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# THE IS CURVE AND MONETARY POLICY TRANSMISSION IN INDIA: A NEW KEYNESIAN PERSPECTIVE

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# THE IS CURVE AND MONETARY POLICY TRANSMISSION IN INDIA: A NEW KEYNESIAN PERSPECTIVE

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## Abstract

The present study assesses the empirical performance of the New Keynesian IS model by estimating the standard as well as extended specifications of both the backward looking and hybrid models in India over the period 1998Q1 to 2015Q4. It is found that the backward looking IS model fits the data quiet well in comparison to hybrid model. The link between the policy rate and the output gap appeared to be stronger in the extended backward looking IS model as the interest rate coefficient is of greater magnitude than the baseline IS model. Also, besides interest rate, the real exchange rate, external demand and crude oil prices have an impact on the aggregate demand. The results suggest that the standard specification of the IS curve is inadequate to identify the link between the interest rate and aggregate demand and therefore a broader framework which accounts for the additional variables besides interest rate may be required.

*Keyword*: New Keynesian, Monetary Policy, aggregate demand.

*JEL Codes*: E520, E120, C360, E510.

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***"…..and contrary to what some economists might have predicted, the effort to integrate Keynesian-type elements into a dynamic GE framework has gone beyond providing rigorous micro foundations to some pre-existing, though largely ad-hoc, framework."***

*Gali (2002).*

## 1. INTRODUCTION:

In the aftermath of the seminal work by Kydland and Prescott (1982) and Long and Plosser (1983) and Prescott (1986), the Real Business Cycle (RBC) theory provided the essential framework for the analysis of economic fluctuations by introducing the use of dynamic stochastic general equilibrium (DSGE) models as a tool for macroeconomic analysis, where the inter-temporal optimization problems of individuals and firms along with rational expectations assumed the central role. The RBC theory constituted three important claims, such as the efficiency of business cycles, the technology shocks and its role in economic fluctuations, and meagre role of monetary factors. However, the RBC models failed to gain popularity among the central bankers, who continued to use large scale macroeconomic models which were under severe criticism from Lucas (1976). Since, the RBC theory was based on the central assumption of fully flexible prices and wages, the model constructed underlying RBC theory predicted neutrality of money and had no relevance in the policy evaluation. Furthermore, the real variables were modelled in complete isolation of nominal variables and therefore the monetary policy was assumed to have no relevance regarding economic activities (Woodford, 2003b). However, in contrast to this, there was a strong belief among the central bankers that monetary policy is non-neutral in relation to real variables at least in the short run. This view was largely supported by the empirical work of Friedman and Schwartz (1963) and Christiano, Eichenbaum, and Evans (1999, 2005).

The first two generations of the general equilibrium models such as "New Classical" models (Lucas, 1972) and "the real business cycle" models pioneered by Kydland and Prescott (1982), and Long and Plosser (1983), failed to be a suitable tool for monetary policy analysis. The inability of these models to be used in the policy analysis led to the emergence of new Keynesian theory. The New Keynesian approach to macroeconomics evolved in response to the Lucas critique and as an alternative to

the competitive flexible price framework of the real business cycle theory (Goodfriend and King, 1997). The models based on the New Keynesian theory combines the DSGE framework of RBC models with some additional assumptions which are missing in the RBC framework, such as monopolistic competition, nominal rigidities, *etc*. Therefore, the models which combine the Keynesian short run analysis with neoclassical long run analysis are called as "New Neoclassical synthesis" (Goodfriend and King, 1997). The assumption of infinitely living households, maximizing utility from consumption and leisure subject to budget constraint which was at the core of RBC theory, has also been retained in the New Keynesian model. The assumption of nominally rigid prices and wages in the New Keynesian models makes the monetary policy non-neutral in the short run. In the presence of nominal rigidities in the short run, a change in the short term interest rates by central bank leads to a change in the real rate interest rates, which eventually brings about change in optimal consumption and investment decisions of households and firms, that in turn determine the output, inflation and employment in the economy. On the other hand, in the long run prices and wages adjust fully in proportion to initial change in the interest rates and the monetary policy becomes neutral. The non-neutrality of monetary policy in the short run makes it an important tool to intervene to enhance the welfare when the distortionary shocks hit the economy (Gali, 2008b). Since in the inter-temporal maximization problem the behaviour of the economic agents depend on the future as well as current course of monetary policy actions, the credibility of monetary policy gains importance (Clarida, Gali, and Gertler, 1999).

The monetary policy formulated by the central bank has significant role to perform in shaping the outcomes of macroeconomic variables. The policy decisions have a significant impact on the consumption and investment decisions of individuals and firms as changes in the policy instruments such as interest rates directly affects the prices of financial assets and the expected returns from them (Gali, 2008b). Those decisions of the individuals and firms, eventually, determine the output, inflation and employment in the economy. It is important therefore to understand how the policy decisions have an impact on the nominal as well as real variables in the economy. The monetary theory provides us with an account of the process through which that impact occurs, called as the transmission mechanism of monetary policy.

The development of a model of the monetary transmission mechanism with clear micro-foundations in individual optimization is important because it helps to evaluate alterative monetary policies without being subject to the Lucas critique and the outcomes resulting from alternative policies can be evaluated by accounting for the preferences of private individuals that are given in the structural relations of the model (Woodford, 2003b). Also, the choice of monetary policy objective depends on a consideration of welfare of society, determined by deviations of inflation and output from the target. There is a consensus among central bankers and academicians that the appropriate loss function of the central bank involves stabilizing the inflation around predefined target and stabilising the output around its potential (Svensson,1999). The monetary policy, therefore, is entitled with a crucial task of minimising the welfare loss by choosing the relative weights to be assigned to the deviations of inflation and output from the targets, depending upon the understanding of the structural characteristics of the economy. The overall structural characteristics of the economy can be described in a New Keynesian general equilibrium framework.

The New Keynesian models, therefore, have become a standard framework for monetary policy analysis amongst the central bankers (Gali and Gertler,1999; Woodford 2003a,b; McCallum and Nelson,1999 a,b; and Svensson and Woodford 2005; Walsh, 2010, Goodfriend and King,1997; Goodfriend, 2004; Rotemberg and Woodford 1999). There are number of studies which provide an excellent treatment of model and its implications to monetary policy (Clarida, Gali and Gertler 1998, 1999; Gali 2002, 2008a,b; Gali and Gertler 2007, Goodhart and Hofmann 2005a,b). Additionally, Carlin and Soskice (2005) depicts in the graphical framework, of models related to the baseline New Keynesian model that describes the interplay of inflation, output gap and interest rate.

The New Keynesian model captures effectively the key channels of monetary transmission process with great clarity (Anand, Dind and Tulin, 2014). A framework of the model describes the economy with the help of a system of three equations: an aggregate demand or IS curve which links the output gap to the expected future output gap, lagged output gap and the short term real interest rate, a Phillips curve or an aggregate supply curve that relates the price inflation to the expected future inflation, lagged inflation and the output gap. These two equations characterise the aggregate

demand as well as supply dynamics of the economy, respectively. Finally, the model completes with the central bank reaction function denoted by the Taylor type rule which links the policy interest rate with the output gap and the inflation gap. Interestingly, money has no explicit role in this model. In a simple form, the model depicts some important linkages among macroeconomic variables. Firstly, the inflation and output are determined by the aggregate demand, the aggregate demand is determined by the interest rates and the interest rates are in turn set by the monetary policy by considering the expected movements in output and inflation (Patra and Kapur, 2010). From the perspective of monetary policy, the model provides some important insights: the two important linkages *i.e*., the link between the output gap and inflation in the Phillips curve and the output gap and short term real interest rate in the IS curve, ultimately, measure a strength and effectiveness of monetary policy transmission. In addition to this, relative importance of forward looking versus backward looking terms in the IS and Phillips curve also provides some important inputs to the monetary policy formulation (Goodhart and Hofmann 2005a,b). The standard version of the model includes only those variables which are suggested by theory, whereas the extended version of the model includes all the other variables which may have an impact on the output and inflation (Blanchard and Gali, 2007; Iacoviello, 2004). The representation of the supply side in the new Keynesian set up is based on the assumption of Calvo (1983) model of inter-temporal optimal price setting behaviour of monopolistically competitive firms, whereas the demand side of the economy is modelled on the basis of the assumption of inter-temporal optimising behaviour of households. Both these assumptions signify the forward looking IS curve and the Phillips curve, respectively. In the new Keynesian framework, the monetary policy first affects the output through the IS curve and then, inflation through the Phillips curve. There are mixed empirical evidence regarding the strength and effectiveness of the links in monetary transmission process and the relevance of forward looking versus backward looking behaviour of agents.

