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Appendix and Supplemental material not intended for publication-Round 2

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Supplementary file contains details on control variables, data definition and source, Methodology, Model specification and identification, Robustness analysis, References

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## DETERMINANTS OF FDI AND THE ROLE OF DOMESTIC MONETARY POLICY: THEORETICAL PERSPECTIVE

There are many well-established theories explaining why FDI occurs and what its potential determinants are, such as Heckscher-Ohlin's neoclassical trade theory, Vernon's product life cycle theory (1966), Hymer's market imperfection hypothesis (1976), Rugman's internalisation theory (1986) and Dunning's eclectic paradigm/OLI approach (1977, 1981, 1988)[1]. However, it is not entirely clear in the theory how a shock in domestic/host country's monetary policy will affect the FDI flows.

It is said that FDI flows are generally for the longer term. Therefore, they are more likely to be driven by the economy's domestic fundamentals and long-term growth prospects. Hence, a change in domestic monetary policy, which changes the expected return on domestic assets vis-à-vis foreign assets, will not affect FDI flows. There is also another view that if a change in domestic monetary policy causes interest rate differential (between the domestic and foreign country) to increase, foreign investors will access cheaper funds from their own country and invest in developing countries to exploit arbitrage opportunities, leading to an increase in capital inflows including FDI. In this paper, we use two variables—interest rate differential and domestic money supply growth—to empirically assess how domestic monetary policy shock will affect FDI flows to India. Their expected impact is discussed below.

**(a) Interest rate differential**: As stated above, there can be two opposite views on how interest rate differential affects FDI flows. First, an increase in interest rate differential allows foreign investors to access cheaper funds from their own country and invest in developing countries to exploit arbitrage opportunities, leading to a rise in capital inflows, including FDI. Second, as FDI flows are generally for the longer term, they are not likely to be affected by variables representing short-term financial conditions in domestic and foreign countries, such as interest rate differential. The empirical evidence on FDI (Verma and Prakash 2011, Hannan 2017, Belke and Volz 2019) seems to support the second point of view.

**(b) Domestic money supply growth**: Domestic money supply growth is another variable representing domestic monetary policy shock. Given the long-term nature of FDI, a change in domestic money supply growth which changes the interest rate differential (between the domestic and foreign country), is not likely to have a significant effect on FDI flows. However,

[1] OLI denotes Ownership, Location and Internalization.

there is also another view that says that an increase in domestic money supply growth will have a positive impact on ongoing domestic economic growth that creates an expectation of future GDP growth and, thus, more FDI inflows.

The literature suggests that FDI flows are also affected many other domestic and external factors (Calvo et al 2001, Amaya and Rowland 2004, Albuquerque, Loayza and Serven 2005, Sahoo 2006, Yeyati, Panizza and Stein 2007, Wyk and Lal 2008, Demirhan and Masca 2008, Vijayakumar, Sridharan and Rao 2010, Jadhav 2012, Kinda 2012, Dua and Garg 2015, Hannan 2017, Belke and Volz 2019). It is essential to control for these factors while analysing the role of domestic monetary policy. We select these factors based on Dunning's OLI theory (1977, 1981, 1988) and the empirical literature. The domestic macroeconomic factors implied by Dunning's OLI theory are domestic output growth, domestic country's creditworthiness, domestic macroeconomic instability, infrastructure and degree of openness. Exchange rate defined as the rupee cost of a US dollar is also included as one of the potential macroeconomic determinants[2].

While the impacts of domestic economy's creditworthiness, domestic output growth, infrastructure and degree of openness on FDI flows are likely to be positive, domestic macroeconomic instability is expected to affect the FDI flows negatively. The impact of exchange rate is ambiguous because the increase in exchange rate, i.e., the depreciation of domestic currency can have both positive and negative impact on FDI inflows[3]. Finally, to capture the effect of external factors on FDI inflows, the study has incorporated two varibles – the foreign output growth and the volatility in global market.

Hence, we obtain the following empirical model of the study:

$$FDI_t = \varphi + \varphi_1 (i_t - i_t^*) + \varphi_2 Mg_t + \varphi_3 (fd/y)_t + \varphi_4 y_t + \varphi_5 ex_t + \varphi_6 rm_t + \varphi_7 infra_t + \varphi_8 open_t + \varphi_9 globalVol_t + \varphi_{10} y_t^* + \mu_t \quad (1)$$

$\varphi_1 = 0$ or ?, $\varphi_2 = 0$ or ?, $\varphi_3 < 0$, $\varphi_4 > 0$, $\varphi_5 > 0 < 0$, $\varphi_6 > 0$, $\varphi_7 > 0$

[2] There are a wide range of variables that affect FDI flows. However, since our principal interest was to know the impact of domestic monetary policy shock, we opted to include those variables as control variables, which were found to be common across studies in the literature for the quarterly analysis.

