIP)	Δ(OIL)	Δ(WPI)	Δ(CREDIT)
CointEq1	0.039485 (0.01227) [3.21755]	0.007832 (0.01186) [0.66044]	0.028610 (0.00614) [4.65774]	0.000359 (0.00129) [0.27702]
Δ(IIP(-1))	-0.393382 (0.13633) [-2.88556]	-0.102069 (0.13173) [-0.77483]	-0.112086 (0.06824) [-1.64261]	0.029259 (0.01439) [2.03401]
Δ(IIP(-2))	-0.347111 (0.09096) [-3.81627]	0.106489 (0.08789) [1.21163]	-0.111064 (0.04553) [-2.43957]	0.013874 (0.00960) [1.44558]
Δ(IIP(-3))	-0.368176 (0.09315) [-3.95262]	0.016298 (0.09001) [0.18108]	-0.121967 (0.04662) [-2.61599]	0.012392 (0.00983) [1.26076]
Δ(IIP(-4))	0.654599 (0.09699) [6.74925]	0.049963 (0.09372) [0.53312]	-0.105783 (0.04855) [-2.17903]	0.001339 (0.01023) [0.13080]
Δ(IIP(-5))	0.101673 (0.12456)	0.197359 (0.12036)	-0.037604 (0.06235)	-0.011460 (0.01314)

	[0.81624]	[1.63969]	[-0.60312]	[-0.87189]
Δ(OIL(-1))	0.078987 (0.16032) [0.49268]	0.461773 (0.15492) [2.98078]	0.362617 (0.08025) [4.51878]	0.006065 (0.01692) [0.35850]
Δ(OIL(-2))	-0.247986 (0.17315) [-1.43216]	-0.285008 (0.16732) [-1.70340]	0.001305 (0.08667) [0.01506]	0.031234 (0.01827) [1.70948]
Δ(OIL(-3))	-0.423569 (0.18175) [-2.33052]	0.108124 (0.17562) [0.61567]	-0.000786 (0.09097) [-0.00864]	0.026512 (0.01918) [1.38244]
Δ(OIL(-4))	-0.262483 (0.17407) [-1.50790]	-0.366362 (0.16820) [-2.17810]	-0.000423 (0.08713) [-0.00485]	0.021834 (0.01837) [1.18872]
Δ(OIL(-5))	-0.288096 (0.16339) [-1.76319]	-0.130156 (0.15789) [-0.82437]	-0.128581 (0.08178) [-1.57220]	0.020513 (0.01724) [1.18977]
Δ(WPI(-1))	-0.533867 (0.28322) [-1.88498]	-0.235199 (0.27367) [-0.85942]	0.107204 (0.14176) [0.75623]	-0.033905 (0.02989) [-1.13450]
Δ(WPI(-2))	0.050293 (0.30659) [0.16404]	-0.472216 (0.29625) [-1.59396]	-0.162662 (0.15346) [-1.05997]	0.009351 (0.03235) [0.28905]
Δ(WPI(-3))	0.238405 (0.29400) [0.81090]	0.009978 (0.28409) [0.03512]	0.127064 (0.14716) [0.86346]	-0.042914 (0.03102) [-1.38331]
Δ(WPI(-4))	-0.861681 (0.29765) [-2.89496]	0.489341 (0.28761) [1.70139]	0.161437 (0.14898) [1.08359]	0.000917 (0.03141) [0.02918]
Δ(WPI(-5))	0.013007 (0.31429) [0.04138]	-0.253439 (0.30369) [-0.83453]	-0.141230 (0.15731) [-0.89777]	-0.003845 (0.03316) [-0.11593]
Δ(CREDIT(-1))	0.330886 (1.30646) [0.25327]	-0.192898 (1.26241) [-0.15280]	-1.257493 (0.65393) [-1.92299]	-0.200914 (0.13786) [-1.45742]
Δ(CREDIT(-2))	0.281949 (1.28834) [0.21885]	-1.339440 (1.24490) [-1.07594]	-1.108359 (0.64486) [-1.71876]	-0.225432 (0.13594) [-1.65827]
Δ(CREDIT(-3))	0.676888 (1.29317) [0.52343]	0.409109 (1.24957) [0.32740]	-0.500149 (0.64728) [-0.77270]	-0.152487 (0.13645) [-1.11749]
Δ(CREDIT(-4))	-1.758102 (1.21599) [-1.44582]	0.365215 (1.17499) [0.31082]	-0.654463 (0.60865) [-1.07528]	-0.130280 (0.12831) [-1.01535]
Δ(CREDIT(-5))	-0.849381 (1.23466)	0.175298 (1.19304)	-1.814763 (0.61799)	-0.063193 (0.13028)

	[-0.68795]	[0.14693]	[-2.93655]	[-0.48505]
C	19.32270 (4.94659) [3.90627]	2.749648 (4.77981) [0.57526]	11.39602 (2.47593) [4.60272]	0.669507 (0.52196) [1.28269]
R-squared	0.937280	0.460536	0.578621	0.401305
Adj. R-squared	0.914956	0.268523	0.428638	0.188210
Sum sq. resids	5732.908	5352.848	1436.287	63.83124
S.E. equation	9.857379	9.525033	4.933948	1.040137
F-statistic	41.98510	2.398467	3.857925	1.883222

The VECM estimates can be summarized in the following equation:

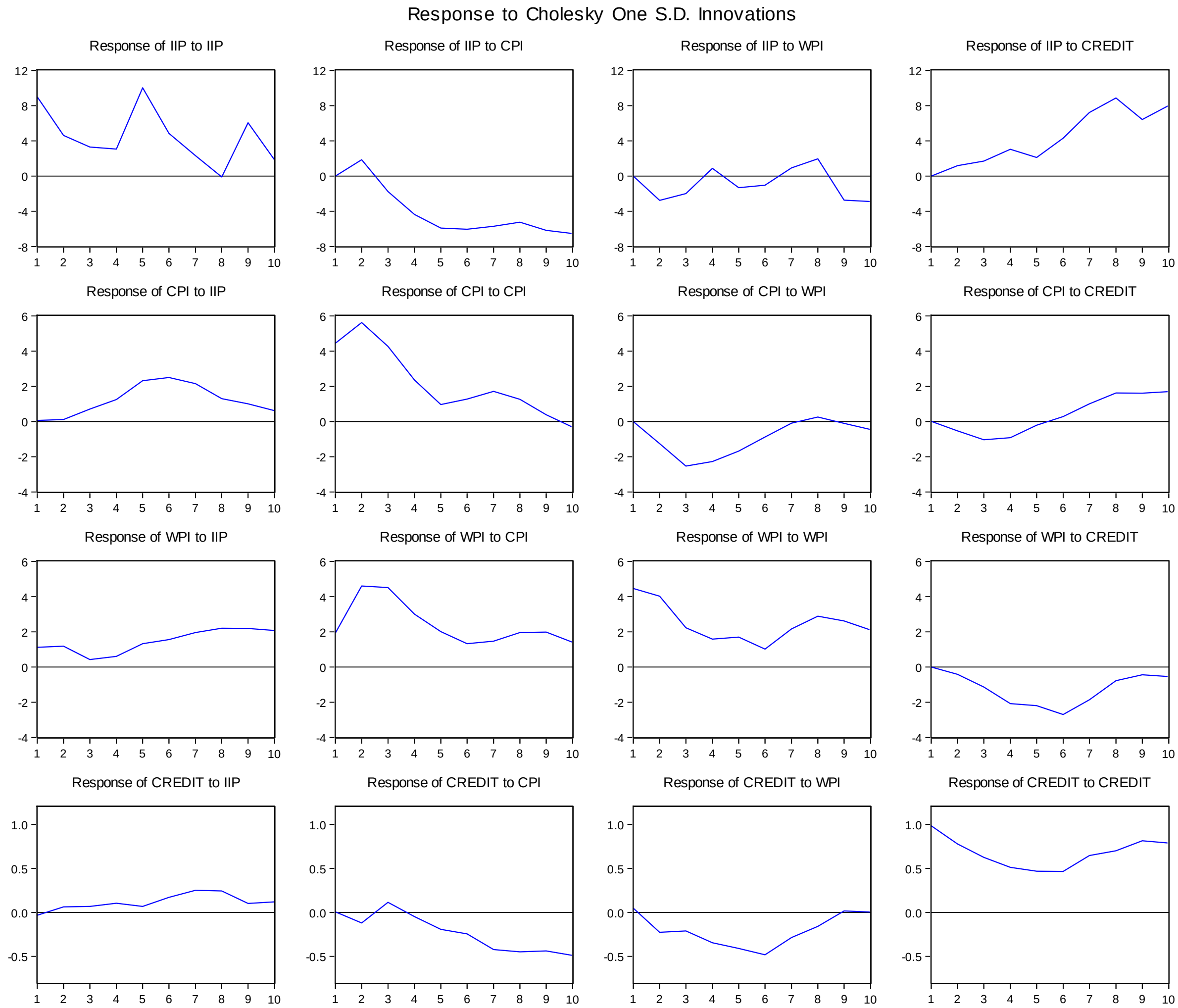
$$\Delta(IIP) = 0.039485*(IIP(-1) - 0.962818895106*OIL(-1) - 2.47927721085*WPI(-1) + 30.9239790826*CREDIT(-1) - 359.861106415) - 0.393382*\Delta(IIP(-1)) - 0.347111*\Delta(IIP(-2)) - 0.368176*\Delta(IIP(-3)) + 0.654599*\Delta(IIP(-4)) - 0.423569*\Delta(OIL(-3)) - 0.288096*\Delta(OIL(-5)) - 0.533867*\Delta(WPI(-1)) - 0.861681*\Delta(WPI(-4)) + 19.32270$$

$$\Delta(WPI) = 0.028610*(IIP(-1) - 0.962818895106*OIL(-1) - 2.47927721085*WPI(-1) + 30.9239790826*CREDIT(-1) - 359.861106415) - 0.111064*\Delta(IIP(-2)) - 0.121967*\Delta(IIP(-3)) - 0.105783*\Delta(IIP(-4)) + 0.362617*\Delta(OIL(-1)) - 1.257493*\Delta(CREDIT(-1)) - 1.108359*\Delta(CREDIT(-2)) - 1.814763*\Delta(CREDIT(-5)) + 11.39602$$

From the above equation we can see that increase in crude oil prices has an inflationary impact on the economy. We can also see that the increase in crude oil prices has a negative impact on industrial production (output). Inflationary impact shows with a lag of one quarter while the impact on output is quite delayed with a lag of three quarters. Furthermore, the Wald-test reinforces underlying macroeconomic interrelationship that there exists a short run relationship between change in output & oil prices and WPI & oil prices.