The monetary policy framework in India has evolved over a period of time with RBI, finally, adopting the inflation targeting framework with CPI inflation as nominal anchor. It is essential to employ a more comprehensive and complete model to analyse the monetary policy transmission in India. The most of literature estimating the New Keynesian models in India have focused on either the New Keynesian Phillips curve

(Paul, 2009; Patra and Ray,2010; Mazumdar, 2011; Singh, Kanakaraj and Sridevi, 2011; Kapur, 2012; Mitra, Biswas and Sanyal, 2015) or the monetary policy reaction function (Mohanty and Klau, 2004; Virmani,2004; Hutchison, Sengupta and Nirvikar, 2010, Singh, 2010). Conversely, very few attempts have been made to test the New Keynesian IS curve empirically.

To fill in this gap in literature, the present study proposes to analyse the significant linkages in monetary transmission process in India, drawing from the New Keynesian framework. Since monetary policy is generally viewed as having a significant impact on the output in the short-run, the analysis using the New Keynesian Phillips curve and the Ney Keynesian IS curve has important implications for monetary policy (Paradiso, Kumar, and Rao, 2013). The estimation of New Keynesian IS curve implies whether the monetary policy will significantly steer the aggregate demand or not. The present study intend to build mainly upon the evidences provided in Goodhart and Hofmann (2005a,b), Paradiso, Kumar and Rao (2013), Patra and Kapur (2010) and Kapur and Behera (2012). In doing so, the standard and extended specifications of the backward looking as well hybrid IS models have been estimated and the role of forward looking and the backward looking components has been analysed. Also, the attempt has been made to estimate the aggregate demand (IS curve) by its two major components that are important from the monetary policy perspective *i.e.*, the private final consumption expenditure (PFCE) and the gross fixed investment expenditure (GFCF). This would provide more insights on the transmission of monetary policy to each of these two components, separately.

The operating procedure of monetary policy in India has undergone significant changes in the last few years. As per the new operating procedure of monetary policy (RBI, 2011), repo rate has become a single policy rate signalling the policy stance and the call rate as operating target of monetary policy. Since, most of the studies in Indian context cover the sample period up to the year 2011 (prior the announcement of new operating procedure) their analysis misses on the important occurrences in the policy arena post 2011 period, where monetary policy was confronted with a puzzle of low growth and high inflation. On this backdrop, the present study gains more importance as it covers the sample period in post 2011.The rest of the paper is organised as follows: Section 2 gives a brief review of literature, Section 3 describes the model, section 4

covers the data, methodology, scheme of empirical estimation and the time path of the key variables under study, section 5 shows the results of empirical estimation and finally, section 6 concludes.

## 2. THE REVIEW OF LITERATURE:

There are a number of national as well as international studies that attempt to explore the important linkages in monetary transmission process using New Keynesian framework. However, the existing literature demonstrates quite diverse and contradictory results. While some studies provide the evidence of strong and highly significant links in monetary transmission (Rudebusch and Svensson, 1999), the others demonstrate insignificant linkage (Goodhart and Hofmann 2005a, b). Similarly, the evidence on the role of forward looking expectations ranges from highly important (Gali and Gertler 1999) to unimportant (Fuhrer, 1997).

Clarida, Gali and Gertler (1999) provide more lucid and comprehensive explanation of the main structural relationships in the New Keynesian model and the design of optimal monetary policy in such a model in the presence of real world complexities. Linde (2005) estimates hybrid versions of the Phillips curve and IS curve for the US along with a Taylor rule and obtained a significant linkage between output gap and the short term real interest rate in the IS curve and the Inflation and output gap in the Phillips curve. Rudebusch and Svensson (1999) estimate backward looking Phillips curves and IS curves for the US and find a significant positive impact of output gap in the Phillips curve and a significant negative impact of real interest rate on output gap in IS curve. Similarly, Peerman and Smets (1999) estimating the Taylor rule, find the same results for the Euro area. In two different studies, Goodhart and Hofmann (2005a, b) asses the empirical performance of the baseline New Keynesian model for G7 countries and the US and the euro area. They estimate both the standard and extended specifications of the IS and Phillips curves. Their results illustrate that the baseline specifications of the model fail to yield a significant link between the monetary policy instrument, output and inflation. However, the extended specifications of the model which accounts for the impact of commodity prices on inflation and asset prices on the output gap help to restore the important linkages in monetary transmission process**.** Paradiso, Kumar, and Rao (2013) found the similar results for Australia. Gali

and Gertler (1999) and Gali, Gertler and D.Lopez-Salido (2001) estimate the hybrid versions of Phillips curve for the US and the euro area. They find that the unit labour cost rather than conventional measure of output gap gives the positive relation between the output gap and inflation. They also find that the expected inflation significantly determines the current inflation and has important role than lagged inflation. Nelson (2001, 2002) estimates the backward looking IS curve for the US and UK, but fails to find a significant impact of the real interest rate on the output gap. The author refers to this finding as the IS puzzle. According to Nelson (2001), the IS puzzle may arise due to i) Simultaneity bias arising from forward looking monetary policy ii) mis-specification due to omission of forward looking elements, and iii) misspecification due to omission of other determinants of aggregate demand. Fuhrer and Rudebusch (2004) estimate hybrid specifications of IS curves for the US by conventional Generalised Method of Moments (GMM) and Maximum Likelihood (ML). Their results show that the ML estimator is unbiased and yields a significant link between the real interest rate and the output gap. Ball (1998) and Svensson (2000), estimating open economy specification of the IS curve found the exchange rate to be an additional variable influencing the aggregate demand. Gali (2008a) demonstrate the valuable insights provided by the New Keynesian model in a design and practical conduct of monetary policy. He puts forward some of the lessons for monetary policy drawn from the New Keynesian research program. The study found that the new Keynesian model is certainly an improvement over poorly statistical models, or the old fashioned atheoretical macroeconometric models. Goodhart and Hofmann (2000) while estimating a small structural model for selected developed countries over the period 1973 to 1998 found that the financial variables such as property prices and share prices indeed have a significant impact on the output gap. Hence, besides the short term real interest rate, the potential impact of several other financial variables on aggregate demand should also be taken in to account in the monetary policy formulation. Clarida, Gali and Gertler (2000) estimate a forward looking monetary policy reaction function characterising the US economy for pre Volcker *i.e.*, pre 1979 period and during Volcker-Greenspan era *i.e.*, post 1979 period. They found a substantial difference in the way monetary policy was conducted in these two sub-periods. The interest rate policy during Volcker-Greenspan period appeared to be more responsive to expected inflation than in the pre-Volcker period, demonstrating the anti-inflationary stance of monetary policy in the post 1979 period. Similarly, Christiano, Eichenbaum, and Evans

(2005) presented a dynamic stochastic general equilibrium model incorporating nominal rigidities, to test the response of the U.S economy to a monetary policy shock. The estimated model yields an inflation inertia and a persistent, hump shaped response of output to a monetary policy shock. The study signifies the importance of the stickiness in nominal wages in performance of the model. Clarida, Gali and Gertler (1998) estimate monetary policy reaction function for the central banks of two group of countries *i.e.*, the G3 (Germany, Japan and the US) and the E3 counties (UK, France, and Italy). Their empirical evidence suggests that each central bank in G3 countries pursued implicit targeting with forward looking nature and responded to the expected future inflation rather than lagged inflation. Their results support the view that to gain nominal anchor for monetary policy, some form of inflation targeting may be superior than choosing the fixed exchange rate alternative.

