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Gold in Monetary Transmission - Some Evidence of Nonlinearities

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Abstract

As a commodity, gold occupies a special place in Indian psyche. With formal capital markets still out of reach for a large section of the Indian population, gold, beyond its traditional use as jewellery, also acts as a store of value, especially under an environment of moderately high inflation. In this paper, we further explore the asset price channel of monetary transmission by endogenizing gold price inflation within the Indian macroeconomic system. Supported by empirical tests in favor of such an inclusion, a linear VAR model results indicate that gold seems to act as a shock absorber by way of shielding other macroeconomic variables, especially GDP growth, from the influence monetary policy shocks. In India, the demand for gold is primarily met by imports. Thus, the dynamics of gold, real exchange rate and inflation are likely to be interlinked in a nonlinear manner. Based on estimation of a TVAR model and simulation methods of inference, we find that there are significant differences in the macroeconomic dynamics of the Indian economy under high and low inflation regimes. Moreover, the TVAR model results suggest that gold seems to matter more in the Indian macroeconomic system during episodes of high inflation.

Keywords: Inflation regime; gold price; hedge; TVAR
JEL: E31; E44; E47; E52; C32

1. Introduction

Deeply rooted in India's culture and tradition, gold occupies a special place in the Indian economy. During the period 2009-2014, the average annual demand for gold in India was around 895 tonnes, amounting to 26 per cent of world's total physical demand for gold [World Gold Council (WGC (2014))]. However with very little domestic supply of gold in India, this demand was primarily met by gold imports. In fact, gold imports in India rose 70 per cent from 492 tonnes in 2002 to 838 tonnes in 2012, according to Kanjilal and Ghosh (2014). This rise in gold imports has had a material impact on India's trade deficit.

Recent import statistics for India suggest that along with 'Petroleum, Crude & Products' and 'Capital Goods,' the 'Gold & Silver' category has been consistently among the top three commodity groups in terms of their share in total imports. In 2007-08, the 'Gold & Silver' category grew at 8.5 per cent annually. However, between 2008-09 and 2011-12, this category's growth rate was between 38 per cent and 52 per cent annually.[1] Only from 2012-13 we have seen a negative growth rate in this category, with the import share coming down to 7.1 per cent in 2013-14 from a recent peak of 12.5 per cent in 2011-12. However, despite this recent moderation in gold imports, its share in India's trade deficit in 2013-14 was still as high as 16.8 per cent, coming down from 27.2 per cent and 24.9 per cent in 2011-12 and 2012-13 respectively.[2] Moreover, we observe that between 2008 and 2013 the Rupee-Dollar nominal exchange rate depreciated by about 55%.

In open economies, such as India, exchange rate fluctuations is likely to affect the behavior of inflation rate and that in turn will have implications for India's monetary policy. The phenomenon of exchange rate pass-through, which is defined as the effect of exchange rate changes on domestic inflation, is well-researched in the economic literature. Working with Indian data, Bhattacharya et al. (2008) and Khundrakpam (2007) find statistically significant evidence of incomplete exchange rate pass-through. Beyond empirically quantifying the degree of exchange rate pass-through, the literature has also delved into the non-linear effects of exchange rate on domestic prices. It is argued that owing to menu costs of changing export price invoices, small exchange rate movements will not see much pass-through to importing

[1] Source: The Directorate General of Commercial Intelligence and Statistics, Ministry of Commerce, Government of India.
[2] Source: The Reserve Bank of India (RBI) Bulletin.

country's domestic prices, although larger exchange rate movements may make the pass-through worthwhile. Ohno (1989) finds evidence of more frequent changes in Japanese export prices during episodes of large exchange rate changes than of small ones. Pollard and Coughlin (2003), while examining exchange rate pass-through into U.S. import prices in the manufacturing sector, also find evidence of this size effect. They find pass-through to be positively related to the size of the change in the exchange rate.

A major theme within gold research pertains to its ability to act as a hedge against inflation [see O'Connor et al. (2015)]. Gold being a hard currency, is expected to gain in value as other fiat currencies lose value through inflation. A large body of empirical literature on this topic finds a positive relation between gold price and inflation. Following works of Fisher (1930) and Fama and Schwert (1977) and using Indian data, Dey (2014) finds gold to be a near complete hedge against expected inflation. In a similar vein, Feldstein (1980) argues that higher expected inflation will lead to higher nominal interest rates, which in turn will lead to higher opportunity costs for holding all other assets, including gold, thereby necessitating higher returns on these alternate assets. Extending the work of Feldstein (1980), Batten et al. (2014) find significant time variation in the relationship between gold and inflation. Their finding shows that US dollar has a significantly negative explanatory power for the time varying relationship between gold and inflation. As a plausible explanation for this finding they argue that dollar depreciations are associated with higher inflation in the US, which, in turn, increases the demand for gold as a hedge.[3]

According to O'Connor et al. (2015), gold today is traded in seven markets around the world: London OTC market, COMEX (New York), the three Shanghai Exchanges, TOCOM (Tokyo), MCX (India), Dubai and Istanbul. In terms of turnover, the London OTC market and the COMEX (New York) are the dominant markets. Despite the dominant size of these two gold markets, the research literature has investigated the relationship between gold prices and price information flows between various world markets. An overwhelming majority of the papers on this issue find New York to be the market that leads in gold price setting and transmission of this price information to other world markets. Although no specific empirical work on the price information transmission links between MCX (India) and other dominant

[3] For further research on the time-varying relationship between gold and inflation, see Worthington and Pahlavani (2007), Beckmann and Czudaj (2013), Bampinas and Panagiotidis (2015), and Hoang et al. (2016).

world gold markets have been done, it will not be a stretch to assume that gold price originates outside India. However given the sheer volume of India's physical gold demand, the importance of Indian demand in the world gold price setting cannot be underestimated.

The use of Vector Autoregression (VAR) model in understanding the transmission of monetary policy goes back a long way in economic literature. Some of the earliest work on this are by Sims (1992), Bernanke and Blinder (1992) and Christiano et al. (1999). More recent work using these models in the Indian context can be found in Aleem (2010) and The Reserve Bank of India (RBI (2014)). Monetary policy shocks transmit within an economy through various channels. For an excellent overview of these channels see Mishkin (1996) and for the specific context of India see RBI (2014). The traditional interest channel of monetary policy works through its effect on cost of capital. However, India lacks a well-functioning bond market and its real estate markets are fragmented and illiquid. As a result, the classic interest channel of monetary policy is usually not found to be dominant in India, according to RBI (2014). In a bank-dominated country, such as India, there is, however, robust evidence of a presence of the credit channel of monetary policy through its effects on bank lending [see Aleem (2010), Pandit and Vashisht (2011), Khundrakpam (2011) and Khundrakpam and Jain (2012)].

