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The Effectiveness of Monetary Policy in India: an ARDL Analysis of Cointegration

KEYWORDS: Monetary Policy Effectiveness, Co-integration, Autoregressive Distributed Lag.

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ABSTRACT *The present study analyzes the effectiveness of monetary policy in India over the period 1991:M4-2014:M9 using Autoregressive Distributed Lag (ARDL) cointegration framework. From analysis, it has been observed that monetary policy is effective to control both prices and output in long-run as well as in short-run.*

1. Introduction

Transmission mechanism describes the process by which an economy will react to monetary shock exercised by the central bank of that nation. The execution of monetary policy may cause a set of changes in macro variables like changes in fiscal market and price levels that leads to inflation. There are many controversies regarding the effectiveness of monetary policy in long-run. The Real Business Cycle (*RBC*) School believed that the quantity of money does not have any effect on real variables in the short-run, so transmission mechanism is very limited and it is better not to study about it. However, other schools, including Keynesians, Monetarism, Neoclassical and Neo-Keynesian believes that monetary shock is effective both in short-run as well as in long-run. Some factors like uncertainty about its effects, effectiveness of various channels, an essential time for the beginning of its effect, durability of effect and the peak of durability are to create different ideas about the transmission mechanism between economists. Therefore, in short-run, the economy can utilize to stabilize economic activities and inflation management. In addition, all economists and the central banks realize this fact that they would have acceptable awareness about the transmission mechanism until it would be effective in performance.

The analysis in this paper is an endeavor to test the hypothesis that output and prices are sensitive to monetary policy shocks in India. The relevance of testing such hypothesis emerges from Classical and Monetarist views about the significance of the monetary policy to target output and prices. Moreover, the analysis of monetary policy transmission mechanism is relevant only if the monetary policy significantly affects the output and prices in country. In the state of insensitive output and prices to monetary policy shocks, the analysis of transmission mechanism becomes redundant. Hence, an attempt has been made to check the presence of relationship between Money Supply, output and prices in India. An additional objective of the present section is to evaluate both long-run and short-run effectiveness of monetary policy in India during the post-reforms period. Given its potential to influence the real economy, monetary policy has been subject to intense academic research over the years. A huge number of economic papers analyzed effectivenss of monetary policy along with the various channels through which monetary policy is transmitted to the real economy.

2. Review of Literature

The literature survey is must to know about the research gaps already existing in the literature. There exist ample studies on analyzing effectiveness of monetary policy internationally and at Indian level. The following are the two sub-sections on the review of international and national studies, respectively.

2.1. Effectiveness of Monetary Policy – An International Experience

Brubakk and Sveen (2009) conducted a new macroeconomic model *NEMO* to analyze the Norwegian economy and monetary policy. The *NEMO* model played a key role in designing the interest rate path. The model is estimated on quarterly data for the period 1981–2007 and has used a Bayesian approach to determine the parameters. The authors described the Norwegian Economy Model *NEMO* which was Nroges Bank's new Forecasting and monetary policy model that it was based on the assumption that Norway with a national currency can determine its own inflation level over time. This model may be referred to as a New Keynesian *DSGE* model that it would be a useful decision making tool in monetary policy. The empirical results have presented that *NEMO* was less accurate in the projecting short-run movement and in the long-run. Also *NEMO* based real exchange rate forecasts were accurate at the longest horizons. Finally, the forecasting properties of *NEMO* are compared with those of alternative models like *VAR* and *BVAR,* consequently, the *NEMO* was relatively accurate compared other models. In this model, the central bank must set the interest rate so that inflation expectations over time are consistent with the inflation target.

Ferman (2011) studied exogenous monetary policy impulses jointly transmit to the US macroeconomic. The study utilized quarterly US data in two periods: 1959:01–1979:03 and 1979:04 –2007:04 and analyzed sample data in two period's pre and post Volcker. The study found that both subsamples monetary policy shocks trigger relevant movements in long run bond premia. Also, there was an exogenous increase in the short rate temporarily basis term premia across different maturities by a statistically significant amount. The main point of this study was the importance of term premium channel in monetary policy. The study measured GAP and INF based on the methodology proposed by stock and Waston (1998) and utilized *VAR* method. The study found that shocks to policy expectations produce more pronounced and more plausible responses to the macroeconomic variables than standard shocks to the contemporane-

Volume : 5 | Issue : 11 | November 2015 | ISSN - 2249-555X

ous value of the monetary policy instrument and it was very important to understand the dynamics of key macroeconomic variables such as inflation and output.

Kasai (2011) has attempted to study analysis of monetary policy rules in South Africa. The study determined an in-sample and out-samples assessment of how The South Africa Reserve Bank managed its policy rate and it compared to forecast performance of linear and nonlinear policy roles. The study used time series data during 2006:01 to 2012:02 and it utilized Generalized Method of Moments (*GMM*) estimators. The study revealed that the model performed better in terms of the goodness of fit when it focused on coincident business cycle indicator. The study found that the nonlinear model was superiority and the South Africa Reserve Bank paid attention to business cycle movement when setting its policy rate. The results are described the concern over the high level of inflation observed during the second semester of 2008 because the SARB's response of monetary policy to the output during the crisis has significantly dropped. Further, there has been a controlled reaction of inflation, output and financial condition that it caused to increase economic uncertainty in the crisis. Also the study found that there was an intermediate target of inflation and a calm reaction to inflation, so the *SARB* behave with some degree of non-responsiveness when inflation is the zone of discretion.