There are few selected studies in the Indian context which attempt to estimate the complete New Keynesian model to examine the monetary policy transmission in India (RBI, 2002; Patra and Kapur, 2010; Kapur and Behera, 2012; Anand, Dind, and Tulin ,2014; Bhattacharya and Patnaik,2014). In addition to this, a number of studies attempt to estimate at least one of the blocks of New Keynesian model separately, *i.e.*, the Phillips curve equation (Paul, 2009; Patra and Ray,2010; Mazumdar,2011; Singh, Kanakaraj and Sridevi, 2011, Kapur, 2012; Mitra, Biswas and Sanyal; 2015) and the monetary policy reaction function in the form of a Taylor-type rule (Mohanty and Klau, 2004; Virmani,2004; Hutchison, Sengupta, and Singh, 2010; Singh, 2010). A very few or no attempt has been made to test the IS curve, separately.

The RBI (2002) made the first systematic attempt to estimate the New Keynesian model for the Indian economy using the annual data with purely backward looking specification of the model. The empirical results therein turned out to be reasonably robust. Mohanty and Klau (2004) estimates an open economy Taylor rule for 13 emerging economies including India. They found the output gap to be a significant determinant of the short term interest rate. While the interest rate was negatively correlated with exchange rate, the relationship between the short term interest rate and inflation was found to be weak. Virmani (2004) found that an open economy backward-looking Taylor rule and a McCallum rule captures the evolution of short-term interest rate. Singh (2010) uses a Taylor-type rules framework to identify

the behaviour of monetary policy for the period 1950-51 to 2008-09 in India. The empirical evidence illustrate that the monetary policy seems to be more reactive to the output gap than the inflation gap during 1951-52 to 1987-88, whereas the policy appears to be more responsive to the inflation gap than the output gap in the period 1987-88 to 2008-09. The evidence from the VAR estimation also confirms that the variations in the short-term interest rates are largely driven by the inflation gap than the output gap. On the same line, Hutchison, Sengupta, and Singh (2010) estimate the exchange rate augmented Taylor-Rule for India over the period 1980Q1 TO 2008Q4. Their analysis for the pre and post liberalisation periods depicts that the output gap seems to be a major factor in determining the policy stance than inflation. Also, the policy action appears to be more sensitive to consumer price inflation than the WPI inflation. Their empirical evidence suggests that the exchange rate movements do not constitute a significant determinant of the policy action of the RBI. Patra and Kapur (2010) estimate the new Keynesian model to analyse the interaction of monetary policy with the changing structure and functioning of the Indian economy in the period 1996 to 2009. Their empirical evidence illustrates that the interest rate impacts the aggregate demand after a lag of three quarters and that the inflation after a lag of seven quarters. The inflation control is the major concern of monetary policy in India, along with a commitment to stabilise the output. Bhattacharya and Patnaik (2014) introduce a semi-structure new Keynesian open economy model for monetary policy analysis in India. The model provides valuable insights regarding various shocks to the economy in the post global financial crisis in the form of fiscal stimulus, expansionary monetary policy, *etc*. and their impact on growth and inflation trajectory. Importantly, the study provides essential inputs in setting the inflation targeting framework for monetary policy in India as monetary policy failed to anchor the inflation expectations at the desired level in the post crisis period. Anand, Ding, and Tulin (2014) estimate a variant of small "New Keynesian" macroeconomic model with rational expectations to analyse the dynamics of inflation and monetary transmission in India over a period from 1996Q1 to 2013Q4. Their results illustrate the evidence of a strong second round effect of food and fuel inflation in India. The inflation seems to be inertial and persistence making the case for tight monetary policy over considerable period of time. Azad (2016) presents a critical view of the new Keynesian macroeconomics in comparison to the old Keynesian perspective. According to the study mainstream new Keynesian macroeconomics

acknowledges the effective role played by monetary policy in stabilising prices and output, which the Keynes was sceptical about.

Mitra, Biswas and Sanyal (2015) estimate the sacrifice ratio in time varying framework for India from the expectation augmented Phillips curve over the period 1997-98Q2 to 2013-14Q3.They found higher sacrifice ratio estimates during the expansionary phase of monetary policy and a lower sacrifice ratio over the contractionary phase. Kapur and Behera (2012) examine the monetary policy transmission mechanism over the period 1996 to 2012 in India using a small macro model with New Keynesian features. They found that the interest rate channels are effective in the Indian context and the magnitude of the impact on growth and inflation is comparable to that in major advanced and emerging economies. Kapur (2012) uses augmented Phillips curve to model and forecast inflation in India. The study finds that both the demand and supply factors are determinant of inflation. The evidence suggest that the demand conditions have a strong impact on non-food manufacturing inflation vis-à-vis headline inflation. Also, the non-food manufacturing inflation was found to be more persistent than headline inflation. Paul (2009) found the empirical evidence supporting the existence of Phillips curve in India only when the industrial production was used as proxy for economic activity (instead of real GDP) and the data was rearranged from crop year to fiscal year. Patra and Ray (2010) in an attempt to explore the determinants of inflation expectations, estimate a New Keynesian Type Phillips curve for India that takes the account of country-specific factors, the stance of monetary and fiscal policies, marginal costs and exogenous supply shocks. The empirical findings suggest that high inflation could easily percolate into peoples' expectations of future inflation and linger. Muzumadar (2011) find the evidence in favour of existence of Phillips curve in India over the period 1970 to 2008 by proxing economic activities by industrial production and accounting for the supply shocks through oil price movements. The Phillips curve relationship was found to be stable across the tenure of different governors, hence does not subject to Lucas critique. Singh, Kankaraj and Sridevi (2011) found that after accounting for supply shocks and using the Kalmon Filter to measure the output gap, there is clear evidence supporting the existence of Phillips curve in India

The existing literature provides some mixed and contradictory results regarding empirical estimation of the New Keynesian model. Also, there are limited empirical evidence on the IS curve as compared to Phillips curve.

## 3. THE MODEL:

The New Keynesian model reduces the economy into a two-equation system comprising an aggregate supply or Phillips curve and an aggregate demand or IS curve. In the model, monetary policy affects the output gap through IS curve in the first stage and then the inflation through the Phillips curve in the second stage. The model, grounded in dynamic general equilibrium theory, is an improvement over the traditional IS-LM model in two contexts: Firstly, the Phillips curve and the IS curve are based on microeconomic foundations and take into consideration forward looking economic behaviour and secondly, the monetary policy reaction function demonstrates the operating procedure of modern central banks more accurately (Patra and Kapur 2010). The New Keynesian IS curve depicts the real aggregate demand as a negative function of the real interest rate giving scope for monetary policy to steer aggregate demand by exercising control over the interest rates. It assumes inter-temporally optimising households and is derived from log linearizing the Consumption Euler equation:

$$y_t = \mathrm{E}_t y_{t+1} - \alpha (i_t - \mathrm{E}_t \pi_{t+1}) + \varepsilon_t \qquad (1)$$

Where, $y_t$ is the output gap, $\mathrm{E}_t y_{t+1}$ is the current periods expectations of next period's output gap, $i_t$ is the short term nominal interest rate, $\mathrm{E}_t \pi_{t+1}$ is the current period's expectation of next period's inflation rate and $\varepsilon_t$ is an aggregate demand shock unanticipated by central bank and is serially uncorrelated with mean zero. It is the ex-ante real interest rate, defined as $i_t - \mathrm{E}_t \pi_{t+1}$ that is used in the IS equation. The negative coefficient of the ex-ante real interest rate signifies the inter-temporal interest elasticity of substitution between consumption and saving. Since inter-temporal optimizing households prefer to smooth consumption in response to higher income in future, expectations of higher future output impel them to consume more in the current period, which leads to an increase in aggregate demand and output. The current period output, therefore, depends on the expected future output and interest rate. With forward

iteration of equation (1), it can be shown that the output gap depends on the current as well as expected future path of the real interest rate and the demand shocks. Hence, to the extent monetary policy exercises control over the short-term real interest rate due to nominal rigidities, expected as well as current policy actions affect aggregate demand (Clarida, Gali and Gertler, 1999).