[3] Studies such as Froot and Stein (1991), Klein and Rosengren (1994), Blonigen (1997), Ang (2008), and Vijayakumar, Sridharan and Rao (2010) find a positive relationship between domestic currency depreciation and FDI inflows. On the other hand, studies by Alba, Wang and Park 2010, Lily et al. (2014), and Wyk and Lal (2008) find that domestic currency depreciation resulted in a fall in FDI inflows.

## DEFINITION OF DATA AND SOURCE

| Variable | Definition | Frequency Used | Source |
|---|---|---|---|
| Net Foreign Direct Investment (*FDI*) | Net Foreign Direct Investment, US$ million | Quarterly | Reserve Bank of India |
| Interest Rate Differential (*i-i**) | (Yield on 91 Day Indian Treasury Bills - Yield on 3 Month US Treasury Bills) | Quarterly | Reserve Bank of India and Federal Reserve Bank |
| Domestic Money Supply Growth (*Mg*) | Growth rate of Broad Money Supply in India (M3) | Quarterly | Reserve Bank of India |
| Domestic Output Growth (*y*) | GDP growth rate of India | Quarterly | Reserve Bank of India |
| Domestic Fiscal Deficit to GDP Ratio (*fd/y*) | Ratio of Gross Fiscal deficit to GDP | Quarterly | Reserve Bank of India |
| Exchange rate (*ex*) | Re/$ Nominal Exchange Rate | Quarterly | Reserve Bank of India |
| Domestic Infrastructure (*infra*) | Index of Industrial Production for Electricity Sector in India, Base Year 2011-12 | Quarterly | Ministry of Statistics and Programme Implementation |
| Foreign Exchange Reserves to Import Ratio (*rm*) | Ratio of total Foreign Exchange Reserves and Imports | Quarterly | Reserve Bank of India |
| Degree of Openness (*open*) | Trade openness defined as the Sum of Export and Import to GDP ratio | Quarterly | Reserve Bank of India |
| | Financial Openness - (KAOpen) index for India developed by Chinn and Ito | Quarterly | Chinn and Ito (2008) |
| Foreign Output Growth (*y**) | OECD Output Growth | Quarterly | OECD Database |
| Volatility in Global Market (*globalVol*) | CBOE Volatility Index (VIX) | Quarterly | Federal Reserve Bank |
| Dummy for US Crisis (UScrisis) | Takes value of '1' for the US Crisis period and '0' otherwise. | | Constructed |
| Dummy for Eurozone Debt Crisis (EUcrisis) | Takes value of '1' for the Eurozone Debt Crisis period and '0' otherwise. | | Constructed |

## METHODOLOGY

This study employs the structural VAR model to empirically analyse how domestic monetary policy shock affects foreign direct investment to India. In particular, the study utilizes the applications of innovation analysis—the impulse response function and the variance decomposition function—under the structural VAR model to obtain empirical results. Impulse response function (IRF) is a useful tool for tracking the dynamic behaviour of a variable following a unit standard deviation shock to another variable. Forecast error variance

decomposition function (VDF) calculates the percentage of total volatility in a given variable that can be attributed to shocks to other variables within the model. The two applications together makes it possible to determine the influence and the relative significance of domestic monetary policy shock in explaining FDI flows to India. Additionally, the study makes use of Monte Carlo Integration for innovation accounting analysis. Monte Carlo Integration, a Bayesian technique, is utilized to calculate confidence bands around the impulse responses, allowing for an assessment of their statistical significance (Doan 1990).

## Structural VAR Model

The pth order structural VAR representation is defined as follows, considering Z as a vector of 'n' stationary endogenous variables and excluding the constant term:

$$E(L)Z_t = \varepsilon_t \qquad (2)$$

where E(L) is the pth order matrix polynomial in the lag operator L, defined as $E(L) = E_0 – E_1L – E_2L^2 – …… – E_pL^p$ (where p represents the number of lags employed in the model). $E_0$ has ones on the diagonal, is a non-singular matrix, and represents contemporaneous relationships among variable in vector Z. $\varepsilon_t$ refers to a vector of 'n' serially uncorrelated structural errors, also known as structural shocks or innovations, which have a mean of zero. $\Omega$ is taken as the var-covariance matrix of $\varepsilon_t$. We assume that $\Omega$ is a diagonal matrix, in which elements in the diagonal denote the variances of structural errors, implying that structural errors are uncorrelated with each other.