The impulse response functions (Figure 10) indicate that the impact of oil price shocks on IIP lasts up to four quarters after which the effect becomes constant. We can also observe that oil price shocks have a positive impact on WPI pointing out the domestic inflationary effect. The impact becomes constant from eight-quarter onwards.

Fig. 10: Impulse Response Functions of Commodity Prices



b. The Schwarz Information Criterion (SIC) and the Hannan-Quinn information criterion is least for a lag of five therefore indicating that a lag of five periods is the optimal. Furthermore, trace test and maxium eigenvalue test indicates three cointegrating equations. The high value of Adjusted-R-Squared for Δ(IIP) and other variables indicates a good fit among these variables. The F-statistics also indicate a significant relationship. Therefore, we may infer that there exists a significant relationship between the change in output, non-energy commodity prices, WPI and credit to private sector as indicated in Table 2.

Table 2: VECM of Commodity Prices, Credit, WPI and IIP

Cointegrating Equation	Cointegrating Equation 1	Cointegrating Equation 2	Cointegrating Equation 3	
IIP(-1)	1.000000	0.000000	0.000000	
CPI(-1)	0.000000	1.000000	0.000000	
WPI(-1)	0.000000	0.000000	1.000000	
CREDIT(-1)	-15.21386 (0.84892) [-17.9214]	-3.189810 (0.59865) [-5.32835]	-16.53888 (1.27067) [-13.0159]	
C	27.75052	44.59095	107.2058	
Error Correction:	Δ(IIP)	Δ(CPI)	Δ(WPI)	Δ(CREDIT)
CointEq1	-0.102486 (0.05492) [-1.86621]	0.025314 (0.02717) [0.93167]	0.110795 (0.03047) [3.63678]	0.012209 (0.00603) [2.02480]
CointEq2	-0.171633 (0.09053) [-1.89591]	-0.071143 (0.04479) [-1.58838]	0.036705 (0.05022) [0.73087]	-0.016831 (0.00994) [-1.69336]
CointEq3	-0.078628 (0.03350) [-2.34685]	-0.001147 (0.01658) [-0.06922]	-0.086848 (0.01859) [-4.67271]	0.000137 (0.00368) [0.03736]
Δ(IIP(-1))	-0.305643 (0.12924) [-2.36500]	0.010538 (0.06394) [0.16481]	-0.097159 (0.07169) [-1.35519]	0.005195 (0.01419) [0.36611]
Δ(IIP(-2))	-0.261084 (0.09435) [-2.76709]	0.089075 (0.04668) [1.90813]	-0.159831 (0.05234) [-3.05354]	-0.001509 (0.01036) [-0.14571]
Δ(IIP(-3))	-0.306654 (0.09261) [-3.31132]	0.053769 (0.04582) [1.17352]	-0.147825 (0.05137) [-2.87740]	0.001385 (0.01017) [0.13624]
Δ(IIP(-4))	0.679727 (0.09339) [7.27816]	0.149631 (0.04621) [3.23830]	-0.076039 (0.05181) [-1.46765]	-0.004536 (0.01025) [-0.44237]
Δ(IIP(-5))	0.107608 (0.12803) [0.84051]	0.070103 (0.06334) [1.10674]	-0.125277 (0.07102) [-1.76389]	-0.000332 (0.01406) [-0.02359]
Δ(CPI(-1))	0.858481 (0.27406) [3.13244]	0.453358 (0.13559) [3.34349]	0.606632 (0.15204) [3.99004]	0.013772 (0.03009) [0.45770]
Δ(CPI(-2))	-0.283217 (0.31388) [-0.90231]	-0.105150 (0.15529) [-0.67710]	-0.081644 (0.17413) [-0.46888]	0.094280 (0.03446) [2.73573]
Δ(CPI(-3))	-0.533421 (0.31670) [-1.68430]	-0.089233 (0.15669) [-0.56949]	0.053605 (0.17569) [0.30511]	-0.008340 (0.03477) [-0.23984]