The exchange rate channel of monetary policy works through expenditure switching between domestic and foreign goods, thereby affecting both real GDP and aggregate price level. Although Indian data show consistent evidence of significant, yet incomplete, pass-through of exchange rates to domestic prices, their effects on real GDP is found to be weak and short-lived [see Aleem (2010) and RBI (2014)]. Other asset price channels refer to those involving equities and houses. These channels work through the effects of consumption and investment demand on real GDP via the changes in household and firm net worth in response to monetary policy shocks. Paucity of data in the Indian context rendered the use of house prices in testing the asset price channel infeasible. Moreover, Aleem (2010), Singh and Pattanaik (2012) and Singh (2012) find negligible real effects to monetary policy shocks via the equity price channel. As an explanation for this lack of importance of equity-based asset price channel of monetary policy, the RBI (2014) report state that "….during periods of high inflation, there is a tendency for households to shift away from financial savings to other forms of savings such as gold and real estate that tend to provide a better hedge against inflation." In fact we see this statement from the RBI report as an indication of the potential benefit of using a so far overlooked asset, such as gold, in reviving the importance of the asset price channel of monetary policy transmission for the Indian economy, especially in light of the low penetration of formal capital markets in India. In this paper, we use gold as an asset within a quarterly VAR model of the Indian economy to test its contribution in transmitting monetary policy shocks. Our linear VAR model results indicate that endogenizing gold price inflation within the Indian macroeconomic system, makes gold act as a shock absorber wherein by absorbing the significant adverse impact of a contractionary monetary policy shock it shields other macroeconomic variables, especially output growth.

The foregoing literature review has shown that pass-through from exchange rates to domestic prices is positively related to the size of the changes in the exchange rates. Moreover, due to the well-documented inflation hedging motive of gold purchases, the relationship between gold and inflation is found to be stronger during episodes of high inflation. In a primarily gold-importing country, such as India, during a regime of high inflation, not only that gold consumption is expected to accelerate, the Indian rupee is also likely to rapidly depreciate. This, by way of the exchange rate pass-through, is expected to set a cycle of high inflation, high gold consumption and rapid rupee depreciation in a positive feedback loop. However, during a low inflation regime, the role of gold in the dynamics of inflation and exchange rate is likely to be benign. Hence, the macroeconomic dynamics in the Indian data may suggest the suitability of a regime-dependent model, where the switch between the regimes is endogenously determined by the level of inflation.

One of the earliest uses of a Threshold Vector Autoregression (TVAR) model can be seen in the works of Balke (2000). His paper shows how the credit regime the economy is in matters for the propagation of monetary policy shocks. He finds that policy shocks have a larger effect on output during a ‘tight’ credit regime, and that a contractionary policy shock typically has a larger effect than an expansionary shock. More importantly, the credit regime changes in his model are endogenous as shocks to other variables, such as the US monetary policy rate, can result in a switch in regimes. Mandler (2012) also using a TVAR model shows that the propagation of monetary policy shocks through the US economy differs across the high and low inflation regimes. The lower inflation regime shows no sign of a price puzzle (an increase in prices following an unexpected tightening of monetary policy) and a stronger decline in inflation in response to monetary policy shocks in the US. RBI (2014) uses a TVAR model to justify a range of its inflation target by way of identifying distinct macroeconomic dynamics under high and low inflation regimes of inflation rates calculated using Wholesale Price Index (WPI) and Consumer Price Index (CPI) respectively. In this paper, we extend our VAR model to a TVAR model to test the presence of inflation-regime-dependence in the macroeconomic dynamics of Indian data. The TVAR model's impulse response functions clearly indicate perceptible differences in the macroeconomic structure of the Indian economy in the high and low inflation regimes. Moreover, we find that gold has more relevance in the Indian macroeconomic system during episodes of high inflation.

2. Data

We have collected our data from various sources including, International Monetary Fund (IMF) *International Financial Statistics* (*IFS*), Reserve Bank of India (RBI) *Database on Indian Economy*, World Gold Council and *Federal Reserve Economic Data* (*FRED*). The Consumer Price Index (CPI) and the Wholesale Price Index (WPI) data is obtained from *IFS* at quarterly frequency. The CPI data for India is a Laspeyres index that represents the cost of living of the entire Indian population, rural and urban combined with a base year of 2010. The prices are at the retail level for actual transactions, inclusive of sales tax and other such charges payable by the consumer, after taking care of discounts or rebates, if any. Similarly, the WPI data is a pan-India cost of living Laspeyres index at the wholesale level with a base year of 2010. The wholesale price is the price of bulk transactions at a primary stage. For agricultural commodities these prices may be farm harvest prices, or prices at the village market or procurement prices. As for manufactured goods, these are administered prices, ex-factory gate/ex-mill, ex-mine prices. Ex-factory prices exclude all rebates, other taxes and levies; however, these include excise duties. The World Gold Council database provides quarterly average gold prices per troy ounce in rupees. The quarterly average Call Money Rate data is obtained using the RBI database. The Call Money Rate is the overnight lending and borrowing rate for money market participants in India. This rate is considered to be the consensus proxy for the monetary policy rate among researchers using India data. Finally, from the Federal Reserve Bank of St. Louis *FRED* database we obtain data on Indian GDP at constant prices (seasonally adjusted and in billions) and the Real Broad Effective Exchange Rate for India (BIS) at quarterly frequency. Our sample for estimation is 1996Q2 to 2014Q4.

3. Empirical Model

Since the beginning of the 1990's, the RBI began to rely on indirect instruments, such as interest rates, as the primary tool to conduct its monetary policy. Monetary policy in India was always conducted in order to maintain a judicious balance between economic growth and price stability.[4] Moreover, since the 1990's, the Call Money Rate was implicitly and since 2011, was explicitly recognized as the operating target rate of monetary policy in India. In view of this background, we intend to understand the extent to which the conduct of monetary policy, which essentially tries to influence the rate at which money market participants borrow and lend to each other overnight funds, is able to influence Indian economic growth and inflation.

Just as we saw a shift in the way monetary policy is conducted in India post 1990's, so did India's policy towards gold. The Gold Control Act (1968), which controlled sale and possession of gold and had essentially prohibited official gold imports in India, was repealed in 1990. Since then the gold market in India has been gradually deregulated.

Gold has always been socioeconomically important in India. Since its liberalization from the early 1990's, India, with its negligible domestic output of gold, gradually became one of the largest importers of gold in the world. From an official import of practically nothing in 1991, India officially imported 492 tonnes in 2002 to a peak of 838 tonnes in 2012. Only from 2013 did we see the import volume come down, with the figures for 2013 and 2014 being 825 tonnes and 769 tonnes respectively.[5] It is important to note that this increase in Indian gold imports was happening at a period when gold price was increasing at a compound annual growth rate of 10%. Moreover, the same growth rate of gold price was 13% since 2000, coinciding with a period of a steadily depreciating rupee-dollar exchange rate, a stubbornly high Indian inflation rate, a persistent increase in world commodity prices and two U.S. recessions of 2001 and 2007-2009.