Due to the issue of endogeneity, the estimation of parameters in the structural VAR model is not possible using ordinary least squares (OLS). It is necessary to employ a reduced-form VAR to recover/identify the parameters of the structural model. We obtain a reduced-form VAR by pre-multiplying the both sides of equation (2) by the matrix $E_0^{-1}$, given by:

$$E_0^{-1}E(L)Z_t = E_0^{-1}\varepsilon_t \text{ or}$$

$$F(L)Z_t = e_t \qquad (3)$$

where $F(L)$ is the pth order matrix polynomial. $e_t$ refers to a vector of 'n' serially uncorrelated reduced-form errors/disturbances and $\sum$ denotes the variance-covariance matrix of $e_t$. The connection between equations (2) and (3) can be described as follows:

$$F(L) = E_0^{-1}E(L) = I - F_0 – F_1L – F_2L^2 – …… – F_pL^p \qquad (4)$$

and

$e_t = E_0^{-1}\varepsilon_t \quad or \quad \varepsilon_t = E_0 e_t$ *(5)*

The OLS estimation is applicable to the reduced-form VAR because its right hand side involves only the predetermined variables. In other words, the parameters F(L), $e_t$, and $\sum$ of the reduced-form VAR can be recovered or are observable. However, the challenge is to recover/identify the unobserved parameters of the structural VAR model (E(L), $\varepsilon_t$, and $\Omega$) based on the observed parameters in the reduced-form VAR. To address this issue, Sims (1986) and Bernanke (1986) suggest that there is a need to impose a minimum of $(n^2-n)/2$ restrictions on the SVAR model or on the contemporaneous relation matrix ($E_0$). These restrictions in the structural VAR model comes from the economic theory. Once the required restrictions are imposed, structural shocks ($\varepsilon_t$) are identified from reduced-form shocks ($e_t$) based on equation (5). The identification of structural shocks helps perform impulse response and variance decomposition analysis to derive empirical results of the present study.

## Model Specification And Identification

The empirical model for FDI has 8 endogenous variables, namely, domestic money supply growth (Mg), interest rate differential (i-i*), domestic output growth (y), foreign exchange reserves to import ratio (rm), domestic infrastructure (infra), domestic fiscal deficit to GDP ratio (fd/y), exchange rate (ex), and net FDI flows (FDI). Thus, the vector of variables for the structural VAR model is given by:

*Z = [Mg, (i -i*), y, ex, (fd/y), rm, infra, FDI]*

With n = 8, it is necessary to impose a minimum of $(8^2-8)/2 = 28$ restrictions on matrix $E_0$ to successfully identify or recover the structural shocks. The identification process, based on equation $\boldsymbol{\varepsilon_t = E_0 e_t}$, has been achieved by applying the following restrictions on matrix $E_0$:

$$\begin{bmatrix} \varepsilon_{Mg} \\ \varepsilon_{i-i*} \\ \varepsilon_{y} \\ \varepsilon_{ex} \\ \varepsilon_{fd/y} \\ \varepsilon_{rm} \\ \varepsilon_{infra} \\ \varepsilon_{FDI} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & b_{23} & b_{24} & 0 & 0 & 0 & 0 \\ 0 & b_{32} & 1 & b_{34} & 0 & 0 & 0 & 0 \\ 0 & b_{42} & b_{43} & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{53} & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & b_{63} & b_{64} & 0 & 1 & 0 & 0 \\ 0 & b_{72} & b_{73} & 0 & 0 & 0 & 1 & 0 \\ b_{81} & b_{82} & b_{83} & b_{84} & b_{85} & b_{86} & b_{87} & 1 \end{bmatrix} \begin{bmatrix} e_{Mg} \\ e_{i-i*} \\ e_{y} \\ e_{ex} \\ e_{fd/y} \\ e_{rm} \\ e_{Infra} \\ e_{FDI} \end{bmatrix}$$