Δ(CPI(-4))	-0.322145 (0.30087) [-1.07070]	-0.061575 (0.14886) [-0.41365]	0.051068 (0.16691) [0.30596]	0.045258 (0.03303) [1.37005]
Δ(CPI(-5))	-0.713313 (0.29900) [-2.38566]	0.155606 (0.14793) [1.05187]	0.053192 (0.16587) [0.32068]	0.061960 (0.03283) [1.88738]
Δ(WPI(-1))	-0.553586 (0.26795) [-2.06599]	-0.273820 (0.13257) [-2.06546]	-0.006350 (0.14865) [-0.04272]	-0.059212 (0.02942) [-2.01267]
Δ(WPI(-2))	0.183640 (0.29572) [0.62099]	-0.209412 (0.14631) [-1.43129]	-0.155767 (0.16405) [-0.94950]	-0.002531 (0.03247) [-0.07795]
Δ(WPI(-3))	0.447353 (0.27380) [1.63384]	0.021236 (0.13547) [0.15676]	-0.001113 (0.15189) [-0.00733]	-0.041972 (0.03006) [-1.39617]
Δ(WPI(-4))	-0.555818 (0.28386) [-1.95804]	-0.133657 (0.14044) [-0.95167]	-0.116086 (0.15747) [-0.73717]	-0.033946 (0.03117) [-1.08918]
Δ(WPI(-5))	0.349616 (0.26420) [1.32328]	0.027195 (0.13072) [0.20804]	-0.167520 (0.14657) [-1.14295]	-0.057456 (0.02901) [-1.98068]
Δ(CREDIT(-1))	-2.212601 (1.34468) [-1.64545]	-0.406087 (0.66529) [-0.61039]	-0.056815 (0.74597) [-0.07616]	-0.074652 (0.14764) [-0.50564]
Δ(CREDIT(-2))	-2.048196 (1.25471) [-1.63240]	-0.433297 (0.62078) [-0.69799]	-0.164042 (0.69605) [-0.23567]	-0.112413 (0.13776) [-0.81601]
Δ(CREDIT(-3))	-1.257878 (1.23929) [-1.01500]	-0.291816 (0.61315) [-0.47593]	-0.586778 (0.68750) [-0.85350]	-0.090279 (0.13607) [-0.66349]
Δ(CREDIT(-4))	-3.390627 (1.14051) [-2.97290]	-0.217743 (0.56428) [-0.38588]	-0.383342 (0.63270) [-0.60588]	-0.116717 (0.12522) [-0.93208]
Δ(CREDIT(-5))	-2.022628 (1.18476) [-1.70721]	-0.660968 (0.58617) [-1.12761]	-1.239094 (0.65725) [-1.88528]	-0.065036 (0.13008) [-0.49997]
C	13.09904 (5.56969) [2.35184]	2.340239 (2.75564) [0.84925]	14.97679 (3.08980) [4.84717]	1.785703 (0.61152) [2.92011]
R-squared	0.949618	0.569315	0.584213	0.479320
Adj. R-squared	0.929289	0.395529	0.416439	0.269221
Sum sq. resids	4605.110	1127.261	1417.226	55.51352
S.E. equation	8.988404	4.447079	4.986343	0.986875
F-statistic	46.71155	3.275966	3.482145	2.281398

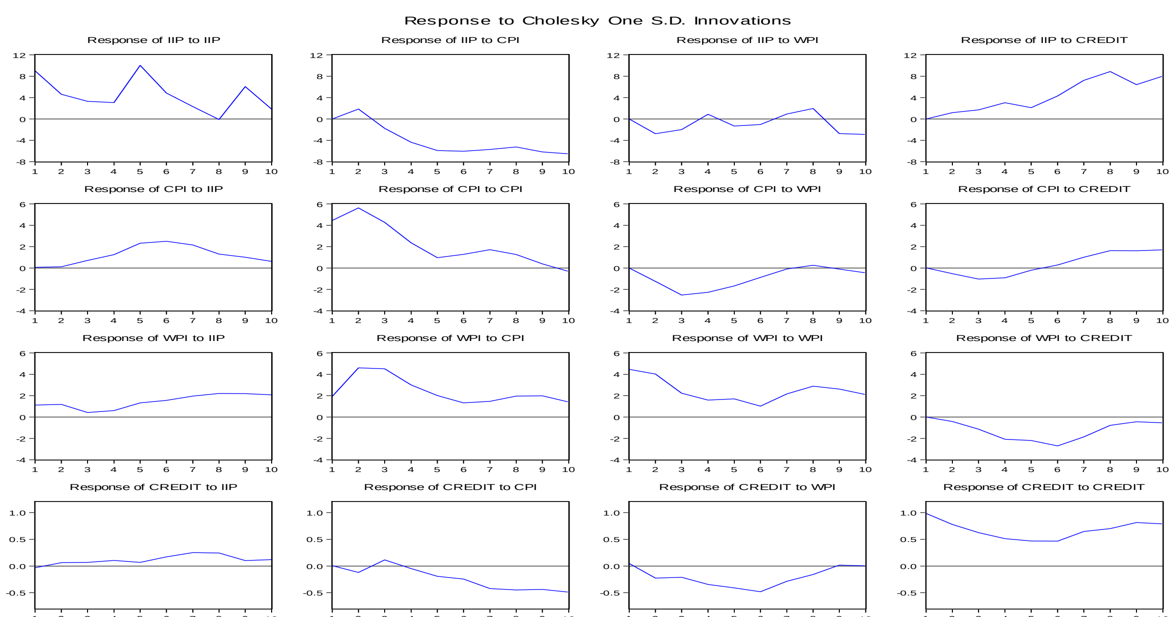
The VECM estimates can be summarized in the following equation:

$$\Delta(IIP) = -0.102486*(IIP(-1) - 15.2138626646*CREDIT(-1) + 27.7505172739) + -0.171633*(CPI(-1) - 3.18980969409*CREDIT(-1) + 44.590953894) - 0.078628*(WPI(-1) - 16.5388808415*CREDIT(-1) + 107.205810474) - 0.305643*\Delta(IIP(-1)) - 0.261084*\Delta(IIP(-2)) - 0.306654*\Delta(IIP(-3)) + 0.679727*\Delta(IIP(-4)) + 0.858481*\Delta(CPI(-1)) - 0.533421*\Delta(CPI(-3)) - 0.713313*\Delta(CPI(-5)) - 0.553586*\Delta(WPI(-1)) - 0.555818*\Delta(WPI(-4)) - 3.390627*\Delta(CREDIT(-4)) - 2.022628*\Delta(CREDIT(-5)) + 13.09904$$

$$\Delta(WPI) = 0.110795*(IIP(-1) - 15.2138626646*CREDIT(-1) + 27.7505172739) - 3.18980969409*CREDIT(-1) + 44.590953894)) -0.086848*(WPI(-1) - 16.5388808415*CREDIT(-1) + 107.205810474) - 0.159831*\Delta(IIP(-2)) - 0.147825*\Delta(IIP(-3)) - 0.125277*\Delta(IIP(-5)) + 0.606632*\Delta(CPI(-1)) - 1.239094*\Delta(CREDIT(-5)) + 14.97679$$

From the above VECM equation we can observe that increase in commodity prices has an inflationary impact on the economy. The increase in commodity prices has a negative impact on output. Inflationary impact comes with a lag of one quarter while the negative impact on output is quite delayed with a lag of three quarters. Furthermore, the Wald-test reinforces underlying macroeconomic theory that there exists a short run relationship between output & commodity prices and WPI & commodity prices.