Following the long tradition of empirical research using VAR models to assess the efficacy of transmission of monetary policy and particularly following the work of Al-Mashat (2003),

[4] See RBI (2011).
[5] Source World Gold Council.

Aleem (2010) and The Reserve Bank of India (RBI (2014)) in the Indian context, we intend to explore the importance of gold as an asset in transmitting monetary policy shocks in the Indian economy. Our VAR(p) model is represented as follows:

$$y_t = A^0(L)y_{t-1} + Bx_t + \epsilon_t \tag{1}$$

where, $\epsilon_t \backsim iid\ N(0, \Sigma)$, y_t is a k x 1 vector of endogenous variables at time t, x_t is a d x 1 vector of exogenous variables at time t, $A^0(L)$ is a lag polynomial matrix, with $A^0(L) = A_0L^0 + A_1L^1 + \cdots + A_{p-1}L^{p-1}$ and $L^k y_t = y_{t-k}$. Moreover, $A_0, A_1, \ldots, A_{p-1}$ and B are matrices of coefficients to be estimated. We ensure that all variables in the VAR model are stationary. Except for the Call Money Rate and the Real Broad Effective Exchange Rate (REER), all included variables are in log differences, representing the annualized rates of quarter-to-quarter changes.[6]

The benchmark VAR model has the ordering of variables as GDP Growth Rate, CPI/WPI Inflation, Call Money Rate, REER and Gold Price Inflation. The lag order of the VAR model is selected based on several lag selection criteria and the *LM* test for autocorrelation. For the VAR model based on the CPI Inflation, the Akaike Information Criterion (*AIC*) and the Final Prediction Error (*FPE*) point to an optimal lag order of 6 and the *LM* test on a model using this lag order also indicates no significant autocorrelation problem in the residuals (see Table 2 in Appendix). With a similar reasoning we also arrive at a lag order of 6 for the VAR model based on the WPI Inflation. In the benchmark VAR model we have the constant term as only added exogenous variable.

Based on the aforementioned ordering of variables in our benchmark VAR, we now proceed to analyze the impulse response functions (with $\pm$ 2 standard error confidence band) of one standard deviation change in orthogonalized Call Money Rate shocks (see Appendix Figure 1). For the CPI-VAR model, we find that in response to a monetary policy shock the GDP growth falls initially, although the magnitude of fall is statistically insignificant in the first 8 quarters. A statistically significant fall in the GDP growth comes only as far as 11 quarters into the future, when growth rate falls by 0.52 percentage point. CPI inflation, in response to a policy shock, behaves as expected – starting with a 0.14 percentage point increase in quarter 2 (some evidence of *price puzzle*[7]) to a steady fall throughout the forecast horizon.

[6] See Appendix Table 1 for a summary of the unit root tests.
[7] See Eichenbaum (1992).

The *price puzzle*, however, is not observed in case we calculate the generalized impulse responses, where the orthogonalization is not dependent on the ordering of variables in the VAR. The response of CPI inflation is, however, within the confidence interval. Expectedly, the response of REER is also negative after a policy surprise, although not significantly in most periods of the forecasting horizon. Finally, gold price inflation after going up marginally in quarter 1 falls significantly in quarter 3 by as much as 3.8 percentage points. This overall negative response of gold price, albeit with the initial temporary increase, after a contractionary monetary policy is also observed when we consider generalized impulses.

We now contrast the impulse responses obtained from our benchmark CPI-VAR model with those out of a VAR model where the contemporaneous gold price inflation is treated as an exogenous variable along with the constant term and where the ordering of other endogenous variables is kept the same as the benchmark CPI-VAR. In this comparison CPI-VAR, we find that the response of GDP growth to a contractionary monetary policy shock is much more pronounced (see Appendix Figure 2). In fact the fall in GDP growth is significant between 3 and 6 quarters, with the quarter 5 showing a fall by almost 0.65 percentage points. Although the benchmark VAR is able to bring down CPI inflation by a larger percentage point farther down the forecast horizon, the 3 to 6 quarters response of CPI inflation in the comparison VAR is also more pronounced. There is also no evidence of *price puzzle* in the comparison VAR. Even for the REER, we find the 3 to 6 quarters response after the policy shock to be of a higher magnitude.

This seems to suggest that in our benchmark VAR model, gold by virtue of being within the endogenous macroeconomic system, is acting as a shock absorber by way of absorbing the significant adverse impact of a contractionary monetary policy shock and in the process shielding other macroeconomic variables, especially out growth. A contractionary monetary policy by inducing a significant fall in gold prices seems to wean investors away from gold to other productive assets, thus causing a reduced negative impact on output growth. An endogenous gold price inflation model also delays the influence of monetary policy on other macroeconomic variables. A similar dynamics of our macroeconomic model is observed when we replace CPI inflation with WPI inflation in the VAR (see Appendix Figures 3 and 4).[8]

Nonlinearities in Macroeconomic Dynamics

Based on the discussions of the impulse response functions of the VAR(p) model and the results of the pairwise Granger causality tests, we can justify the inclusion of gold price inflation as part of the endogenous macroeconomic system. Moreover, the extant literature has found the importance of inflation regimes in propagation of monetary policy shocks through the economy. Mandler (2012) argue that the economy may behave differently if the prevailing inflation rate deviates beyond a particular threshold in the economy as it dents the credibility of the central bank and market participants start adjusting their inflation expectations. In addition, due the well-documented inflation hedging motive of gold purchases in a primarily gold-importing country, such as India, the macroeconomic effects of high inflation is expected to be augmented by gold price inflation and exchange rate depreciation, thus affecting the degree of influence of monetary policy. Hence, we believe that the macroeconomic structure of the Indian economy may necessitate a model where inflation plays a role as a nonlinear propagator of shocks. Following Balke (2000), a convenient way to model such nonlinearities is to estimate a TVAR model that allows estimation of different sets of model parameters for different states of the economy.