Melosi (2011) studied the interaction between public expectations and monetary policy decision in England. The study illustrated that firms have private information and their expectations are heterogeneous and it designed a channel of monetary transmission, which is based on affecting firm's expectations with the interest rate. So the Dynamic Stochastic General Equilibrium (*DSGE*) to optimize their prices needed to forecast the evolution of their nominal marginal cost when taking their price setting decisions. Data of the study is taken from the survey of professional forecasters as a measure of the price setter's inflation expectations for the year 1970 – 1980. Findings are presented that inflation expectations responded positively to monetary shocks because firms interpret the rise of the policy rate as a response of the central bank to a positive demand shock. Monetary policy has no effect on the dispersion of expectations about output when the central bank was to be successful in coordinating inflation expectations by maneuvering the policy rate. This model introduced two channels of monetary policy: First, the traditional new Keynesian channel based on price stickiness and real interest rate. Second, changing the policy rate conveys non-reluctant information about inflation and out gap to price setters. In sum, the central bank was not allowed to vocally communicate to price setters the state of the economy because the central bank has an incentive to lie and to make surprise inflation so as to raise output and reduce the monopolistic distortion.

Abbassi and Linzert (2012) analyzed the effectiveness monetary policy in steering euro area money market rates. The study explored the predictably of money market rates on the basis of monetary of money market rates on the basis of monetary policy expectations and the impact of extraordinary central bank on money market rates. The main finding of the study has presented a loss in the effectiveness of standard monetary policy during the crises compared to the pre-crises period because changes in euro area money market rates were driven by elevated liquidity premia and become more persistent during the crises. So Euribor rate has become weaker between August 2007 and October 2008. But this loss was compensated by the use of non-standard monetary policy. The ECB's crisis related monetary policy measures were highly effective, reducing euro rates and the uncertainty around the prevailing term money market rates. The study utilized daily data of the three months (3M) six-month (6M) and twelve month maturities of the euro rate. (Sample of study covers the period from 10 March 2004 through 31 December 2009) and has employed the old approach.

Cevik and Teksoz (2013) investigated the effectiveness of monetary transmission in the Gulf Cooperation Council (GCC) countries. A Structural Vector Autoregressive *SVAR* model is performed to analyze. The GCC countries have moved toward closer economic and financial integration, aiming to form a monetary union since 1981. Data collection is done for the year 1990–2010 with quarterly data for individual countries separately and the synthetic GCC aggregate. The estimated results indicated that the interest rate channel had a significant influence on real non-hydrocarbon output and the consumer price index CPI while the exchange rate channel did not appear to have a meaningful role in monetary transmission. Also, there was a dominant role by The Central Bank Lending Channel in transmission monetary shocks and bank lending tented to increase with monetary expansion and the impact of monetary policy shocks dependent on the propagation mechanism. Also the effectiveness of interest rate and bank lending depended on the bank balance sheet. According the impact of supply shock to bank credits, Saudi Arabia and the United Arab Emirate exhibited a greater degree of responsiveness relative to other Gulf countries and credit conditions in the GCC countries appeared to be immune to demand shocks. So real exchange rates could vary and allowed a limited scope for monetary policy to affect real variables through the exchange rate channel. In sum, the empirical analysis has presented that the GCC countries has low and heterogeneous synchronization in non hydrocarbon business cycles. Another important factor in heterogeneous and diverging Fiscal policies was the limited level of intra-regional trade & financial integration and variance in the degree of economic diversification.

2.2. Indian Experience on Effectiveness of Monetary Policy

Joshi and Joshi (1990) have attempted to describe the indicators of monetary policy or : some arguments and evidence. The study utilized data for the *RBI* committee report, *RBI*, 1985 for the data of 1970-1984. The study found that most of the empirical evidence of this study suggests that is a more suitable variable for the money targeting them. The real value of money stock indicates correctly the appropriate monetary stance because the direction of monetary policy in terms of nominal magnitudes is highly misleading.

Rangarajan and Arif (1990) have attempted to describe the money, output and prices: a macro econometric model. The study utilized annual data for the period 1961-1962 to 1984-1985; data sources are national accounts statistics (1970-1971) series of the *CSO* and reports on currency and finance of *RBI*. The study found that the policy simulations show that while a substantial increase in government capital expenditure increases output, its impact on output and prices also depend on the extent of the resource gap met by borrowing from *RBI*. As the proportion of the resource gap met by borrowing from the *RBI* increases, the trade-off between output and prices. As total expenditure has increased at a rate higher than the rate of growth in current revenue the resource gap of government has been widening. An increase in the real output results in a fall in the price level while an increase in money stock will lead to an increase in the price level. Price effects of an increase in money supply are stronger than the output effects.

Volume : 5 | Issue : 11 | November 2015 | ISSN - 2249-555X

Srimany and Samantha (1998) have attempted to describe the identification of monetary policy shock and its effects on output and price: a structural *VAR* approach. The study utilized analysis covered the period July 1991 to March 1997, data source is the website of *SBI*. They emphasized on the difference between two components of monetary policy action-feedback component and exogenous policy shocks and identified the component of RBI policy action when other variables were not reactive. The study found that structural *VAR'S* results showed that monetary shocks exert significant effect on output and prices for the substantial period. A theoretical standard *VAR* may lead to sub optimal results, so structural *VAR* analysis based on economic theories is better. The statistical results indicated the policy was reasonably tight during October 1992 to March 1993 while it was easy during October 1991 to March 1992 and April 1994 to September 1994. In the rest of period, a neutral policy stance was in evidence.