Fig. 11: Impulse Response Functions of Commodity Prices



We can also observe that commodity price shock has a positive impact on WPI which points out the domestic inflationary effect and its impact lasts for three quarters. Whereas, its impact on output is negative and lasts longer.

c. The Schwarz Information Criterion, Hannan-Quinn Information Criterion, Akaike Information Criterion and final prediction error are the least for a lag of two, therefore, indicating that a lag of two periods is the optimal. Furthermore, trace test indicates two co-integrating equations. The high value of Adjusted-R-squared for Δ(REER) and other variables indicates a good fit between these variables. The F-statistics also indicate a significant relationship. Therefore, we may infer that there exists a significant relationship between the REER, oil price, foreign exchange reserves and credit to private sector as indicated in Table 3.

Table 3: VECM of REER, Oil Prices, Foreign Exchange Reserves and Credit

Cointegrating Equation:	Cointegrated Equation 1	Cointegrated Equation 2		
REER(-1)	1.000000	0.000000		
OIL(-1)	0.000000	1.000000		
RESERVES(-1)	0.136725 (0.05424) [2.52079]	0.354605 (0.13132) [2.70022]		
CREDIT(-1)	-1.576840 (0.55566) [-2.83778]	-6.365719 (1.34538) [-4.73155]		
C	-63.14794	127.8455		
Error Correction:	Δ(REER)	Δ(OIL)	Δ(RESERVES)	Δ(CREDIT)
CointEq1	-0.393169 (0.08673) [-4.53325]	0.651572 (0.26129) [2.49370]	0.141969 (0.24458) [0.58045]	-0.063904 (0.04146) [-1.54137]
CointEq2	0.090454 (0.03849) [2.35033]	-0.386269 (0.11594) [-3.33153]	-0.308563 (0.10853) [-2.84306]	0.024333 (0.01840) [1.32265]
Δ(REER(-1))	0.288864 (0.11498) [2.51241]	-0.778764 (0.34638) [-2.24830]	-0.000989 (0.32424) [-0.00305]	0.031711 (0.05496) [0.57697]
Δ(REER(-2))	0.407714 (0.11662)	0.006254 (0.35133)	0.241756 (0.32887)	-0.005270 (0.05575)

	[3.49615]	[0.01780]	[0.73511]	[-0.09453]
Δ(OIL(-1))	0.001483	0.234126	0.019009	-0.014953
	(0.04198)	(0.12648)	(0.11840)	(0.02007)
	[0.03532]	[1.85108]	[0.16055]	[-0.74507]
Δ(OIL(-2))	-0.091516	-0.144927	-0.044480	-0.007737
	(0.04180)	(0.12593)	(0.11788)	(0.01998)
	[-2.18939]	[-1.15088]	[-0.37734]	[-0.38721]
Δ(RESERVES(-1))	0.037011	0.420266	0.646402	0.007203
	(0.04048)	(0.12197)	(0.11417)	(0.01935)
	[0.91418]	[3.44574]	[5.66174]	[0.37217]
Δ(RESERVES(-2))	0.023098	-0.014959	-0.040699	0.038289
	(0.04502)	(0.13562)	(0.12695)	(0.02152)
	[0.51311]	[-0.11030]	[-0.32060]	[1.77934]
Δ(CREDIT(-1))	-0.449378	-0.523686	-2.006198	-0.164163
	(0.24723)	(0.74482)	(0.69721)	(0.11818)
	[-1.81763]	[-0.70310]	[-2.87746]	[-1.38904]
Δ(CREDIT(-2))	-0.228187	-1.955085	-0.717031	-0.165490
	(0.25115)	(0.75663)	(0.70827)	(0.12006)
	[-0.90856]	[-2.58392]	[-1.01237]	[-1.37842]
C	0.141393	0.052112	2.364416	0.314642
	(0.30740)	(0.92608)	(0.86688)	(0.14694)
	[0.45997]	[0.05627]	[2.72751]	[2.14124]
R-squared	0.352079	0.519839	0.602038	0.153108
Adj. R-squared	0.263323	0.454064	0.547523	0.037096
Sum sq. resids	396.5127	3598.770	3153.376	90.60734
S.E. equation	2.330597	7.021269	6.572437	1.114090
F-statistic	3.966808	7.903236	11.04347	1.319755
Log likelihood	-184.3703	-277.0071	-271.4581	-122.3710
Akaike AIC	4.651673	6.857312	6.725194	3.175500
Schwarz SC	4.969994	7.175634	7.043515	3.493822
Mean dependent	0.078410	0.687817	3.616846	0.345238
S.D. dependent	2.715367	9.502646	9.770754	1.135347