We propose the following TVAR(p) model for the Indian economy:

$$y_t = A^1(L)y_{t-1} + B^0 x_t + (A^2(L)y_{t-1} + B^1 x_t)I(c_{t-d} > \gamma) + u_t \qquad (2)$$

where $u_t \backsim iid\ N(0, \Sigma)$, y_t is a vector of stationary endogenous variables at time t with the variable ordering as GDP Growth Rate, CPI/WPI Inflation, Call Money Rate, REER and Gold Price Inflation, x_t is a vector of stationary exogenous variables at time t (here we use a constant), $A^1(L)$ and $A^2(L)$ are lag polynomial matrices that along with B^0 and B^1 are to be estimated. c_{t-d} is the threshold variable determining the regime of the macroeconomic system and $I(c_{t-d} > \gamma)$ is an indicator function that takes a value 1 when $c_{t-d} > \gamma$ and 0 otherwise. Our threshold variable is a function of the inflation rate, which is part of y_t. Hence, the TVAR

[8] We also present in Table 4 of the Appendix the results of pairwise Granger causality tests whether an endogenous variable can be treated as exogenous. Our tests indicate that gold prices matter for output growth and the policy rate and in turn policy rate and real exchange rate dynamics affect gold prices.

model describes both the evolution of y_t and the inflation regimes, and shocks to other variables, such as the Call Money Rate, can result in a switch of the inflation regimes.

Following Balke (2000), in order to test for the threshold effect we first estimate the model by OLS using a grid of possible threshold values and then generate a set of Wald statistics under the null hypothesis of no threshold behavior.[9] Testing for threshold behavior in (2) involves nonstandard inference since the threshold value γ is not identified under the null hypothesis of no threshold effects. Following the simulation method of Hansen (1996), the empirical distributions of the set of Wald statistics was used to conduct inference. In order to guard against overfitting, the range of threshold values were restricted so that at least the number of observations in each inflation regime equaled the number of parameters for an individual equation.

4. Results

4.1 Estimates for Threshold Effects

Since testing for the threshold behavior involves nonstandard inference using simulation methods due to Hansen (1996), we experiment with different types of threshold variables for our tests. We choose the lag order of our TVAR model as four since it corresponds closely to the standard monetary policy VAR model in the literature. We test for threshold effects using lags of up to an order of two of the CPI/WPI inflation rates and their moving averages. The actual threshold variable and the threshold value is chosen based on the statistical significance of the highest value of the "Avg" and "Exp" versions of the Wald tests. We present the results of the tests of threshold behavior for a linear VAR in Table 5. Based on our chosen criteria, we find that a three-period moving average with a threshold delay of two is the threshold variable for the model with CPI inflation data and the value of the inflation threshold beyond which the macroeconomic structure becomes statistically different comes out to be 7.8 percent. For the WPI inflation model, the chosen threshold variable is a two-period moving average with a threshold delay of one and the value of the significant inflation threshold is 6.4 percent.

[9] The set of Wald statistics calculated are: Sup-Wald, which is the maximum Wald statistic over all possible threshold values; Avg-Wald, which is the average Wald statistic over all possible threshold values; and Exp-Wald, which is a function of the sum of exponential Wald statistics. According to Balke (2000), Andrews and Ploberger (1994) suggest the "Avg" and "Exp" versions of the Wald test for inference.

In order to elaborate our results, we plot GDP growth, CPI inflation and gold price inflation in Figure 5 and specifically observe the behavior of these variables during the periods of high inflation regimes as highlighted by the CPI-based inflation threshold variable. The shaded regions in Figure 5 represent the two high inflation regimes identified in our data (1998Q2-1999Q2 and 2008Q4-2014Q2). In the first high inflation episode, the CPI-based threshold variable and the gold price inflation almost perfectly match their ups and downs, while the output growth hold steady. Then in the first half of the second high inflation regime we observe a rise in output growth, inflation and gold prices, followed by a reversal of this dynamics in the second half.

4.2 Nonlinear Impulse Responses

Following Balke (2000), we generate nonlinear impulse response functions using simulation methods. Figure 6 presents the results for up to two standard deviations positive and negative monetary policy shocks on selected variables of the CPI-based TVAR model. At the outset, we notice that the monetary policy shocks are symmetric, in the sense that expansionary and contractionary shocks have similar effects, in magnitude, on the macroeconomic structure of the Indian economy. Positive Call Money Rate shocks lead to decline in output growth both in high and low inflation regimes, with the effect on output being distinctly stronger in the low inflation regime. The impulse response function of CPI inflation rate in response to policy shocks suffers from *price puzzle* in the low inflation regime only. The CPI inflation rate, however, responds much more to these shocks in the high inflation regime. In the low inflation regime the real exchange rate responds very little initially after a surprise change in the policy rate; however, over the forecasting horizon the eventual decline in REER is quite substantial. This observed dynamics of the REER is exactly opposite during the high inflation regime. Finally, the initial response of gold prices to monetary policy shocks is much more pronounced in the low inflation regime, although in high inflation regime the overall impact on gold prices is higher as the impulse responses show no sign of oscillation. Overall, the impulse response functions indicate noticeable differences in the macroeconomic dynamics of the Indian economy in the high and low inflation regimes. By comparing our TVAR model results with those obtained from the linear VAR model, we observe that gold seems to act more like an exogenous variable in the low inflation regime, where the monetary policy is able to influence output growth much more. Only in the high inflation regime that we see a reduced ability of monetary policy shocks in affecting GDP growth rates. This seems to suggest that gold in the Indian macroeconomic system has more relevance during episodes of high inflation.

5. Conclusions

India's culture and tradition makes gold a special commodity. Gold's use in jewellery in most countries around the world and especially in India is well known. Moreover, given its liquidity and India's low penetration of formal capital markets, gold plays an important dual role as a store of value in India. Gold price literature has extensively researched the role of gold as a hedge against inflation. This combined with the fact that India's gold demand is primarily met by imports is likely to make the dynamics of gold price, real exchange rate and inflation intricately interlinked. In this regard, we believe that the literature has not fully explored the role of gold in the asset price channel of monetary policy transmission for the Indian economy. Supported by empirical tests, our linear VAR model results indicate that endogenizing gold price inflation within the Indian macroeconomic structure makes gold act as a shock absorber wherein it shields other macroeconomic variables, especially output growth, from the adverse impact of contractionary monetary policy shocks.

The literature on monetary policy has explored the role of various macroeconomic variables as nonlinear propagator of shocks using TVAR models. We believe the incentive to use gold as a hedge against inflation is stronger in episodes of high inflation. Moreover, high inflation episodes is likely to have adverse impact on Indian exchange rate and a depreciating rupee is then likely to feed-in to an already high India inflation rate through exchange rate pass-through. Hence, it is argued in this paper that the dynamic macroeconomic structure of the Indian economy may be significantly different during high inflation episodes when compared to relatively benign periods of inflation. Following the simulation-based methods of inference from the TVAR literature, we find that there are significant differences in the macroeconomic dynamics of the Indian economy when the CPI inflation process crosses 7.8 percent or the WPI inflation process is above 6.4 percent. We also find that gold seems to matter more in the Indian macroeconomic system during episodes of high inflation.