As far as theory is concerned, both the New Keynesian IS curve and the Phillips curve are purely forward looking. The Phillips curve demonstrates how inflation is related to expected future inflation and the output gap, whereas the IS curve depicts how the output gap depends on the expected future output gap and the ex-ante real interest rate. Since, the purely forward looking model fails to attain the robust estimates empirically, many researchers use the backward looking and hybrid versions of the model to estimate the lagged and persistent response of inflation and output to monetary policy measures (Rudebusch, 2002; Goodhart and Hofmann 2005a,b; Rudebusch and Svensson 1999; Peerman and Smets 1999). To introduce the backward looking terms in the IS curve and Phillips curve, Gali and Gertler (1999) assumes that a fraction of price setters simply applies a rule of thumb price adjustment rule and simply adjust their prices to past prices and inflation. Hence, the expected future values of inflation and the output gap can partly be approximated by lag polynomials (Goodhart and Hofmann 2005b). Moreover, though the backward looking terms in the IS curve are inconsistent with theory, they can be introduced by assuming habit persistence in consumption behaviour of households, so that households' utility also depends on lagged consumption (Fuhrer 2000).

The empirical findings on the back-ward looking and hybrid IS models are mixed. The details regarding that are provided in the literature review section. The number of studies estimating backward looking IS curve found the insignificant relationship between the real interest rate and output gap (Nelson 2002, Goodhart and Hofmann 2005a,b). It has been argued that omitting the variables which may have a significant impact on the aggregate demand besides interest rate is the main cause of the insignificant real interest rate coefficient as the interest rate effects are transmitted to aggregate demand via these variables (Goodhart and Hofmann, 2005a). To account for this, several studies augmented the baseline backward looking and hybrid models

with some additional variables and found the significant coefficient on the real interest rate (Svensson, 2000; Nelson, 2002; Hofmann, 2001).

On this backdrop and given limited literature as well as still evolving debate on New Keynesian models in India and abroad, the present study examines the links in the monetary transmission process along with the role of forward looking vis-à-vis backward looking elements in a baseline New Keynesian characterisation of the Indian economy. In doing so, both the standard and extended specifications of the purely backward looking and the hybrid version of New Keynesian IS curve have been estimated. In the standard specification only those variables which are directly suggested by theory are included in the model. On the other hand, in the extended specification, all those variables that embody significant demand side effects, such as the exchange rate, external demand, crude oil prices, non-food credit growth, monetary supply growth, fiscal deficit have been inducted in the model. The inclusion of additional variables in the equation here is ad-hoc, but could be rationalised by appropriate extensions of the basic theoretical model (Goodhart and Hofmann, 2005b, Blanchard and Gali, 2007, Iacoviello 2004).

The present study estimates four specifications of IS curve:

1) The baseline backward looking IS curve:

$$yt = \alpha_0 + \alpha_1 y_{t-1} + \beta \underbrace{(\underbrace{i_{t-1} - \pi_{t-1}}_{r_{t-1}})}_{} + \varepsilon_t \quad (2)$$

2) The Baseline Hybrid IS curve:

$$yt = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 \mathrm{E}_t y_{t+1} + \beta \underbrace{(\underbrace{i_t - \mathrm{E}_t \pi_{t+1}}_{r_t})}_{} + \varepsilon_t \quad (3)$$

3) The extended Hybrid IS curve:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 \mathrm{E}_t y_{t+1} + \beta \underbrace{(\underbrace{i_t - \mathrm{E}_t \pi_{t+1}}_{r_t})}_{} + \gamma_1 REER_t + \gamma_2 EXDD_t + \gamma_3 CRUD_t + \gamma_4 NFC_t + \gamma_5 BSE_t + \gamma_6 FISD_t + \gamma_7 M3_t + \varepsilon_t \quad (4)$$

4) The extended backward looking IS curve:

$$yt = \alpha_0 + \alpha_1 y_{t-1} + \beta \underbrace{(\underbrace{i_{t-1} - \pi_{t-1}}_{r_{t-1}})}_{} + \gamma_1 REER_{t-1} + \gamma_2 EXDD_{t-1} + \gamma_3 CRUD_{t-1} + \gamma_4 NFC_{t-1} + \gamma_5 BSE_{t-1} + \gamma_6 FISD_{t-1} + \gamma_7 M3_{t-1} + \varepsilon_t \quad (5)$$

Where $yt$ is the output gap, $i_t$ is the short term nominal interest rate, $\pi_t$ is the inflation rate, $\varepsilon_t$ is the aggregate demand shock, $E_t y_{t+1}$ is the current periods expectation of next period's output gap, $E_t \pi_{t+1}$ is the current period's expectation of next period's inflation rate, $i_t - E_t \pi_{t+1}$ is the ex-ante real interest rate ($r_t$). All the additional variables are listed below:

REER= growth rate in real effective exchange rate of Indian rupee against the dollar (Trade weighted (36 currencies).

$EXDD$ = external demand proxied by real world export growth.

$CRUD$ = change in crude oil prices

$NFC$ =non-food credit growth

$BSE$ =Bombay stock exchange Sensex growth rate

$FISD$ = change in Gross Fiscal deficit as percentage of GDP

$M3$ = real M3 growth

## 4. DATA, METHODOLOGY AND SCHEME OF EMPIRICAL ESTIMATION:

The present study estimates different specifications of the IS curve for India using quarterly data over the period 1998Q1 to 2015Q4.The monthly data series have been converted into quarterly series by taking average over the quarter. While the data on GDP series, non-food credit growth, weighted average call rate, BSE Sensex, M3 growth, and REER (36-currency trade weighted) and gross fiscal deficit have been sourced from the RBI's handbook of statistics on Indian Economy, the data on CPI-IW (Inflation) have been sourced from Central statistical Office (CSO). Similarly, the data regarding crude oil prices, real world exports have been taken from IMF's International Financial Statistics.

Since the effective monetary policy rate switched between the bank rate, repo rate and reverse repo rate depending upon overall macroeconomic conditions during the sample period the weighted average call money rate has been used as proxy for the policy rate. Most of the studies in the Indian context use the Index of Industrial production(IIP) as an activity variable which is inappropriate as IIP forms only one fifth of total GDP (Patra and Kapur, 2010). The present study, therefore, uses the real GDP as the activity variable. The output gap is calculated by de-trending the seasonally

adjusted GDP using Hodrick-Prescott filter, where the λ was set to be equal to 1600. The output gap is measured by the difference between actual real GDP and its trend obtained by the HP filter. Since all of the variables barring the output gap, have been measured on y-o-y basis, they show no seasonality. The policy rate and the REER have not been de-seasonalised. As far as methodology is concerned, the present study follows Clarida *et al.* (1998, 2000), (Goodhart and Hofmann (2005a) and Paradiso, Kumar and Rao (2013) to estimate the equations by Generalised Method of Moments (GMM) in view of leads of the explanatory variables being used and potential endogeneity of the variables. However, the purely backward looking models have been estimated by the Ordinary Least Square (OLS) method.

**The scheme of empirical estimation:**

A) Testing the data for stationarity.