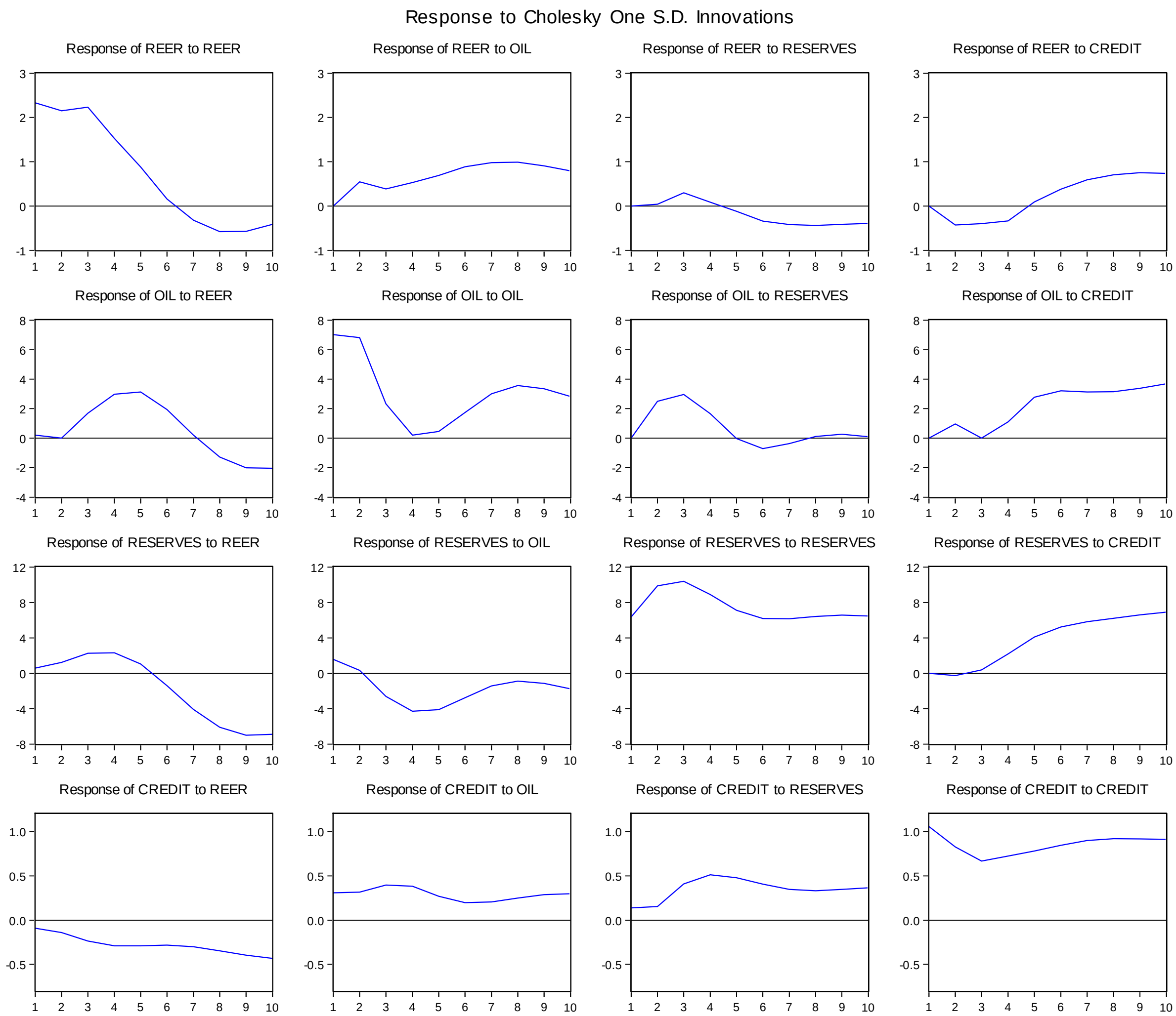
The VECM estimates can be summarized using the following equation

$$\Delta(REER) = - 0.393169*(REER(-1) + 0.136724740451*RESERVES(-1) - 1.57683971132*CREDIT(-1) - 63.1479402277) + 0.090454*(OIL(-1) +0.354604988832*RESERVES(-1) - 6.3657188568*CREDIT(-1) +127.845523865) + 0.288864*\Delta(REER(-1)) + 0.407714*\Delta(REER(-2)) -0.091516*\Delta(OIL(-2))$$

From the above equation we can observe that increase in oil prices has an impact on the rate of exchange rate adjustment. We can see from the above equation that positive (increase) shock in oil prices has a depreciating impact on the REER, as expected given the heavy dependence of Indian economy on oil imports. However, the impact comes with a lag of two quarters, therefore, the monetary authority (central bank) gets a time window to minimise the adverse impact. Furthermore, financial markets (credit to private sector) and foreign exchange reserves help in mitigating the negative impact of oil price spikes on REER.

The impulse response functions (Figure 12) indicate that the impact lasts up to eight quarters after which the effect tends to becomes constant

Fig. 12: Impulse Response Functions of REER



d. The Akaike Information Criterion and final prediction error are the least for a lag of three therefore indicating that a lag of three periods is the optimal. Furthermore, trace test indicates one co-integrating equation. The high value of Adjusted-R-squared for Δ(REER) and other variables indicates a good fit between these variables. The F-statistics also indicate a significant relationship. Therefore, we may infer that there exists a significant relationship between REER, commodity price, foreign exchange reserves and credit to private sector as indicated in Table 4.