References

Aleem, A. (2010), 'Transmission Mechanism of Monetary Policy in India'. *Journal of Asian Economics*, 21, 186–197.

Al-Mashat, R. (2003). 'Monetary Policy Transmission in India: Selected Issues and Statistical Appendix'. *Country Report No. 03/261*, International Monetary Fund, Washington D.C.

Andrews, D. and Ploberger, W. (1994), 'Optimal Tests When a Nuisance Parameter Is Present Only under the Alternative'. *Econometrica*, 62, 1383–1414.

Balke, N.S. (2000), 'Credit and Economic Activity: Credit Regimes and the Nonlinear Propagation of Shocks'. *Review of Economics and Statistics*, 82, 516–536.

Bampinas, G. and Panagiotidis, T. (2015), 'Are Gold and Silver a Hedge against Inflation? A Two Century Perspective'. *International Review of Financial Analysis*, 41, 267–276.

Batten, J.A., Ciner, C., and Lucey, B.M. (2014), 'On the Economic Determinants of the Gold Inflation Relation'. *Resources Policy*, 41, 101–108.

Bhattacharya, R., Patnaik, I., and Shah, A. (2008) 'Exchange Rate Pass-through in India.' National Institute of Public Finance and Policy, New Delhi.

Beckmann, J. and Czudaj, R. (2013), 'Gold as an Inflation Hedge in a Time-varying Coefficient Framework'. *The North American Journal of Economics and Finance*, 24, 208–222.

Bernanke, B. S. and Blinder, A.S. (1992), 'The Federal Funds Rate and the Channels of Monetary Transmission'. *American Economic Review*, 82, 901–21.

Christiano, L.J., Eichenbaum, M., Evans, C.L. (1999), 'Monetary Policy Shocks: What Have We Learned and to What End? In: Taylor, J.B., Woodford, M. (Eds.), *Handbook of Macroeconomics*, vol. 1A. North-Holland, Amsterdam, pp. 65–148.

Dey, S. (2014), 'Inflation Hedging in India'. Indian Institute of Management Kozhikode Working Paper, IIMK/WPS/164/ECO/2014/22.

Eichenbaum, M. (1992), 'Comment on Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy'. *European Economic Review*, 36, 1001–1011.

Fama, E.F. and Schwert, G.W. (1977), 'Asset Returns and Inflation'. *Journal of Financial Economics*, 5, 115–146.

Feldstein, M. (1980), 'Inflation, Tax Rules, and the Prices of Land and Gold'. *Journal of Public Economics*, 14, 309–317.

Hansen, B.E. (1996), 'Inference When a Nuisance Parameter is Not Identified under the Null Hypothesis'. *Econometrica*, 64, 413–430.

Hoang, T.H.V., Lahiani, A., and Heller, D. (2016), 'Is Gold a Hedge Against Inflation? New Evidence from a Nonlinear ARDL Approach.' *Economic Modelling*, 54, 54–66.

Kanjilal, K. and Ghosh, S. (2014), 'Income and Price Elasticity of Gold Import Demand in India: Empirical Evidence from Threshold and ARDL Bounds Test Cointegration.' *Resources Policy*, 41, 123–142.

Khundrakpam, J.K. (2007), 'Economic Reforms and Exchange Rate Pass-through to Domestic Prices in India'. *BIS Working Papers 225*, Bank for International Settlements, Basel.

Khundrakpam, J.K. (2011), 'Credit Channel of Monetary Transmission in India - How Effective and Long is the Lag?' *RBI Working Paper No. 20*, Reserve Bank of India, Mumbai.

Khundrakpam, J.K. and Jain, R. (2012), 'Monetary Policy Transmission in India: A Peep Inside the Black Box'. *RBI Working Paper No. 11*, Reserve Bank of India, Mumbai.

Mishkin, F.S. (1996), 'The Channels of Monetary Transmission: Lessons for Monetary Policy'. *NBER Working Paper No. 5464*, National Bureau of Economic Research, Boston.

O'Connor, F.A., Lucey, B.M., Batten, J.A., and Baur, D.G. (2015), 'The Financial Economics of Gold – A Survey'. *International Review of Financial Analysis*, 41, 186–205.

Ohno, K. (1989), 'Export Pricing Behavior of Manufacturing: A U.S.-Japan Comparison'. *IMF Staff Papers*, 550–579.

Pandit, B.L. and Vashisht, P. (2011), 'Monetary Policy and Credit Demand in India and Some EMEs'. *Working Paper No.256*, Indian Council for Research on International Economic Relations, New Delhi.

Pollard, P.S. and Coughlin, C.C. (2003), 'Size Matters: Asymmetric Exchange Rate Pass-through at the industry level'. Working Paper, Federal Reserve Bank of St. Louis.

RBI (2011), 'Working Group on Operating Procedure of Monetary Policy'. Chairman: Deepak Mohanty, Reserve Bank of India, Mumbai.

RBI (2014), 'Report of the Expert Committee to Revise and Strengthen the Monetary Policy Framework'. Chairman: Urjit Patel, Reserve Bank of India, Mumbai.

Sims, C.A. (1992), 'Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy'. *European Economic Review*, 36, 975–1000.

Singh, B. (2012), 'How Important Is the Stock Market Wealth Effect on Consumption in India?' *Empirical Economics*, 43, 915–927.

Singh, B. and Pattanaik, S. (2012), 'Monetary Policy and Asset Price Interactions in India: Should Financial Stability Concerns from Asset Prices be Addressed through Monetary Policy?' *Journal of Economic Integration*, 27,167–194.

Worthington, A.C. and Pahlavani, M. (2007), 'Gold Investment as an Inflationary Hedge: Cointegration Evidence with Allowance for Endogenous Structural Breaks'. *Applied Financial Economics Letters*, 3, 259–262.

Appendix

Table 1: Unit Root Tests

Variable	ADF[a]	Philips-Perron[a]	KPSS[b]
CPI Inflation	-2.33	-2.54	0.40
WPI Inflation	-5.36***	-2.49	0.39
Call Money Rate	-4.24***	-4.24***	0.19
GDP Growth Rate	-2.53	-3.43**	0.26
REER	-3.26**	-2.61	0.30
Gold Price Inflation	-3.52**	-2.72	0.35

[a] H_0 is presence of unit root; [b] H_0 is stationarity.
*** Significant at 1% level; ** Significant at 5% level.