B) Estimating the baseline backward looking model (OLS).

C) Estimating the extended backward looking model (OLS)

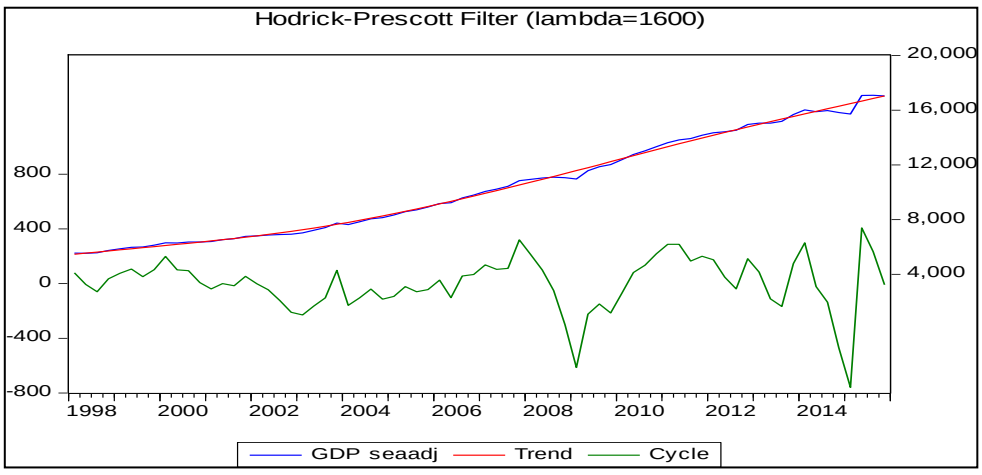
D) Estimating the baseline forward looking model (GMM).

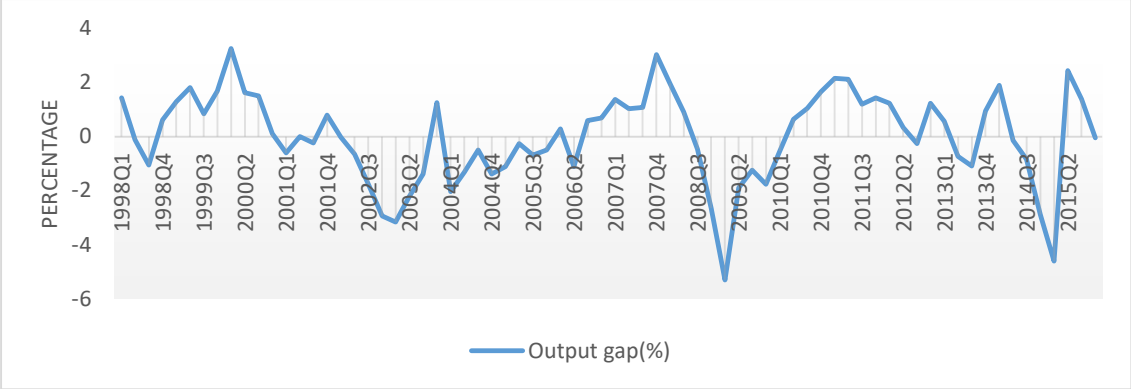
E) Estimating the extended forward looking model (GMM).

## 4.1 The path of the variables under study:

### *4.1.1 The Output Gap:*

**Figure 1:** The Output Gap

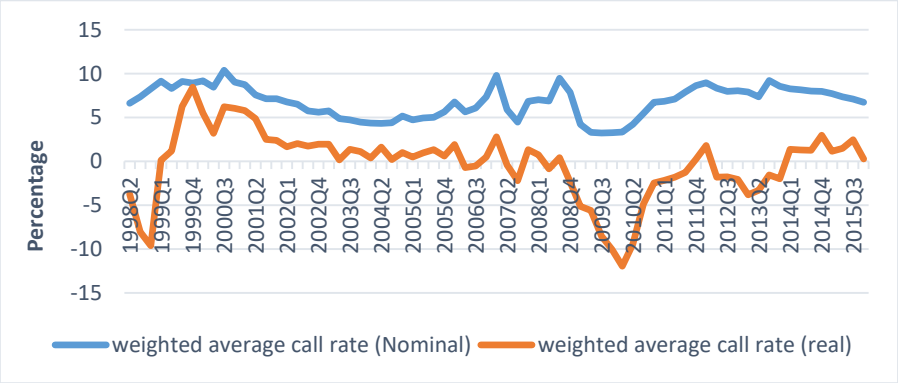





In figure 1, the output gap has been expressed as a percentage of potential output. The positive output gap between the late 1999 to early 2000 and the late 2010 to early 2013 indicates the periods of overheating of the economy. The output gap is seen to be negative over the few quarters of 2014-15, denoting the slack in the economy in recent periods, due to a weak global demand. It can be seen that the output gap reaches its peak of around 3% in 2007Q4, a period just before the financial crisis broke out in the US. However, in the subsequent period (especially in 2008), the output gap turns negative due to the repercussions of financial crisis and seen to be narrowing in late 2009.

### *4.1.2 Weighted Average Call Rate:*

**Figure 2**: Weighted Average Call Rate




The monetary policy framework and operating procedure in India have undergone significant changes during the sample period. The liquidity adjustment facility (LAF) was introduced in early 2000s to manage day-to-day liquidity in the

system through repo and reverse repo operations. The monetary policy signals were provided through repo as well as reverse repo rates. Hence, during the excess liquidity conditions, the reverse repo rate was the effective policy rate, whereas in the tight liquidity conditions, the repo rate was the effective policy rate. Therefore, the policy rate switched between the repo rate and the reverse repo rate (Patra and Kapur, 2010). As a result, there was a need for a single rate to signal the monetary policy stance and hence, the monetary policy operating framework was modified and the new operating framework came into effect in May, 2011. In the new framework, the repo rate was made the single independently varying policy rate to signal the policy stance and the weighted average overnight call money rate was explicitly recognised as the operating target of monetary policy, as the transmission of monetary policy signals to this segment was faster than the other money market segments (RBI report, 2011). The present study, therefore, uses the weighted average call rate as a proxy for the policy rate, as it has been seen moving in tandem with the effective policy rate *i.e.*, either repo or reverse repo rate as the case may be depending on the prevailing liquidity conditions.

The Figure 2 depicts the path of both the nominal and real call rate over the sample period. The fluctuation in the call rate signify the different phases of expansionary and contractionary monetary policy in India. The monetary policy was highly expansionary in the post crisis period as it can be seen from the step fall in the call rate to provide a stimulus to the economy. However, the stance of monetary policy shifted towards a tightening phase in post 2009 period, as inflation became a major threat in the economy. Along with the nominal interest rate, the real interest rate also is an important determinant of consumption and investment decisions. The real call money rate is computed by adjusting the nominal rate for CPI inflation. The path of the real rate depends on the underlying nominal interest rate and inflation dynamics in the economy. Even though the monetary policy was in contractionary mode in post 2010, the real interest rate was negative over the span due to high inflation. The real interest rate has remained around two percent in recent period.

## 5. EMPIRICAL ESTIMATION AND RESULTS:

### 5.1 The Unit Root Tests:

All the variables were tested for stationarity using the Augmented Dickey Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests. All the variables except, non-food credit growth and M3 growth, found to be stationary by atleast two of the tests. The first differences of non-food credit growth and M3 growth have been used for the analysis.