Mohanty and Mitra (1999) have attempted to describe the experience with monetary targeting in India. The study utilized Argy.V et al.(1989), monetary targeting: the international experience, studies in money and credit, reserve bank of Australia, Oct., *BIS* annual report, various issues, *RBI* annual report, various issues, circulars issued by credit planning cell/monetary policy department *RBI*. The study found that *RBI* has explicitly preferred to adopt multiplier indicator approach. Not with standings the reasonable stability of the money demand function, the expansion of money supply emanating from monetization of government deficit and in more recent periods from capital flows rendered the control of monetary aggregates more difficult. In India, the monetary targeting exercise produced a mixed result during 13 years (1985-1998). The inflation rate in developed countries came down during the targeting period, but it could not be entirely attributed to monetary targeting exercise. In developed countries, where financial sector innovations and deregulation fostered integration of financial markets and cross-border flows of capital, the effectiveness of monetary targeting, the use of unremunerated reserves based operating procedure and direct controls diminished over time.

Bhattacharyy and Sensarma (2005) have attempted to describe signaling of instruments of monetary policy: the Indian experience. The study utilized data for the period 1996:M4-2004:M3 is collected from handbook of statistics on Indian economy 2003-2004 and various issues of *RBI* bulletin. The study found that instantaneous impact of monetary policy signals on most financial markets points towards increasing integration and sophistication of markets. Increasing reliance on indirect instruments, great market integration and technological innovations improved the channels of communication between *the RBI* and the financial markets and facilitated the conduct of monetary policy. The signaling role of monetary policy is effective in case of India, empirical evidence favors rate channel.

Mohanty (2010) has attempted to describe the monetary policy framework in India: experience with multiple indicators approach. The study utilized data sources report on currency and finance 2005-2006 and annual report 2008-2009, *RBI*. The study found that this improved performance of monetary policy was facilitated by the supportive fiscal policy. Performances of indicators of economic growth have improved a lot during multiple indicator approach.

3. Database and Methodology

We use Indian monthly data mainly sourced from the RBI database. The sample ranges from 1991:M4 to 2014:M9, which is confined to the post-reform period in India. Wholesale Price Index(WPI)has been used as an inflation variable, Index of Industrial Production(IIP)has been taken as a proxy variable for real output because the monthly series of GDP for the period covered under the study is not available and the Broad measure of Money Supply $(i.e., M_3)$ has been used as the liquidity measure in India. Any policy shock by RBI targets money supply and thus, money supply variations are supposed to reflect the movement of monetary policy. These movements, if got successfully translated to output and prices, are referred to represent the effective monetary policy. Otherwise, if the effect of money supply changes is insignificant, the monetary policy is said to be ineffective.

The Autoregressive Distributed Lag (ARDL) models are known as powerful time saving tools for estimating different variables. The ARDL models are standardized least squares regression which includes lags of both the dependent and explanation variables as regressores (Greene 2008). At first, it is necessary to explain about the origin of The ARDL in econometric. The Almon estimator could actually be re-written as a restricted least squares estimator. The Almon's approach allowed restrictions to be placed on the shape of the "decay path" of the gamma coefficients, as well as on the values and slopes of this decay path at the endpoints, $t=0$ and $t=q$. The Almon's estimator is still included in a number of econometric packages, including reviews. The main characteristic of ARDL is to examine long-run and co-integration relationships between variables hence it has been become famous in econometric in recent years. In its basic form, an ARDL regression model looks like this:

$$y_t = \alpha + \sum_{i=1}^{p} \gamma_i y_{t-i} + \sum_{j=1}^{k} \sum_{i=0}^{q_j} X_{j,t-i}{}' \beta_{j,i} + \varepsilon_t \qquad (1)$$

Some of the explanatory variables, X_j , may have no lagged terms in the model ($q_j = 0$). These variables are called static or fixed regressors. Explanatory variables with at least one lagged term are called dynamic regressors.

Given the presence of lagged values of the dependent variable as regressors, OLS estimation of an ARDL model will yield *biased* coefficient estimates. If the disturbance term, ε_t , is autocorrelated, the OLS will also be an *inconsistent* estimator, and in this case Instrumental Variables estimation was generally used in applications of this model. Before using ARDL model, it would be determined number of lags of each variable. Of course, there are many simple methods selection estimate lags like standard Akaike, Schwarz and Hannan-Quinn, etc. The model can be transformed into a long-run representation. It means that the long-run response of the dependent variable can be converted to the explanatory variable.

$$\theta_j = \frac{\sum_{i=1}^{q_j} \hat{\beta}_{j,i}}{1 - \sum_{j=1}^{p} \gamma_i} \qquad (2)$$

3.1. Cointegrating relationship

Traditional methods of estimating cointegrating relationships, such as Engle-Granger (1987) or Johansen's (1991, 1995) method, or single equation methods such as Fully Modified OLS, or Dynamic OLS either require all variables to be I(1), or require prior knowledge and specification of which variables are I(0) and which are I(1). To alleviate this

Volume : 5 | Issue : 11 | November 2015 | ISSN - 2249-555X

problem, Pesaran and Shin (1999) showed that cointegrating systems can be estimated as ARDL models, with the advantage that the variables in the cointegrating relationship can be either I(0) or I(1), without needing to pre-specify which are I(0) or I(1). Pesaran and Shin also note that unlike other methods of estimating cointegrating relationships, the ARDL Representation does not require symmetry of lag lengths; each variable can have a different number of lag terms.