Table 2: CPI-VAR Autocorrelation Tests

Lags	LM-Stat	Probability
1	24.72048	0.4781
2	23.63079	0.5408
3	15.10721	0.9388
4	20.14323	0.7393
5	18.94229	0.7999
6	29.85452	0.2298
7	21.60344	0.6585
8	22.10794	0.6295
9	28.93024	0.2668
10	17.33263	0.8694
11	29.14989	0.2577
12	24.83312	0.4718

Table 3: WPI-VAR Autocorrelation Tests

Lags	LM-Stat	Probability
1	28.25769	0.2961
2	33.42974	0.1207
3	15.86715	0.9187
4	35.32544	0.0825
5	20.72482	0.7078
6	33.26721	0.1245
7	26.19139	0.3974
8	25.72097	0.4226
9	32.23091	0.1514
10	30.11118	0.2202
11	31.14756	0.1842
12	40.04252	0.0289

Table 4: Pairwise Granger Causality Tests

Excluded Variables	Chi-sq.	Probability
GDP Growth Rate		
CPI Inflation	11.00541	0.0882
Call Money Rate	5.263055	0.5105
REER	15.07037	0.0197
Gold Price Inflation	12.45275	0.0526
CPI Inflation		
GDP Growth Rate	2.209101	0.8995
Call Money Rate	21.50595	0.0015
REER	10.50279	0.1050
Gold Price Inflation	8.101207	0.2308
Call Money Rate		
GDP Growth Rate	5.018526	0.5414
CPI Inflation	14.01211	0.0295
RBEER10	7.417571	0.2839
Gold Price Inflation	19.06337	0.0041
REER		
GDP Growth Rate	10.65979	0.0995
CPI Inflation	2.761262	0.8382
Call Money Rate	2.317007	0.8884
Gold Price Inflation	9.282308	0.1583
Gold Price Inflation		
GDP Growth Rate	1.977805	0.9217
CPI Inflation	5.922438	0.4319
Call Money Rate	13.12248	0.0411
REER	11.52031	0.0736

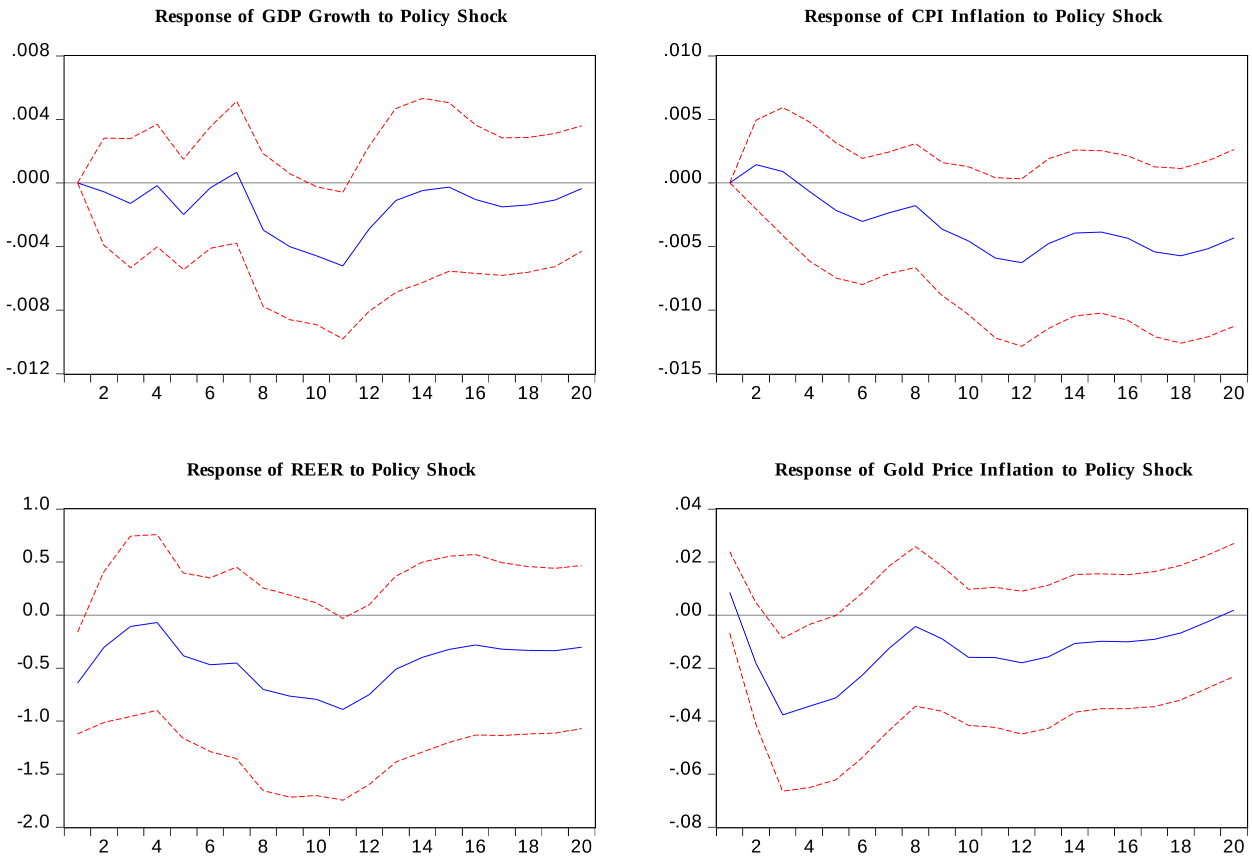

Figure 1: Impulse Response Functions to Monetary Policy Shocks in CPI-VAR

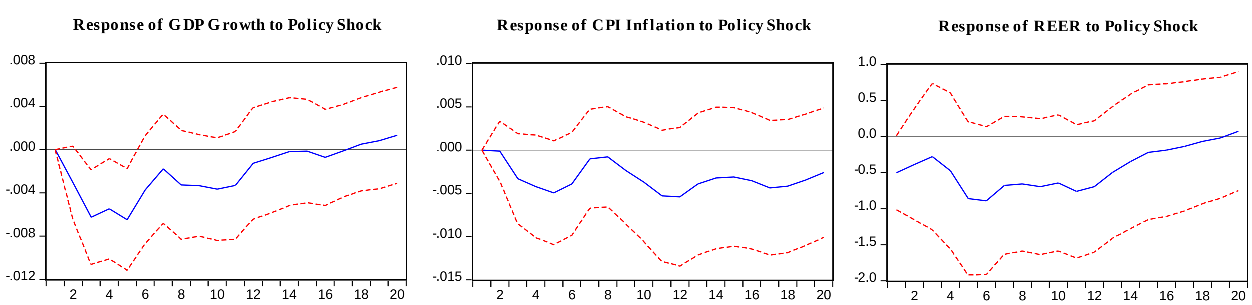

Figure 2: Impulse Response Functions to Monetary Policy Shocks in CPI-VAR (Gold Exogenous)