**Table 1.** Results of the Unit Root Test

| Variable | Tests Statistic | | |
|---|---|---|---|
| | ADF Test | PP Test | KPSS Test |
| Output Gap | -3.5144** | -30.31*** | 0.12082 |
| Nominal Interest Rate | -5.2432*** | -33.463*** | 0.48045** |
| Real Interest Rate | -3.8478** | -22.263** | 0.74601** |
| REER | -5.6623*** | -27.215*** | 0.093424 |
| EXDD | -3.6882** | -23.738** | 0.23132 |
| CRUD | -3.678** | -22.781** | 0.34481 |
| BSE | -2.5992 | -21.282** | 0.16224 |
| FISD | -2.8889 | -61.311** | 0.16872 |
| ΔM3 | -4.6944*** | -47.396*** | 0.031336 |
| ΔNFC | -6.5415*** | -54.736*** | 0.13902 |
| PFCE | -4.9977*** | -60.643*** | 0.095701 |
| GFCF | -3.4086* | -36.806*** | 0.092537 |

*Note*: '***', '**'and '*'indicate statistical significance at 1%, 5% and 10%, respectively. The null hypothesis is of non-stationarity in the case of ADF and PP tests, and stationarity in the case of KPSS test.

### 5.2 Baseline backward looking IS model:

In empirical estimation, the forward looking theoretical IS curve is often approximated by a backward looking specification (Fuhrer and Moore,1995; Rudebusch and Svensson 1999; and Rudebusch 2002). Following the Goodhart and

Hofmann (2005a) and Paradiso, Kumar and Rao (2013), the baseline backward looking IS model has been specified of the form:

$$yt = \alpha_0 + \alpha_1 y_{t-1} + \beta(\underbrace{i_{t-1} - \pi_{t-1}}_{r_{t-1}}) + \varepsilon_t \quad (6)$$

The results of the empirical estimation of equation (6) by OLS, are shown in Table 2 below. The real interest rate ($r_t$) on the right-hand side of the equation represents the monetary transmission mechanism which in the case of many central banks may include nominal interest rates, ex-ante real short and long rates, exchange rates, as well as direct credit quantities (Rudebusch and Svensson, 1999).

**Table 2.** OLS estimates of the baseline backward looking IS curve.

| Dependent variable $y_t$ | | | | |
|---|---|---|---|---|
| | Coefficients | Std. Error | t-statistic | P-value |
| α | -0.07574 | 0.17044 | -0.444 | 0.6583 |
| $y_{t-1}$ | 0.51684 | 0.1064 | 4.858 | 0.00000842*** |
| $r_{t-6}$ | -0.08611 | 0.04482 | -1.921 | 0.0593* |
| Adjusted R square | 0.37 | Q-statistic | 3.2191 | |

*Note*: 1) '***', '**'and '*'indicate statistical significance at 1%, 5% and 10%, respectively.

2) Q-statistic denotes Box-Ljung test statistic for residual autocorrelation.

The results depict that both the lagged output gap and the real interest rate ($r_t$) are significant at 1% and 10% level, respectively and have the expected sign. The real interest rate has a negative impact on the output gap. However, the coefficient is mere (-0.08). Thus, the increase in the policy rate by 100 basis points leads to a narrowing of the output gap by 8 basis points (0.08 %) after a lag of six quarters. This signifies, a huge time lag in the transmission of monetary policy to real sector in the economy.[3] The coefficient on the one period lagged output gap is highly significant and positive at (0.51). The diagnostic test results show that there is no serial correlation in the residuals.

[3] Patra and Kapur (2010) reported the policy rate coefficients of (-0.10) with a lag of three quarters.

Even though the results suggest a significant link between the policy rate and output, the transmission of policy impulses to the output is weak (coefficient is mere 0.08) and subject to the lag of six quarters. There are a number of factors responsible for the weak transmission of monetary policy to output. The banking system in India is majorly dominated by the public sector banks. Inspite of the multiple rate cuts by RBI and the corresponding fall in the short term rates, the banks failed to pass-on the benefits of those rate cuts to people by showing reluctance to reduce their lending rates. The bank lending rates have gone down, but not commensurate with the policy rate cut (Rajan, 2016). While the interest rates in the money market and bond market segments are flexible enough to smoothen the transmission of policy impulses, the credit market is characterized by asymmetries and bank deposit and lending rates show stickiness due to a various institutional factors such as administered interest rates on deposits in small savings and provident fund and the interest rate ceilings and statutory pre-emptions for loans to agriculture and export sectors (Subbarao, 2010). However, the marginal cost of funding approach recently implemented by RBI is a positive step and may help bringing a desirable result in this regard. It is possible that some other variables may also determine the output gap, besides interest rate. Hence, the extended version of backward looking model has been estimated next.

### 5.3 Extended backward looking IS model:

$$yt = \alpha_0 + \alpha_1 y_{t-1} + \beta(\underbrace{i_{t-1} - \pi_{t-1}}_{r_{t-1}}) + \gamma_1 REER_{t-1} + \gamma_2 EXDD_{t-1} + \gamma_3 CRUD_{t-1} + \gamma_4 NFC_{t-1} + \gamma_5 BSE_{t-1} + \gamma_6 FISD_{t-1} + \gamma_7 M3_{t-1} + \varepsilon_t \quad (7)$$

If aggregate demand is determined also by other variables besides interest rate and if interest rates are a function of these variables, then the estimated interest rate coefficients will be biased towards zero (Goodhart and Hofmann, 2005a). To account for this, the baseline IS model has been augmented with some additional variables besides real interest rate, such as the annual rate of change in the real effective exchange rate(REER), real world export (proxy for external demand), real share prices, real money supply (M3), crude oil prices, non-food credit, and fiscal deficit. To avoid the multi collinearity problem, the equation (7) has been estimated in full specification form first, and then the least significant variables are progressively eliminated until all the

retained variables are statistically significant at conventional levels. The table 3 reports the results of OLS estimation of equation (7).[4]

**Table 3.** OLS estimates of the extended backward looking IS model.

| Dependent variable $y_t$ | | | | |
|---|---|---|---|---|
| | coefficients | Std Error | t statistic | P value |
| α | -0.2972 | 0.223129 | -1.332 | 0.188272 |
| $y_{t-1}$ | 0.461363 | 0.110913 | 4.16 | 0.000111*** |
| $r_{t-6}$ | -0.13716 | 0.054392 | -2.522 | 0.014551** |
| $REER_{t-6}$ | -0.07876 | 0.029853 | -2.638 | 0.010771** |
| $EXDD_{t-2}$ | 0.09124 | 0.036553 | 2.496 | 0.015527** |
| $CRUDE_{t-2}$ | -0.018388 | 0.007056 | -2.606 | 0.01171** |
| Adjusted R Square | 0.43 | Q-statistic | 1.65 | |

*Note*: 1) '***', '**'and '*'indicate statistical significance at 1%, 5% and 10%, respectively.

2) Q-statistic denotes Box-Ljung test statistic for residual autocorrelation.

As depicted in table 3, the real policy rate ($r_t$) has a significant negative impact on the output gap after a lag of six quarters in the augmented model as well. However, the interest rate coefficient is now (-0.13) a tad greater than the coefficient in the backward looking IS model. This finding has an important implication from the perspective of monetary policy transmission. By accounting for the additional variables which may influence the aggregate demand, the link between the real policy rate and the output gap has become stronger. The 100 basis point increase in real interest rate leads to a fall in the output gap by 13 basis points. Besides, interest rate, REER growth rate, change in external demand, and change in crude oil prices also have a significant and expected impact on the output gap. The real appreciation of the exchange rate has the expected contracting impact on real activities. An appreciation of the real exchange rate by 100 basis points results in reduction into the output gap by 7 basis points with a lag of six quarters. Similarly, the external demand as proxied by the real world export has a significant positive impact on economic activity. A 100 basis point increase in the

[4] We also augmented the equation to evaluate the impact of stock prices, money supply, non-food credit, and fiscal deficit on aggregate demand, but none of these variables was found to be significant.