The cointegrating regression form of an ARDL model is obtained by transforming (1) into differences and substituting the long-run coefficients from (2):

$$EC_t = y_t - \alpha - \sum_{j=1} X_{j,t}'\hat{\theta}_j$$

$$\hat{\phi} = 1 - \sum_{i=1}^{p} \hat{\gamma}_i$$

$$\gamma_i^* = \sum_{m=i+1}^{p} \hat{\gamma}_m$$

$$j,i^* = \sum_{i=0}^{q_j} \beta_{j,m}$$

$$\Delta_{yt} = -\sum_{i=1}^{p-1} \gamma_i * \Delta y_{t-1} + \sum_{j=1}^{k} \sum_{i=0}^{q_j-1} \Delta X_{j,t-i}'\beta_{j,i^*} - \hat{\phi} EC_{t-1} + \varepsilon_t \qquad (3)$$

Where

The standard error of the cointegrating relationship coefficients can be calculated from the standard errors of the original regression using the delta method.

3.2. Bounds Tests

If there are a group of time-series with long-run relationships some of each may be stationary, while are not so it can be used Bound test. First, recall that the basic form of an ARDL regression model is:

$$y_t = \alpha + \sum_{i=1}^{p} \gamma_i y_{t-i} + \sum_{j=1}^{k} \sum_{i=0}^{q_j} X_{j,t-i}'\beta_{j,i} + \varepsilon_t$$

The Bounds test procedure transforms into the following representation:

$$\Delta_{yt} = -\sum_{i=1}^{p-1} \gamma_i * \Delta y_{t-1} + \sum_{j=1}^{k} \sum_{i=0}^{q_j-1} \Delta X_{j,t-i}'\beta_{j,i^*} - \rho y_{t-1} - \alpha - \sum_{j=1}^{k} X_{j,t-1}'\delta_j + \varepsilon_t$$

The test for the existence of level relationships is then simply a test of

$$\rho = 0$$

$$\delta_1 = \delta_2 = \ldots = \delta_k = 0$$

Where ε_t is a random "disturbance" term, which we'll assume is "well-behaved" in the usual sense? In particular, it will be serially independent. We're going to modify this model somewhat for our purposes here. Specifically, we'll work with a mixture of differences and levels of the data. Let's suppose that we have a set of time-series variables, and we want to model the relationship between them, taking into account any unit roots and/or cointegration associated with the data. First, note that there are three straightforward situations that we're going to put to one side, because they can be dealt with in standard ways:

1. We know that all of the series are I(0), and hence stationary. In this case, we can simply model the data in their levels, using OLS estimation, for example.

2. We know that all of the series are integrated of the same order (*e.g.*, I(1)), but they are not cointegrated. In this case, we can just (appropriately) difference each series, and estimate a standard regression model using OLS.

3. We know that all of the series are integrated of the same order, and they *are* cointegrated. In this case, we can estimate two types of models: (i) An OLS regression model using the *levels* of the data. This will provide the long-run equilibrating relationship between the variables. (ii) An error-correction model (ECM), estimated by OLS. This model will represent the short-run dynamics of the relationship between the variables. *Some* of the variables may *be* stationary, some *may be* I(1) or even fractionally integrated, and there is also the possibility of cointegration among some of the I(1) variables. What do we do in such cases if we want to model the data appropriately and extract both long-run and short-run relationships? This is where the ARDL model enters the picture. The ARDL / Bounds Testing methodology of Pesaran and Shin (1999) and Pesaran et al. (2001) has a number of features that many researchers feel give it some advantages over conventional cointegration testing. For instance:It can be used with a mixture of I(0) and I(1) data.It involves just a single-equation set-up, making it simple to implement and interpret.Different variables can be assigned different lag-lengths as they enter the model.

We need a road map to help us. Here are the basic steps that were going to follow (with details to be added below): 1. Make sure than none of the variables are I(2), as such data will invalidate the methodology; 2. Formulate an "unrestricted" error-correction model (ECM). This will be a particular type of ARDL model; 3. Determine the appropriate lag structure of the model in step-II; 4. Make sure that the errors of this model are serially independent; 5. Make sure that the model is "dynamically stable"; 6. Perform a "Bounds Test" to see if there is evidence of a long-run relationship between the variables; 7. If the outcome at step 6 is positive, estimate a long-run "levels model", as well as a separate "restricted" ECM. Use the results of the models estimated in step 7 to measure short-run dynamic effects, and the long-run equilibrating relationship between the variables.

4. Preliminary Analysis: Testing Seasonal and Regular Unit-Roots

As discussed above, the analysis of order of integration is important to apply the cointegration analysis. Thus, the present section entails to search out the existence of seasonal and regular unit-roots; also the structural breaks in moments and time series properties have been analyzed in the monthly time series data of three aforesaid variables over the period 1991:M4 to 2014:M9. Before using the pervious mentioned series in regression analysis, preliminary analysis of testing seasonal and regular unit-roots is required. The use of HEGY test statistics has been preferred to analyze the existence of seasonal roots (i.e., problem of seasonality), while alternative tests statistics such as Augmented Dickey-Fuller (ADF), Philips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) have been utilized to test the presence of regular unit root. The existence of structural breaks has also been tested using the Chao test statistics for the stability of parameters.