The specification given above assumes that shocks to other variables do not contemporaneously influence domestic money supply growth. This is due to the belief that monetary authorities determine money supply growth exogenously. As a result, the following restrictions are imposed: $b_{12} = b_{13} = b_{14} = b_{15} = b_{16} = b_{17} = b_{18} = 0$. In addition, we have made an assumption in line with the observation found in the literature that changes in money supply affects the economic variables with a lag. That's why most of the variables have been assumed to be unaffected by money supply growth in the same quarter. Interest rate differential (i-i*) is expected to be contemporaneously affected only by shocks to domestic money supply growth, domestic output growth and exchange rate. This assumption yields following restrictions: $b_{25} = b_{26} = b_{27} = b_{28} = 0$. Domestic output growth (y) is expected to be contemporaneously affected only by shocks to interest rate differential and exchange rate. This produces following restrictions: $b_{31} = b_{35} = b_{36} = b_{37} = b_{38} = 0$. Exchange rate (ex) has been assumed to be contemporaneously affected only by shocks to interest rate differential and domestic output growth. This assumption results in following restrictions: $b_{41} = b_{45} = b_{46} = b_{47} = b_{48} = 0$.

Domestic fiscal deficit to GDP ratio (fd/y) is expected to be contemporaneously affected only by shocks to domestic output growth. This produces following restrictions: $b_{51} = b_{52} = b_{54} = b_{56} = b_{57} = b_{58} = 0$. Foreign exchange reserves to import ratio (rm) is assumed to be contemporaneously affected only by shocks to domestic output growth and exchange rate. This assumption results in following restrictions: $b_{61} = b_{62} = b_{65} = b_{67} = b_{68} = 0$. Domestic infrastructure (infra)-measured by IIP for electricity is expected to be contemporaneously affected only by shocks to interest rate differential and domestic output growth. This assumption produces following restrictions: $b_{71} = b_{74} = b_{75} = b_{76} = b_{78} = 0$. shocks to all variables are deemed to have a contemporaneous influence on FDI flows to India, as indicated by the non-zero values for coefficients (b's) in the eighth row. The presence of zeroes in the matrix $E_0$ signifies the restrictions imposed based on economic theory. Since there are 37 zeroes, the SVAR model is subject to 37 restrictions, which makes it over-identified.

## STRUCTURAL VAR RESULTS

The structural VAR model is estimated using two as the optimal lag length[4,5]. It is established previously that the structural VAR model for FDI is over-identified. To ascertain the validity of the restrictions imposed, we conduct the likelihood ratio test of the validity of over-identifying restrictions. The test result is displayed in following table. Notably, the likelihood ratio test is not rejected at the 5% level of significance, which verifies the validity of our restrictions.

Likelihood Ratio Test of Validity of Overidentifying Restrictions

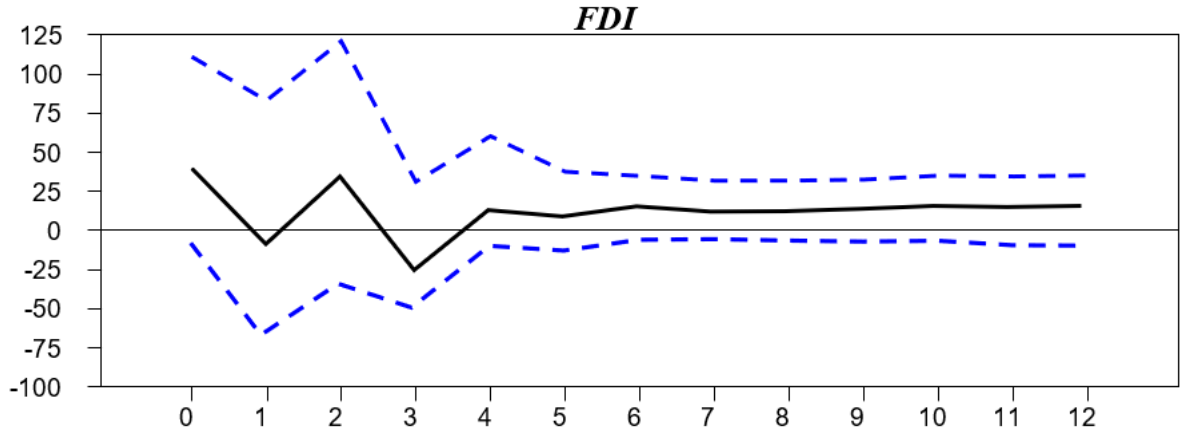
| | **FDI** |
|---|---|
| Log Likelihood | -1577.452 |
| Log Likelihood Unrestricted | -1567.172 |
| Chi-Squared | 20.560 |
| **Significance level** | **0.064** |