real world export growth leads to a widening of the output gap by 8 basis points. The crude oil forms the substantial part of overall imports in India. Therefore, the crude oil prices have an important bearing over the aggregate price level and the output. The results show the significant negative impact of the change in crude oil prices on aggregate demand. A rise of 100 basis points in the crude oil prices leads to a narrowing of the output gap by 1 basis point. Even though the crude oil coefficient is a tad (-0.01), it signifies the repercussions of a volatile global crude oil prices for economic activities. It is important to note that, besides interest rate, these additional variables also determine the aggregate demand and therefore have a major say in policy formulation. The Q-statistics denotes no serial correlation. The estimated baseline backward looking model may not be structural and therefore the present study estimates the baseline and the extended specifications of the hybrid IS model.[5]

### 5.4 The baseline hybrid model:

$$yt = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 \mathrm{E}_t y_{t+1} + \beta (\underbrace{i_t - \mathrm{E}_t \pi_{t+1}}_{r_t}) + \varepsilon_t \tag{8}$$

Equations (8) shows the specification for the baseline hybrid model. In addition to the lag of output gap, it comprises current period's expectation of next period's output gap ($\mathrm{E}_t y_{t+1}$) to avoid downward biased interest rate elasticity which leads to IS puzzle (Nelson,2001). Also, instead of the ex-post real interest rate, an ex-ante real interest rate defined as current period's short term nominal interest rate less current period's expectation of next period's inflation rate ($\mathrm{E}_t \pi_{t+1}$), has been used. Equation (8) has been estimated by Generalised Method of moments (GMM) using four lags of the output gap, the ex-ante real interest rate, and intercept as instruments. The results of GMM estimates are given in table 4.

[5] Since, the purely forward looking IS curve failed to match the dynamics of aggregate output (Cogley and Nason, 1995; Estrella and Fuhrer,1998), hybrid specifications of the IS curve, including both forward-looking and backward looking elements, are preferred in empirical analysis (Goodhart and Hofmann,2005a).

**Table 4**. GMM estimates of baseline hybrid model

| Dependent variable $y_t$ | | | | |
|---|---|---|---|---|
| | Coefficients | Std Error | t-statistic | P-value |
| $\alpha$ | 0.020519 | 0.085668 | 0.239519 | 0.8115 |
| $y_{t-1}$ | 0.541958 | 0.100349 | 5.400736 | 0.0000*** |
| $y_{t+1}$ | 0.3468 | 0.137414 | 2.523754 | 0.0142** |
| $r_t$ | -0.0068 | 0.022012 | -0.30908 | 0.7583 |
| Adjusted R square | 0.53 | Q-statistic | 12.006 | |
| J-statistic | 3.829375 | Probability Of J-Statistic | 0.574234 | |

*Note*: 1) '***', '**'and '*'indicate statistical significance at a 1%, 5% and 10%, respectively.

2) Q-statistic denotes Box-Ljung test statistic for residual autocorrelation.

3) J-statistic and its probability value is test for over-identifying restrictions.

The t-statistics were calculated based on heteroscedasticity and autocorrelation robust Newey-West standard errors. The Hansen's (1982) J-test statistic indicates that the selected instruments are valid. The results show the link between the policy rate and the output gap does not exist in the hybrid model as the real interest rate coefficient is insignificant. This finding is relevant as far as inflation targeting framework adopted by RBI is concerned. It is argued that the monetary policy needs a forward looking dimension (Battini and Haldane, 1999). In reality, monetary policy has to be forward-looking and should respond to expected inflation and growth rather than their past value (Kapur and Behera, 2012). The policy decisions in such a framework are driven by anticipated future path of the variables than the lagged outcomes. The coefficients on the one quarter ahead expected output gap and lagged output gap are significant and positive with coefficient on lagged output gap is greater than the coefficient on its lead. It is, therefore, the past outcomes that impact the current output gap more than the expected future outcome. However, the Q-statistic suggests serial correlation in residuals. Since, the baseline hybrid model rejects the existence of a significant link between the policy rate and the output gap, the augmented specification of the hybrid model has been estimated to control for the variables that may influence the aggregate demand.

## 5.5 The extended hybrid model:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 E_t y_{t+1} + \beta(\underbrace{i_t - E_t \pi_{t+1}}_{r_t}) + \gamma_1 REER_t + \gamma_2 EXDD_t + \gamma_3 CRUD_t + \gamma_4 NFC_t + \gamma_5 BSE_t + \gamma_6 FISD_t + \gamma_7 M3_t + \varepsilon_t \quad (9)$$

The baseline hybrid model is augmented to control for some additional variables besides real interest rate such as the annual rate of change in the real effective exchange rate, real world export (proxy for external demand), real share prices, real money supply (M3), crude oil prices, non-food credit, and fiscal deficit. The equation (9) has been estimated again by Generalised Method of Moments (GMM). The four lags of ex-ante real interest rate, the output gap and all additional variables mentioned above has been used as instruments. The results of estimation are showed in table 5.

**Table 5**. GMM estimates for extended hybrid model

| Dependent variable $y_t$ | | | | |
|---|---|---|---|---|
| | coefficients | Std Error | t statistic | P value |
| α | -0.09947 | 0.092652 | -1.07353 | 0.2877 |
| $y_{t-1}$ | 0.472393 | 0.05046 | 9.361803 | 0.0000*** |
| $y_{t+1}$ | 0.336731 | 0.065575 | 5.135059 | 0.0000*** |
| $r_t$ | -0.02027 | 0.018262 | -1.10978 | 0.2719 |
| $REER_t$ | -0.02173 | 0.012694 | -1.71216 | 0.0925* |
| $EXDD_t$ | 0.024146 | 0.010779 | 2.240138 | 0.0291** |
| Adjusted R square | 0.48 | Q-statistic | 7.7165 | |
| J-statistic | 12.89 | Prob. Of J statistic | 0.95 | |

*Note*: 1) '***', '**'and '*'indicate statistical significance at 1%, 5% and 10%, respectively.

2) Q-statistic denotes Box-Ljung test statistic for residual autocorrelation.

3) J-statistic and its probability value is test for over-identifying restrictions.

The results of GMM estimation depicts that the interest rate coefficient is again insignificant same as the baseline hybrid model, implying no link between the policy rate and the output gap. However, the coefficients on the lagged and expected elements of output gap are significant with coefficient on the lagged element is greater than the lead element. Also, the REER growth and the real word export growth has expected

impact on the output gap[6]. The appreciation of real exchange rate by 100 basis points leads to a contraction in the output gap by 2 basis points. Similarly, increase in the real world exports by 100 basis points, results in an increase in the output gap by 2 basis points. The J-statistic indicates the instruments specified are valid. Also, the Q-statistic denotes no serial correlation in residuals.

From all the above mentioned specifications of the IS model, it is clear that the link between the policy rate and real activity, one of the important linkages in monetary policy transmission process, is present only in the backward looking specifications of the IS model. The hybrid models which include both forward looking and backward looking elements have failed to survive empirically. From among all the specifications of the IS model, it is found that the backward looking extended IS model fits the data quiet well. It is therefore used in model simulation. The equation (7) exhibits a satisfactory performance in the form of in-sample static forecasting. The Theil inequality measure (TIM) is low, and its decomposition shows that bias and variance are quiet low.