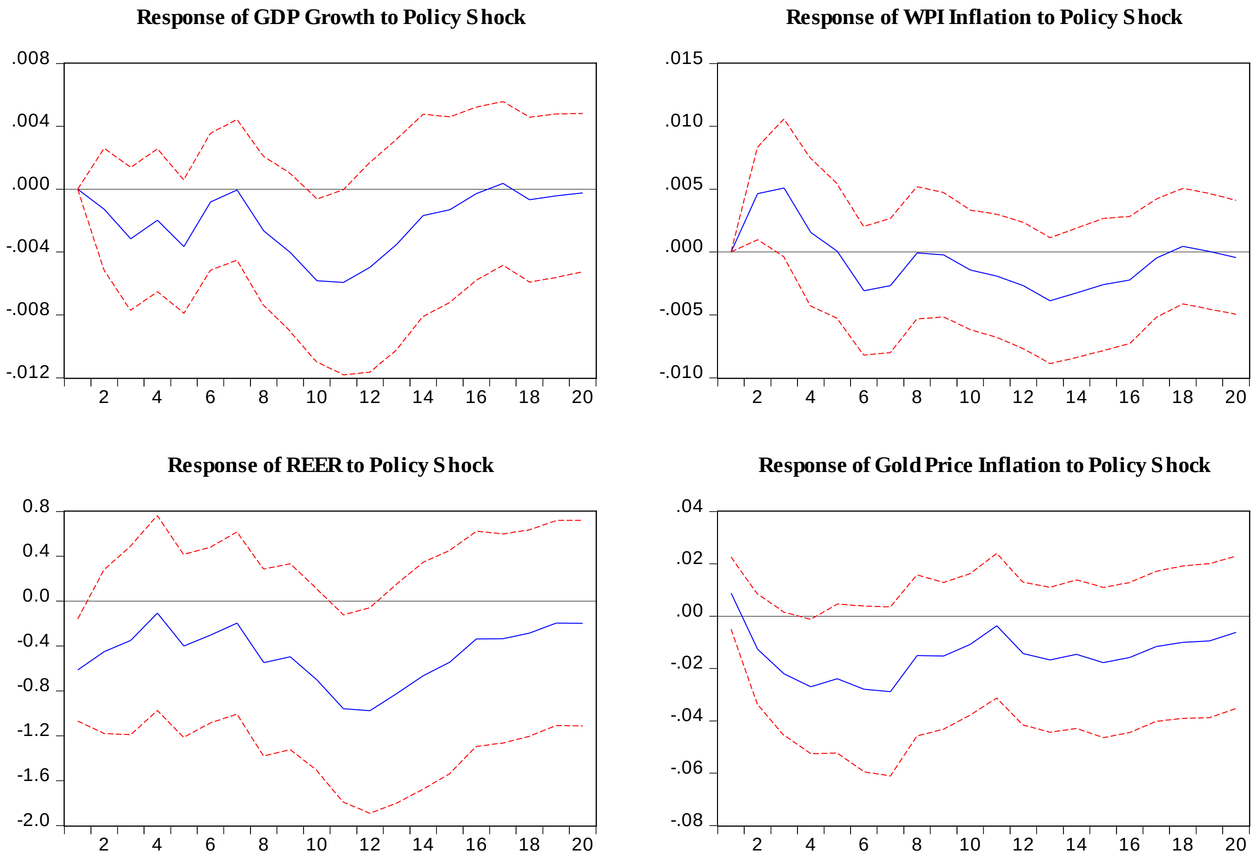

Figure 3: Impulse Response Functions to Monetary Policy Shocks in WPI-VAR

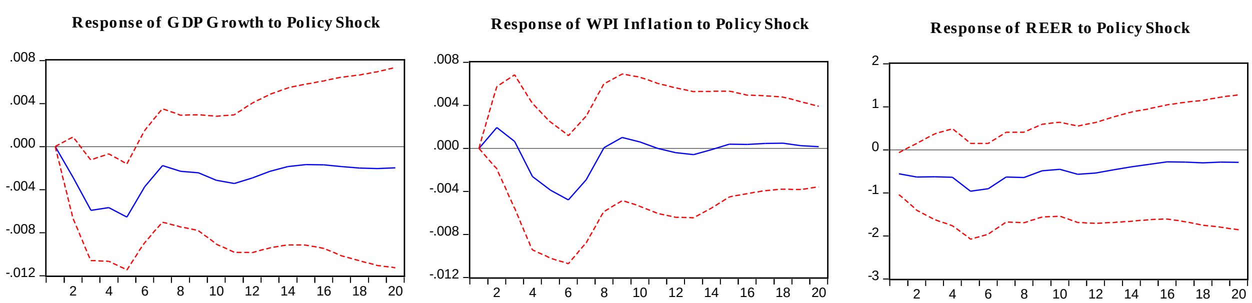

Figure 4: Impulse Response Functions to Monetary Policy Shocks in WPI-VAR (Gold Exogenous)

Table 5

Tests for Threshold Vector Autoregression.

TVAR System: GDP Growth Rate, CPI/WPI Inflation, Call Money Rate, REER and Gold Price Inflation

Threshold Variable	Lag Order	Threshold Estimate	Sup-Wald	Avg-Wald	Exp-Wald
$CPI\ Inf\ [d = 1]$	4	$\gamma = 0.069$	364.80**	293.29***	288.61***
$WPI\ Inf\ [d = 1]$	4	$\gamma = 0.065$	300.15	262.65	262.14
$CPI\ Inf\ [d = 2]$	4	$\gamma = 0.069$	349.11	290.62***	286.11***
$WPI\ Inf\ [d = 2]$	4	$\gamma = 0.058$	299.49	259.39	258.31
$CPI\ Inf\ [MA(2), d = 1]$	4	$\gamma = 0.081$	375.08**	302.49***	297.49***
$WPI\ Inf\ [MA(2), d = 1]$	4	$\gamma = 0.064$	306.50	271.47**	270.54**
$CPI\ Inf\ [MA(2), d = 2]$	4	$\gamma = 0.068$	348.64	294.31***	290.56***
$WPI\ Inf\ [MA(2), d = 2]$	4	$\gamma = 0.065$	283.36	242.86	241.97
$CPI\ Inf\ [MA(3), d = 1]$	4	$\gamma = 0.066$	342.81	290.59***	287.05***
$WPI\ Inf\ [MA(3), d = 1]$	4	$\gamma = 0.058$	314.71	261.77	260.66**
$CPI\ Inf\ [MA(3), d = 2]$	4	$\gamma = 0.078$	356.32	306.89***	302.93***
$WPI\ Inf\ [MA(3), d = 2]$	4	$\gamma = 0.059$	273.88	241.64	241.20

*** Significant at 1% level; ** Significant at 5% level.
Notes: Sample period is 1997:2-2014:4.
The threshold delay variable is given by *d*.
A moving average of length *k* is denoted as *MA*(*k*).
Significance of the threshold values is based on Hansen's (1996) method of inference with 500 replications.