Table 1 provides the estimated values of HEGY test statistics

Volume : 5 | Issue : 11 | November 2015 | ISSN - 2249-555X

along with the tabulated values of each statistics in parenthesis. Following Charemza and Deadman (1997; pp 108), it can be concluded that there exists unit root in all the time series selected for the analysis purpose. In HEGY test $|t(\pi_1)|$ and $|t(\pi_2)|$ are less than tabulated value of *t* at 5 percent level of significance. Thus, the null hypothesis of unit root cannot be rejected among the time series under considerations. In addition, the use of HEGY test also refutes the existence of any-type of seasonality in $LWPI$, $LIIP$ and LM_3 series. As observed, all $F(\pi_i, \pi_{i+1})$ are statistically significant for each monthly series under evaluation; the null hypotheses of conjugate complex root can be rejected. It also substantiates the absence of periodicity in the data series. In sum, the application of HEGY test reveals the absence of seasonality and periodicity, and confirms the presence of regular unit-root in all the three variables to be used for analyzing the sensitivity of output and prices to monetary policy shocks.

The existence of unit-root in level series therefore, compels the need of testing accurate order of integration at which these series become stationary. As identified earlier in Table 2 that all the three series have regular unit-root, the alternative test statistics namely, ADF, PP and KPSS have been utilized to check the order of integration of all the three variables under evaluation. Tables 2 to 4 provide various unit-root test statistics using three alternative models; namely with drift and trend, with drift only, and without drift and trend. These statistics have been obtained for level and first differenced series. In ADF test, $Ln(WPI)$, $Ln(IIP)$ and $Ln(M_3)$ are integrated at levels. While KPSS test statistics results presents that $Ln(IIP)$ and $Ln(M_3)$ are level stationary and $Ln(WPI)$ is integration; PP-test shows that $Ln(IIP)$ and $Ln(M_3)$ are level integration and $Ln(WPI)$ is stationary. In sum, majority of unit-root test statistics reveal that thre variables ($Ln(WPI)$, $Ln(IIP)$, $Ln(M_3)$) are integrated of first order.

Table 1: Testing Seasonality and Unit root Using Hylleberg-Engle-Granger-Yoo (HEGY) Test

Test Statistics	HEGY Test		
	$Ln(IIP)$	$Ln(WPI)$	$Ln(M_3)$
$t(\pi_1)$	1.7045 (-3.35)	2.1971 (-3.35)	1.9447 (-3.35)
$t(\pi_2)$	1.9640 (-2.81)	2.1493 (-2.81)	1.9812 (-2.81)
$F(\pi_3 - \pi_4)$	6.4354*** (6.35)	18.0597*** (6.35)	7.8815*** (6.35)
$F(\pi_5 - \pi_6)$	22.8168*** (6.48)	13.6389*** (6.48)	17.7450*** (6.48)
$F(\pi_7 - \pi_8)$	16.6288*** (6.30)	16.8275*** (6.30)	17.4901*** (6.30)
$F(\pi_9 - \pi_{10})$	14.2412*** (6.40)	14.0778*** (6.40)	19.0668*** (6.40)
$F(\pi_{11} - \pi_{12})$	16.7408*** (6.46)	20.5421*** (6.46)	13.5488*** (6.46)
$F(\pi_1 - \pi_{12})$	17.8616*** (4.44)	17.3208*** (4.44)	15.7477*** (4.44)
$F(\pi_2 - \pi_{12})$	18.8259*** (4.58)	18.0566*** (4.58)	16.2641*** (4.58)

Note: i) See Franses, P.H. and Hobijn, B. (1997), "Critical values for unit root-tests in seasonal time series", ***Journal of Applied Statistics***, 24: 25-46, for Numbers from all the tables. The tabulated values for each statistics have been given in parenthesis of type ( ); ii) ***, ** represent significance at 1, 5 and 10 percent, respectively.

Source: Author's Calculations

Table 2: Testing Unit-Root Using Augmented Dickey-Fuller Test

Variables Drift		With Drift and Trend			With Drift Only		Without Drift and Trend	Decision About Order of Integration
		Trend	ADF-Statistics	Drift	ADF-Statistics	ADF-Statistics		
$Ln(WPI)$	Level	0.1392*** (0.0008)	0.0002*** (0.0017)	-3.2754* (0.0725)	0.0089* (0.0549)	-1.1789 (0.6842)	6.8073 (1.0000)	$I(1)$
	First Difference	0.0041*** (0.0000)	-4.32E-06 (0.3775)	-11.6920*** (0.0000)	0.0035*** (0.0000)	-11.6634*** (0.0000)	-6.4161*** (0.0000)	
$Ln(IIP)$	Level	0.2277** (0.0506)	0.0003* (0.0813)	-1.8760 (0.6642)	0.0268* (0.0988)	-1.2369 (0.6589)	2.5348 (0.9974)	$I(1)$
	First Difference	0.0104** (0.0121)	-2.03E-05 (0.3005)	-3.5684** (0.0345)	0.0070*** (0.0060)	-3.4456** (0.0103)	-2.0244** (0.0413)	
$Ln(M_3)$	Level	0.2647** (0.0440)	0.0004 (0.0565)	-1.9382 (0.6316)	0.0145** (0.0224)	-0.7829 (0.8219)	2.2196 (0.9939)	$I(1)$
	First Difference	0.0114*** (0.0019)	-4.75E-06 (0.4687)	-3.2809* (0.0716)	0.0103*** (0.0021)	-3.2102** (0.0205)	-0.8623 (0.3416)	

Note: *,**, and *** represents significance at 10, 5, and 1 percent levels of significance, respectively.