Table 3: VECM of REER, Commodity Prices, Foreign Exchange Reserves and Credit

Cointegrating Equation:	Cointegrating Equation 1			
REER(-1)	1.000000			
CPI(-1)	-0.302502 (0.06358) [-4.75771]			
RESERVES(-1)	0.136270 (0.03839) [3.55004]			
CREDIT(-1)	-0.943357 (0.30485) [-3.09448]			
C	-64.36285			
Error Correction:	**Δ(REER)**	**Δ(CPI)**	**Δ(RESERVES)**	**Δ(CREDIT)**
CointEq1	-0.570453 (0.11182) [-5.10135]	-0.320025 (0.21672) [-1.47668]	-0.627836 (0.36188) [-1.73491]	-0.011077 (0.05739) [-0.19303]
Δ(REER(-1))	0.239055 (0.10683) [2.23775]	-0.219944 (0.20704) [-1.06234]	0.603284 (0.34572) [1.74501]	-0.010653 (0.05482) [-0.19433]
Δ(REER(-2))	0.443106 (0.11589) [3.82348]	0.599168 (0.22460) [2.66770]	0.925846 (0.37505) [2.46862]	-0.036762 (0.05947) [-0.61813]
Δ(REER(-3))	0.078949 (0.12836) [0.61508]	0.632835 (0.24876) [2.54399]	0.437917 (0.41538) [1.05425]	0.005980 (0.06587) [0.09078]
Δ(CPI(-1))	-0.008323 (0.07564) [-0.11004]	0.200532 (0.14658) [1.36803]	-0.227241 (0.24477) [-0.92838]	0.034073 (0.03881) [0.87784]
Δ(CPI(-2))	-0.004868 (0.07593) [-0.06411]	-0.203333 (0.14716) [-1.38171]	-0.310483 (0.24573) [-1.26349]	0.019831 (0.03897) [0.50893]
Δ(CPI(-3))	-0.003604 (0.07757) [-0.04646]	-0.140743 (0.15033) [-0.93624]	-0.224212 (0.25102) [-0.89319]	-0.020466 (0.03981) [-0.51415]
Δ(RESERVES(-1))	0.048216	0.245075	0.743733	-0.007924

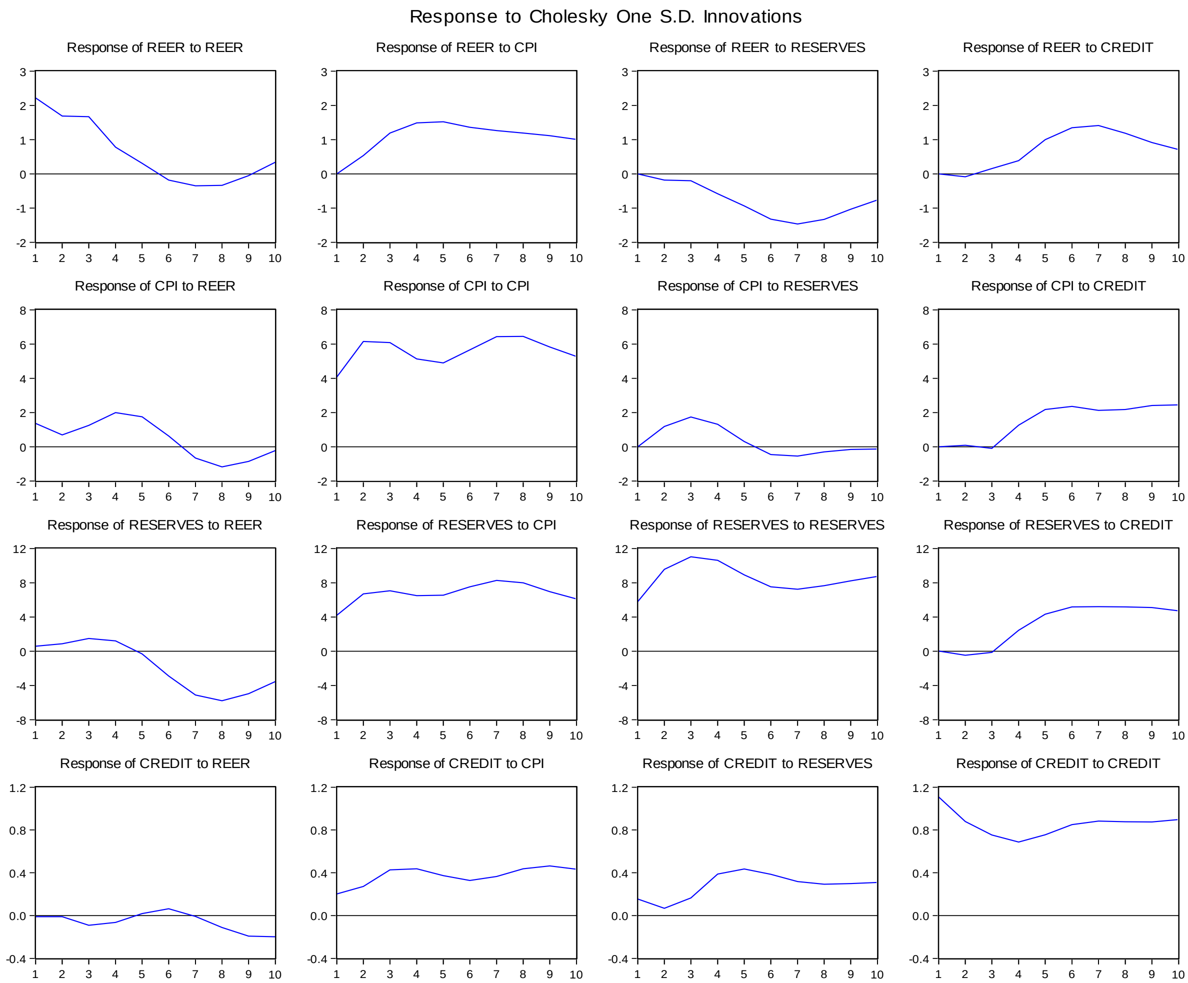
	(0.04431) [1.08824]	(0.08587) [2.85409]	(0.14339) [5.18694]	(0.02274) [-0.34851]
Δ(RESERVES(-2))	0.044278 (0.05254) [0.84276]	-0.063324 (0.10182) [-0.62190]	-0.097884 (0.17003) [-0.57569]	0.017290 (0.02696) [0.64129]
Δ(RESERVES(-3))	-0.018675 (0.05009) [-0.37285]	-0.050807 (0.09707) [-0.52341]	-0.038793 (0.16209) [-0.23933]	0.026212 (0.02570) [1.01978]
Δ(CREDIT(-1))	-0.616131 (0.25342) [-2.43128]	-0.225965 (0.49113) [-0.46009]	-1.025238 (0.82011) [-1.25012]	-0.218579 (0.13005) [-1.68076]
Δ(CREDIT(-2))	-0.392408 (0.24982) [-1.57078]	-0.427635 (0.48416) [-0.88326]	-0.092932 (0.80846) [-0.11495]	-0.174625 (0.12820) [-1.36212]
Δ(CREDIT(-3))	-0.234680 (0.23922) [-0.98101]	0.992454 (0.46362) [2.14064]	1.546697 (0.77418) [1.99786]	-0.113773 (0.12276) [-0.92677]
C	0.194573 (0.31812) [0.61163]	-0.027620 (0.61654) [-0.04480]	1.591974 (1.02952) [1.54633]	0.384957 (0.16325) [2.35802]
R-squared	0.445304	0.506747	0.551783	0.164512
Adj. R-squared	0.340797	0.413815	0.467337	0.007101
Sum sq. resids	339.0410	1273.437	3550.787	89.28647
S.E. equation	2.216673	4.295999	7.173610	1.137544
F-statistic	4.260967	5.452897	6.534104	1.045114
Log likelihood	-176.1740	-231.0932	-273.6494	-120.8018
Akaike AIC	4.582507	5.905861	6.931310	3.248236
Schwarz SC	4.990504	6.313858	7.339308	3.656233
Mean dependent	0.067989	0.496705	3.600853	0.349398
S.D. dependent	2.730184	5.611087	9.829045	1.141605