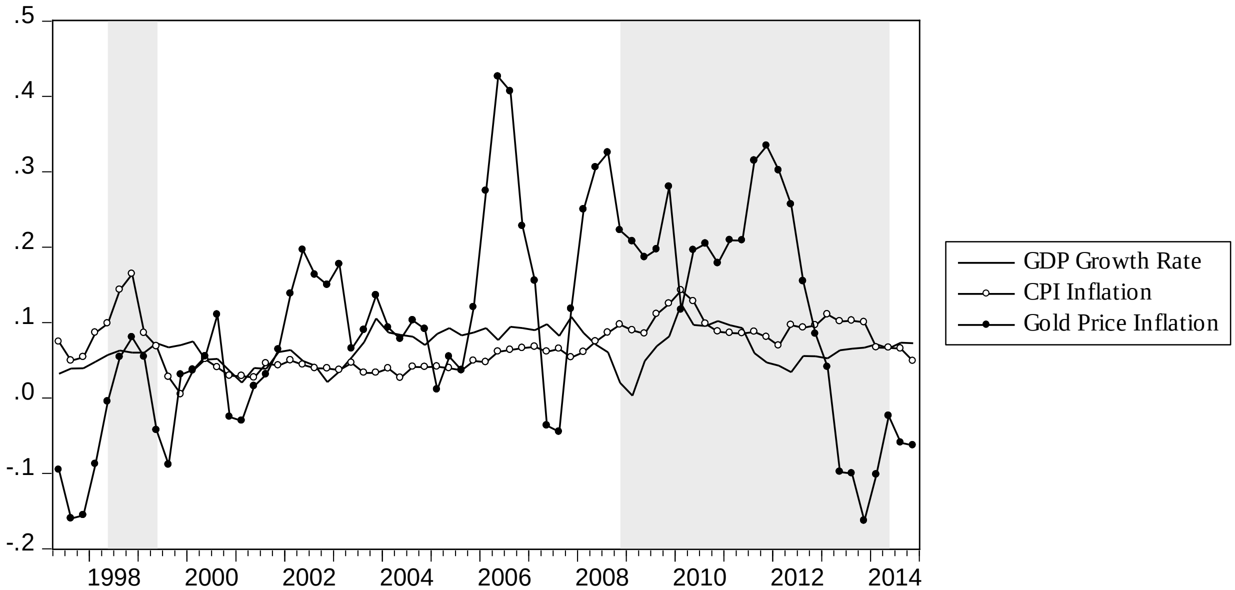

Figure 5: Output, Inflation and Gold Prices in Different Inflation Regimes

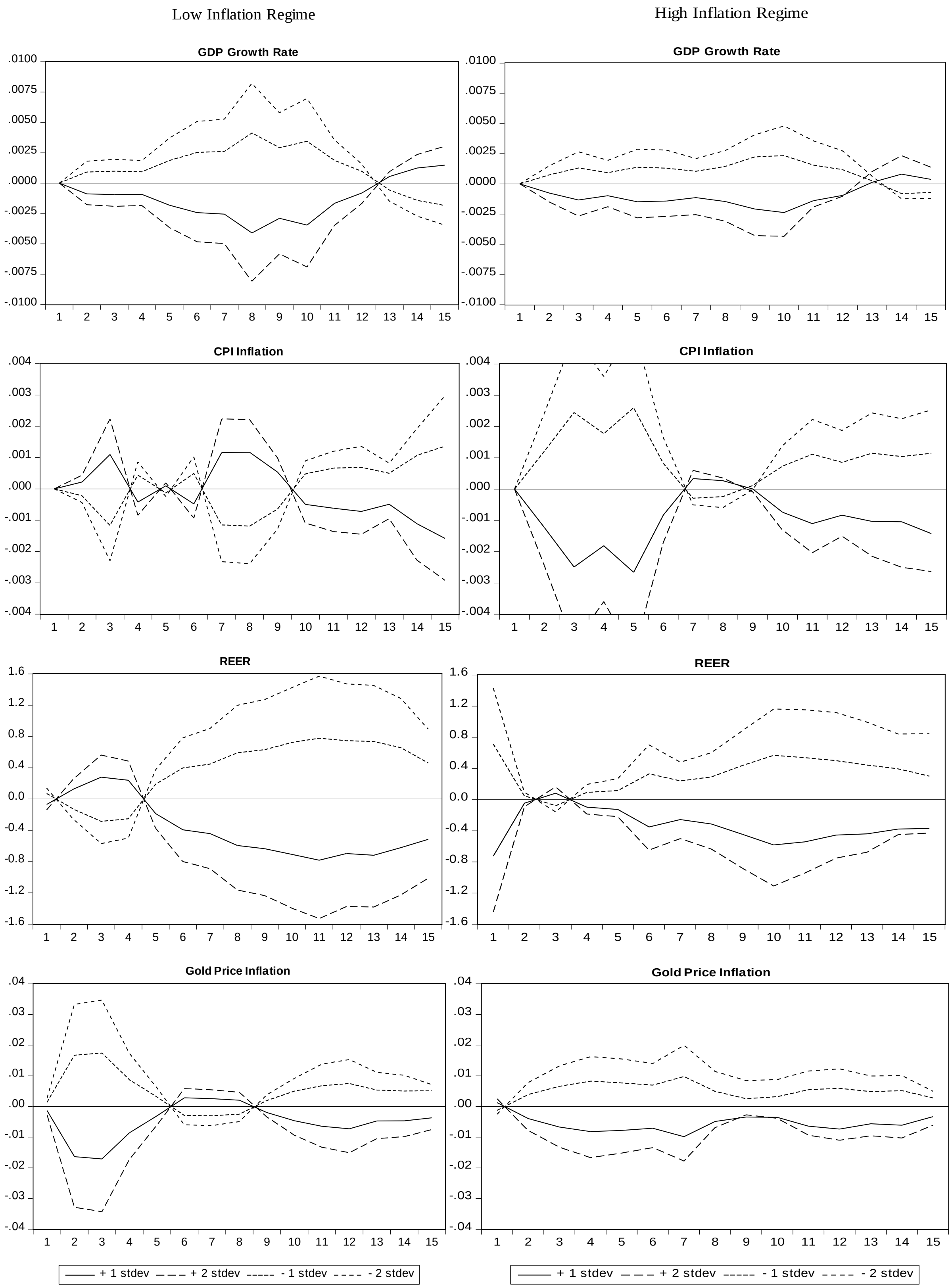

Figure 6: Impulse Responses to Monetary Policy Shocks in Different Inflation Regimes

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