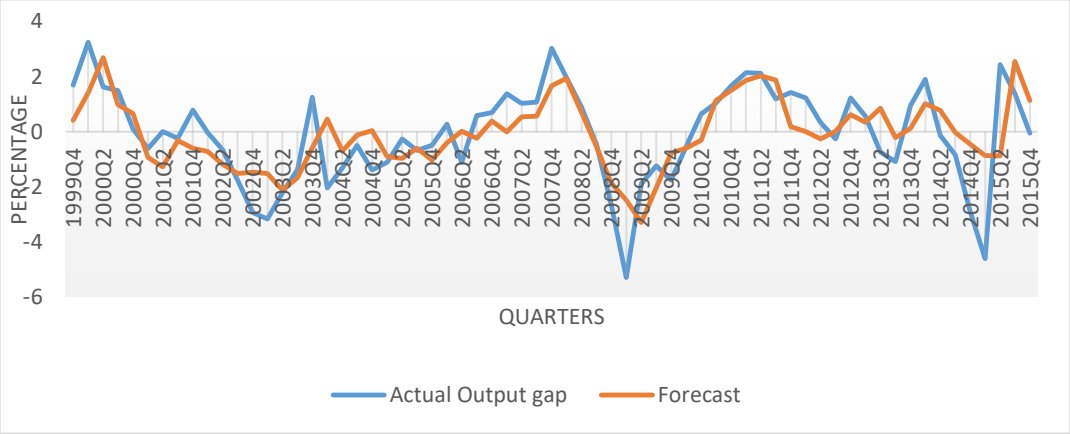
**Table 6**. Forecasting Performance of backward looking extended IS model

| Sr. No. | Statistic | |
|---|---|---|
| 1 | Root Mean Squared Error | 1.19935 |
| 2 | Mean Absolute Error | 0.91664 |
| 3 | Mean Absolute Percentage Error | 726.09 |
| 4 | Theil Inequality Coefficient | 0.41168 |
| | a) Bias Proportion | 0 |
| | b) Variance Proportion | 0.16994 |
| | c) Covariance Proportion | 0.83006 |

Figure 3 demonstrate the actual output gap against its forecast value. It can be seen that the model tracks the actual data quiet well by capturing the various turning points in the actual series.

[6] All the remaining additional variables were statistically insignificant, therefore excluded to attain parsimonious model.

**Figure 3:** Actual versus Forecasted Output gap




## 5.6 Robustness check:

Empirical findings using the real interest rate suggest that it is the backward looking IS model with real interest rate as policy variable that fits the data well. To support these findings further and to check the sensitivity of results to the choice of interest rate, the extended backward looking IS model has been re-estimated using nominal interest rate as policy variable. Even though, in theory, real interest rate matter for consumption and investment decisions, households appear to respond more to nominal interest rates (Fair, 2012). Tables 7 provides the OLS estimation results for the backward looking IS model with nominal interest rate as policy variable.

**Table 7.** Backward looking extended IS curve (nominal interest rate)

| | coefficients | Std Error | t statistic | P value |
|---|---|---|---|---|
| $\alpha$ | 0.501493 | 0.744864 | 0.673 | 0.503498 |
| $y_{t-1}$ | 0.505688 | 0.102217 | 4.947 | 0.0000*** |
| $R_{t-6}$ | -0.29467 | 0.134809 | -2.186 | 0.032949** |
| $REER_{t-2}$ | -0.13828 | 0.036415 | -3.797 | 0.000357*** |
| $EXDD_{t-6}$ | 0.052236 | 0.030453 | 1.715 | 0.091728* |
| $CRUDE_{t-2}$ | -0.01003 | 0.005545 | -1.809 | 0.075793* |
| Adjusted R Square | 0.44 | Q-statistic | 0.899 | |

*Note*: 1) '***', '**'and '*'indicate statistical significance at 1%, 5% and 10%, respectively.

2) Q-statistic denotes Box-Ljung test statistic for residual autocorrelation.

In line with the estimated backward looking extended IS model with real interest rate as policy variable, the IS estimation with nominal interest rate gives similar results. All the significant variables have expected signs. However, the coefficient on the nominal interest rate (-0.29) is doubled than the real interest rate coefficient (-0.13) in earlier estimation. A 100 basis point increase in the nominal interest rate leads to a decrease in the output gap by 29 basis points. It denotes the aggregate demand appears to be more sensitive to nominal interest rate rather than the real interest rate. Similarly, coefficients on change in REER, real world export, and crude prices have expected signs. Also, though the significant link between the policy rate and aggregate demand prevails, a small coefficient on interest rate indicates weak transmission of monetary policy.

A response of different components of aggregate demand to monetary policy actions may give more insights regarding the effectiveness of monetary policy transmission to real sector activities. Therefore, in the next stage the link between the real interest rate and the two important components of aggregate demand *i.e.*, private final consumption expenditure (PFCE) and Gross fixed capital formation (GFCF) has been tested using the backward looking IS Model.

**Table 8.** OLS estimates using PFCE as dependent variable.

| Dependent variable PFCE | | | | |
|---|---|---|---|---|
| | coefficients | Std Error | t statistic | P value |
| $\alpha$ | -82.7368 | 36.9754 | -2.238 | 0.0291** |
| $PFCE_{t-1}$ | 0.2924 | 0.1191 | 2.455 | 0.0171** |
| $r_{t-5}$ | -4.7683 | 2.7321 | -1.745 | 0.0862* |
| $EXDD_{t-6}$ | 3.3761 | 1.9313 | 1.748 | 0.0857* |
| $FISD_{t-3}$ | 10.3176 | 3.9066 | 2.641 | 0.0106** |
| Adjusted R Square | 0.25 | Q-statistic | 8.8095 | |

**Table 9.** OLS estimates using GFCF as dependent variable

| Dependent variable GFCF | | | | |
|---|---|---|---|---|
| | Coefficients | Std Error | t-statistic | P-value |
| $\alpha$ | -29.7853 | 19.9088 | -1.496 | 0.13979 |
| $GFCF_{t-1}$ | 0.3523 | 0.1155 | 3.052 | 0.00337*** |
| $r_{t-5}$ | -11.3925 | 4.0259 | -2.83 | 0.0063*** |
| $EXDD_{t-4}$ | 3.7164 | 2.1494 | 1.729 | 0.08885* |
| Adjusted R Square | 0.3 | Q-statistic | 3.0106 | |

*Note*: 1) '***', '**'and '*'indicate statistical significance at 1%, 5% and 10%, respectively.

2) Q-statistic denotes Box-Ljung test statistic for residual autocorrelation.

The empirical results show that both the components of aggregate demand are sensitive to the real interest rate. However, GFCF responds more to the interest rate than PFCE. The change in fiscal deficit and external demand has significant positive impact on PFCE and on GFCF, respectively. However, the adjusted R square in both the equation is low, suggesting poor fit of the model.

## 6. POLICY IMPLICATION AND CONCLUSION:

The New Keynesian model has become a popular tool for monetary policy analysis. While the baseline theoretical model is purely forward looking, the model that incorporates both forward looking and backward looking elements appear to match the reality quiet well and also extendable to incorporate country specific characteristics and the open economy considerations. The present study assesses the empirical performance of the New Keynesian IS model by estimating the standard and extended specifications of the backward looking and hybrid models in India. It is found that the backward looking models fit the data quiet well in comparison to the hybrid model. The link between the policy rate and the output gap prevails in case of both the standard as well as extended specifications of backward looking IS model. Furthermore, the link in the monetary transmission process appears to be stronger in the extended model as the interest rate coefficient is of greater magnitude in the case of extended model than in the baseline model. Beside interest rate, the real exchange rate, external demand and crude oil prices have an impact on aggregate demand. Thus, the results suggest that the

standard specification of the IS curve is inadequate to identify the link between the interest rate and aggregate demand and therefore, a broader framework which accounts for the additional variables beside interest may be required. The hybrid model is failed to survive the empirical test as the interest rate coefficient is insignificant in both the baseline as well as extended specifications. However, it is found that the current output gap responds more to its lagged value than its lead. This finding has important implications for inflation targeting framework of monetary policy, where forward looking behaviour gains significance as future path of output and inflation determines the present action. Finally, the output gap is found to be sensitive to the choice of interest rates as the coefficient on the nominal interest rate is higher than the coefficient on the real interest rate. It is important to note that given nominal interest rate, the real interest rate would more be a function of the prevailing inflation rate. Thus, in an attempt to control inflation by assuming implicit target for the real interest rate as is done in India, the nominal interest rate should not wander in undesirables' territories as that may hamper the aggregate demand.

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