Source: Author's Calculations

Table 3: Testing Unit-Root Using Philips- Perron Test

Variables Drift		With Drift and Trend			With Drift Only		Without Drift and Trend	Decision About Order of Integration
		Trend	PP-Statistics	Drift	PP-Statistics	PP- Statistics		
$Ln(WPI)$	Level	0.1383*** (0.0014)	0.0002*** (0.0036)	-3.0731 (0.1153)	0.0128*** (0.0080)	-1.4011 (0.5818)	10.7467 (1.0000)	$I(0)$
	First Difference	0.0041*** (0.0000)	-4.32E-06 (0.3775)	-11.3699*** (0.0000)	0.0035*** (0.0000)	-11.3444*** (0.0000)	-9.1207*** (0.0000)	

Volume : 5 | Issue : 11 | November 2015 | ISSN - 2249-555X

$Ln(IIP)$	Level	1.2440*** (0.0000)	-0.0018*** (0.0000)	-7.6667*** (0.0000)	0.0504 (0.1439)	-1.0818 (0.7236)	5.4203 (1.0000)	$I(1)$
	First Difference	0.0105* (0.0876)	-2.10E-05 (0.5751)	-52.7386*** (0.0001)	0.0075** (0.0140)	-46.6085*** (0.0001)	-28.8643*** (0.0000)	
$Ln(M_3)$	Level	0.3047** (0.0315)	0.0004** (0.0424)	-1.9557 (0.6223)	0.0174*** (0.0014)	-0.9451 (0.7728)	23.0107 (1.0000)	$I(1)$
	First Difference	0.0134*** (0.0000)	-5.22E-06 (0.4736)	-16.6049*** (0.0000)	0.0126*** (0.0000)	-16.5912*** (0.0000)	-9.4465*** (0.0000)	
Note: *,**, and *** represents significance at 10, 5, and 1 percent levels of significance, respectively.								
Source: Author's Calculations								

Table 4: Testing Unit-Root Using Kwiatkowski-Phillips-Schmidt-Shim Test

Variables Drift		With Drift and Trend			With Drift Only		Without Drift and Trend	Decision About Order of Integration
		Trend	KPSS-Statistics	Drift	KPSS-Statistics	KPSS-Statistics		
$Ln(WPI)$	Level	3.8375*** (0.0000)	0.0048*** (0.0000)	0.2164*** [0.146]	4.5157*** (0.0000)	1.9574*** [0.463]	N.A.	$I(1)$
	First Difference	0.0063*** (0.0000)	-6.63E-06 (0.1981)	0.1956** [0.146]	0.0053*** (0.0000)	0.2671 [0.463]	N.A.	
$Ln(IIP)$	Level	3.7590*** (0.0000)	-0.0056*** (0.0000)	0.1415 [0.146]	4.5390*** (0.0000)	1.9641*** [0.463]	N.A.	$I(0)$
	First Difference	0.0068 (0.3266)	-1.27E-05 (0.7666)	0.5000*** [0.146]	0.0050 (0.1464)	0.5000*** [0.463]	N.A.	
$Ln(M_3)$	Level	7.9152*** (0.0000)	0.0130*** (0.0000)	0.1204 [0.146]	9.7466*** (0.0000)	1.9809*** [0.463]	N.A.	$I(0)$
	First Difference	0.0136*** (0.0000)	-5.73E-06 (0.4275)	0.0845 [0.146]	0.0128*** (0.0000)	0.1289 [0.463]	N.A.	
Note: i) Tabulated values of KPSS-statistics at 10, 5,and 1 percent levels of significance are 0.119, 0.146, 0.216; and ii)*,**, and *** represents significance at 10, 5, and 1 percent levels of significance, respectively.								
Source: Author's Calculations								

Thus, some test support the stationarity of seris at levels and some other support stationarity at first difference. The analysis lacks consensus among various tests on order of integration of the time series under evaluation. However, the series are either stationary at levels or at maximum of degree one. The next step is to test the existence of structural breaks among the variables under consideration. For cointegration analysis with $Ln(IIP)$ as dependent variable, the analysis of the existence of structural break in $Ln(IIP)$ is needed. However, the existence of structural breaks in other endogenous variables of the model may distort the short-run *VECM* results wherein all the differenced series of first order are regressed upon differenced series of remaining endogenous and exogenous variables. Thus, an analysis of the existence of structural break has been performed. Table 5 provides information on structural break observed in each time series under evaluation. From analysis, a unique structural break has been observed in each variable and thus, the existence of multiple breaks in one series has been avoided. The dependent variable $Ln(IIP)$ has been observed with a significant break in April, 1992 and thus, entails the need of including structural dummy for the said month in analysis of the cointegartion relationships having $Ln(IIP)$ as dependent variable. In the remaining two endogenous variables, structural breaks observed in various months have been identified and provided in the same table too.

After getting the structural breaks, the next step is to search the optimum lag-length. The optimum lag length may be observed using the SBC and AIC criterion; under this method SBC and AIC values of Vector Autoregressive (*VAR*) model estimated for various combinations of lag-length are used. In the light of observed results, i.e. absence of seasonality and presence of structural break, the *VAR* models with exogenous structural dummies have been estimated for various lag lengths.