The VECM estimates can be summarized using the following equation

$$\Delta(REER) = -0.570453*(REER(-1) - 0.302502365474*CPI(-1) + 0.13626977089 *RESERVES(-1) - 0.94335731799*CREDIT(-1) - 64.3628532796) + 0.239055*\Delta(REER(-1)) + 0.443106*\Delta(REER(-2)) - 0.616131*\Delta(CREDIT(-1))$$

From the above equation we find that commodity price shocks do not significantly explain the impact on exchange rate adjustment except for the level of commodity prices. This could possible due to the fact that even though India imports large amount of commodities, it also exports significant amount of commodities after value-adding. Financial markets (credit to private sector) and level of foreign exchange reserves moderate the impact on the exchange rate adjustment. The impulse response functions (Figure 13) indicate that the impact lasts up to eight quarters after which the effect tends to becomes constant

Fig. 13: Impulse Response Functions of REER



IV. Findings and Conclusions

We find empirical evidence on the impact of global commodity and oil price fluctuations on domestic macroeconomic performance of India. Non-energy commodity and oil price fluctuations significantly explain the variation in output and prices in India. While output is negatively affected, commodity and oil price spikes are inflationary in their impact. Moreover, impact of commodity and oil price shocks on inflation is faster than on output with expected characteristics of negative supply shock driven cost-push inflation in their impact. It is discernible to note that the impact of commodity and oil price spikes last for three quarters whereas their impact on output is more lingering in that they last for eight quarters or more.

The real exchange rate adjusts significantly to oil price shocks in that real exchange rate depreciates just about with two quarter lags but having more lingering effect in that it lasts for eight quarters. The levels of foreign exchange reserves and credit to private sector (financial markets) moderate the commodity and oil price shocks. Since real exchange rate adjustment takes place after two-quarter lags, it provides monetary authority (central bank) a time window to intervene and contain the volatility through intervention. However, as has been observed change in reserve variations are not found to be significant in explaining the exchange rate adjustment. It is not surprising since mostly monetary authority (RBI) in India did not try to target the exchange rate per se, but only contained the volatility in its extreme. In fact, either monetary authority following “leaning against the wind”, i.e., allowing nominal depreciation in the wake of capital flows or in the post-2009-10, or, of late, monetary authority almost followed an hands-off approach in letting exchange rate determined by macroeconomic fundamentals.

However, given that monetary authority moving towards inflationary-targeting framework, it may insulate the inflationary impact of commodity and oil price shocks either by stabilising the exchange rate through active intervention and followed by sterilisation or using interest rate to contain inflationary impact borne out of these shocks. Further, monetary policy actions may be complemented by countercyclical fiscal policy given that commodity and oil price shocks are significant in its impact on output variation.

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