Table 5: Structure for Break

Variable	Structural Break Date
$Ln(WPI)$	1998 October (M10)
$Ln(IIP)$	1992 April (M04)
$Ln(M_3)$	2006 March (M03)
Source: Author's Calculations	

Table 6 provides SBC and AIC values of these models. As quoted in the econometrics literature that the lag-length corresponding to minimum SBC and AIC values is the optimum lag-length. However, if any clash emerges between the two criterions then one must decide the optimum lag length based on SBC criteria. The same controversy has been observed in our case too; AIC is minimum with 1-8 lag length and SBC is minimum with 1-2 lag length. Thus, we go with 1-2 lag length and decide the lag length 1-2 for testing the presence of co-integration relationship(s) under Johansen's criterion.

Volume : 5 | Issue : 11 | November 2015 | ISSN - 2249-555X

Table 6: Lag Length Selection for Cointegration Analyses Using VAR					
Lag	LR	FPE	AIC	SC	HQ
0	NA	5.65e-06	-3.571005	-3.531446	-3.555127
1	3574.370	1.07e-11	-16.74372	-16.58548	-16.68021
2	120.1221	7.31e-12	-17.12792	-16.85100*	-17.01677
3	17.38836	7.31e-12	-17.12809	-16.73250	-16.96931
4	40.51781	6.69e-12	-17.21764	-16.70336	-17.01122
5	40.27760	6.11e-12	-17.30806	-16.67511	-17.05401
6	13.61328	6.19e-12	-17.29575	-16.54412	-16.99407
7	46.08743*	5.50e-12*	-17.41295*	-16.54263	-17.06363*
8	13.02666	5.58e-12	-17.39957	-16.41058	-17.00261
Source: Author's Calculations					

In the light of above findings, it has been observed that all the endogenous variables are either non-stationary or integrated of first order. Further, neither of the seasonality and periodicity problems have been observed in the time series under evaluation. The structural breaks are significant among all the series and so must be included in the co-integration model. The trend and drift components are significant in the level series of dependent variable and therefore must be included in co-integration vector(s). In sum, the co-integration model with intercept and a trend component along with three structural breaks as exogenous variables has been selected for the analysis purpose.

5. Sensitivity of Output and Price to Monetary Policy Shocks in India: An ARDL Analysis

From the mixed evidences on order of stationarity, it is evident that the application of Johanson cointegration test is not feasible. Thus, the Auto-regressive and Distributed Lag (ARDL) methodology has been used to test the hypothesis whether there exists long-run relationship between money supply and national out along with testing whether the money supply significantly affect the aggregated price level or not. The earlier hypothesis has been tested with IIP as dependent variable and M_3 as independent variable while, to test the later hypothesis, the dependent variable has been replaced with *WPI*. The structural breaks in IIP has been included in first relationship while the break in WPI has been included on the right hand side in testing the second hypothesis.

However, before applying the ARDL test, the use of bound test is mandatory to check whether there exists long-run relationship among the variables under consideration or not? Table 7 provides the F-Statistics obtained for both equations; both observed to be greater than upper bound values of 1 percent level of significance. Thus, it may be concluded that there exists a long-run relationship between money supply and output and Money supply and price levels.

Table 7: ARDL Bounds Test		
Equation	**F-Statistics**	**Degree of Freedom**
IIP as Dependent	8.792	1
WPI as Dependent	6.356	1
Critical Value Bounds		
Level of Significance	**I0 Bound**	**I1 Bound**
10%	3.02	3.51
5%	3.62	4.16
2.5%	4.18	4.79
1%	4.94	5.58
Source: Authors' Calculations		

The following is the long-run relationship between money supply (M_3) and real output derived using *ARDL* Co-integrating Framework:

$$Ln(IIP) = 0.6899 - \underset{(0.0690)}{0.206}(SbreakLIIP) + \underset{(0.0000)}{0.427^{***}}Ln(M_3)$$

From the said equation, it may be inferred that the money supply positively affect the real output in economy. A one percent increase in money supply will enhance 0.427 percent output (i.e., IIP) in Indian economy. Hence monetary policy is effective in controlling the level of output in economy. The next step is to test long-run relationship between money supply and prices. The following is the equation that represents the effect of monetary policy on prices.

$$Ln(WPI) = 0.8476 - \underset{(0.0394)}{0.064}(SbreakLWPI) + \underset{(0.0000)}{0.386^{***}}Ln(M_3)$$

It may be noticed that the elasticity is to the tune of 0.386 i.e., a one percent increase in money supply will enhance the price level by 0.386 percent. The P-value is zero and thus, the observed elasticity is statistically significant too. In sum, the monetary policy is effective in controlling the prices in Indian economy too. A comparison of the two elasticities, obtained in two models, substantiates the fact that the effect of monetary policy is marginally higher on output than the prices; the output elasticity is 0.427 while price elasticity of M_3 is 0.386.

The next step involves the test of stability in the observed relationships; i.e., if some disequilibrium arises then how much time it will take to correct the disequilibrium. For this purpose, Vector Error Correction (VEC) principle is used. Table 8, provides the error-correction term of both of the co-integration relationships. The principle says that these error correction terms must be negative and significant to ensure the equilibrium. However, the speed of adjustment in a monthly dataset can be determined using the formula $12/Ecm_{t-1}$. In case of output, the same number comes out to be 68 months i.e., 5.68 years. In simple, if there arises the disequilibrium in the long-run relationship between money supply and output, it will take around six years to restore it back. In case of price level adjustment to monetary shocks, the adjustment to equilibrium will take much long period of approximately 21 years. Thus, convergence to equilibrium is slow in both of the cases.

Table 8: ARDL Co-integrating Form		
Variables	**D(LIIP)**	**D(WPI)**
Sample Estimates of EC Term	-0.176092*** [-6.192442]	-0.046730*** [-4.592162]
Notes: *,**, and *** represents significance at 10, 5, and 1 percent levels of significance, respectively.		
Source: Author's Calculations		

In addition to the analysis of the error-correction term, the short-run effect of the monetary policy may be analyzed using the other coefficients of cointeration/VEC form of the two models.

The growth (i.e., first difference of natural log of both dependent variables IIP and WPI) have been regressed upon the first differenced lagged terms of money supply and the lagged cointegration terms. The lagged cointegration term's coefficient has already been discussed. However, the remaining coefficients given in Table 9 are being utilized to explain the short-run effectiveness of monetary

Volume : 5 | Issue : 11 | November 2015 | ISSN - 2249-555X

policy. From the Table 9, it may be inferred that the monetary policy is not instantaneously effective i.e., the growth of money supply $\Delta Ln(M_3)$ will not effect the growth of real output and prices; the coefficient of $\Delta Ln(M_3)$ is statistically insignificant in both of the equations. However, the coefficient of $\Delta Ln(M_3)_{t-1}$ is significant in both of the equations; the inflation rate (i.e., $\Delta Ln(WPI)$) is being positively affected by the growth of money supply in short-run too while, the short-run effect of growth of money supply on real output is negative. As per the Keynesians theory, if inflation is of demand pull nature it will positively effect the level of output however, a cost push inflation will adversely affect the level of output in economy.

Table 9: ARDL Cointegration Form Inflation Expectations					
IIP Depended			**WPI Depended**		
Variable	**Coefficient**	**P-values**	**Variable**	**Coefficient**	**P-values**
D(LIIP(-1))	-0.376826	0.0000	**D(LWPI(-1))**	0.291373	0.0000
D(LIIP(-2))	0.087499	0.1757	**D(LWPI(-2))**	0.085158	0.4782
D(LIIP(-3))	0.247439	0.0000	**D(LM_3)**	-0.032540	0.0741
D(LM_3)	0.289138	0.2296	**D(LM_3(-1))**	0.081771	0.0000
D(LM_3(-1))	-1.373874	0.0000	**D(SBREAK_LWPI_)**	0.011351	
D(SBREAK_LIIP_)	-0.211070	0.0000	**ECM term i.e., CointEq(-1)**	-0.046730	
ECM term i.e., CointEq(-1)	-0.176092	0.0000			

Source: Author's Calculations

6. Summary and Conclusions

The study is based on the analysis of effectiveness of monetary policy to control the output and prices in Indian economy during post-reforms era. To pursue our objective monthly data on three variables IIP, WPI and M_3 has been used for the period 1991:M4 – 2014:M9. First of all, using HEGY test, the presence of seasonal and regular unit roots has been tested. Both of these statistics confirms the presence of regular unit root in all three variables and seasonality only in M_3 series. To confirm the order of integration, ADF, PP and KPSS tests statistics have been executed. The analysis of three test statistics provides mixed evidences regarding the order of stationarity among the three series $Ln(IIP)$, $Ln(WPI)$ and $Ln(M_3)$. Further, the *VAR* system has been estimated with various lag lengths assuming that all of our selected variables are endogenous in this model. The lag length varies from minimum permissible lag length to the maximum. For all the models estimated for divers lag lengths the values of Akaike information criteria (AIC) and Schwarz Bayesian criteria (SBC) have been perceived. The analysis of structural break reflects that the dependent variable $Ln(IIP)$ has a significant break in April, 1992 and thus, entails the need of including structural dummy for the said month in analysis of the co-integration relationships having $Ln(IIP)$ as dependent variable. As quoted in the econometrics literature that the lag-length corresponding to minimum SBC and AIC values is the optimum lag-length. However, if any clash emerges between the two criterions then one must decide the optimum lag length based on SBC criteria. The same controversy has been observed in our case too; AIC is minimum with 1-7 lag length and SBC is minimum with 1-2 lag length. Thus, we go with 1-2 lag length and decide the lag length 1-2 for testing the presence of co-integration relationship(s) under ARDL criterion.

The use of bound test reveals the existence of cointegration relationship among M_3 and *IIP* variables in first model and between M_3 and *WPI* variables in second model. In sum, the monetary policy observed to be effective in long-run. Both dependent variables (i.e., IIP and WPI) found to be positively and significantly affected by M_3 in long-run; the observed elasticities are less than unity and almost near 0.4.

The short-run effectiveness of money supply reflects that inflation is positively and significantly effected by one period lag of exercise of monetary policy; a contractionary monetary policy will reduce the inflation rate and vice-versa. However, the short-run effect of monetary policy is negative. A higher level of money supply is observed to increase the prices in short-run and these enhanced priced supposed to be adversely affecting the level of output because of rising factor prices in short-run. In long-run when firms realize that due to increase in money supply not only factor prices have increased but also the demand has increased, they start increasing the level of output. Thus, the output level is observed to be positively affected in the long-run. In sum, the money supply is observed to be significantly affecting both real output and prices significantly in India.

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