## FOR ROBUSTNESS - STRUCTURAL VAR RESULTS (with real variables)

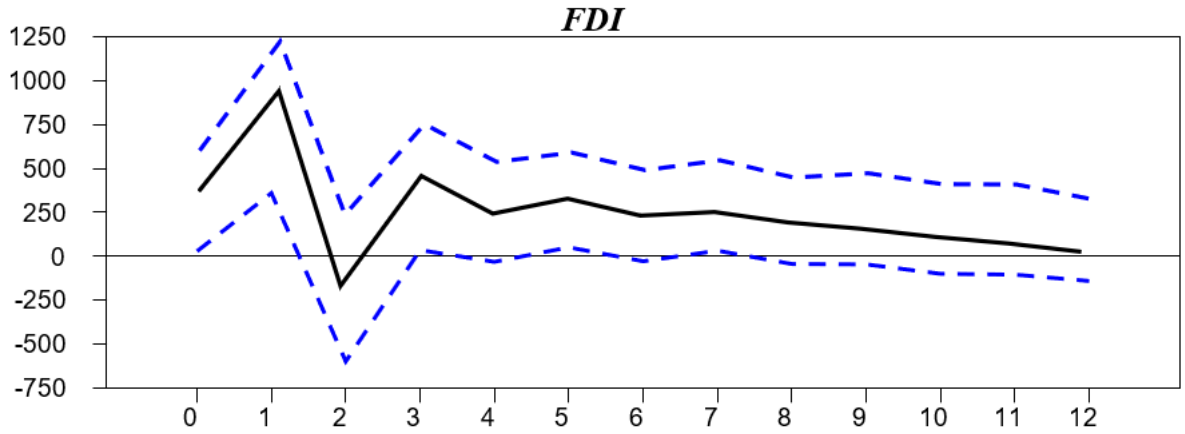
We have also re-estimated the model with following variables in real terms, such as real money supply growth, real interest rate differential, defined as (Real yield on 91 Day Indian Treasury Bills minus Real yield on 3 Month US Treasury Bills), and real exchange rate, defined as the real effective exchange rate (REER). The results of SVAR model (impulse response functions) are shown below. We can note that the results with respect to all variables are broadly similar to what we found originally, thus providing robustness to our original results.

[4] The lag length criteria under VAR was employed to identify the optimal lag length.

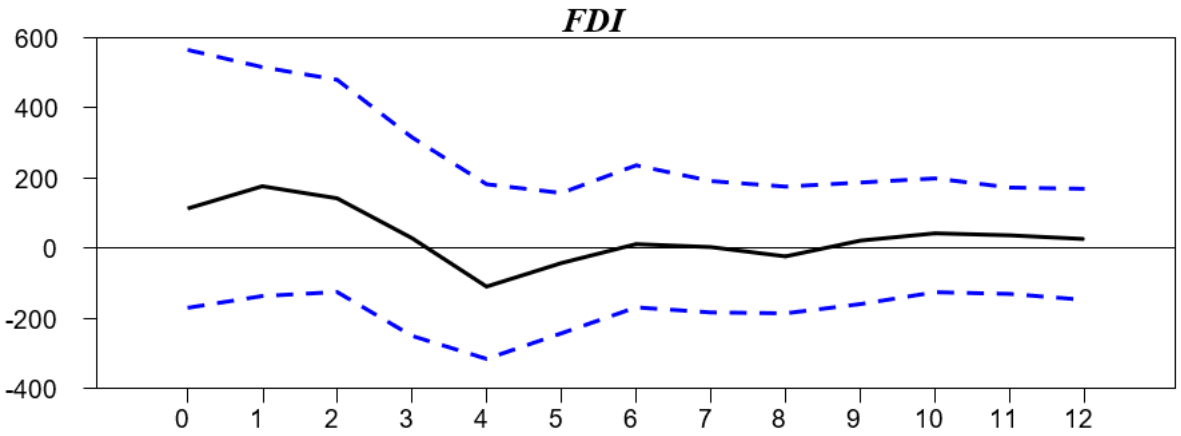
[5] The structural VAR is estimated solely with endogenous variables (domestic money supply growth, interest rate differential, domestic output growth, foreign exchange reserves to import ratio, domestic infrastructure, domestic fiscal deficit to GDP ratio, exchange rate, and net FDI flows) after controlling for all the exogenous variables (EUcrisis dummy, volatilty in global market, degree of openness, UScrisis dummy, foreign output growth).



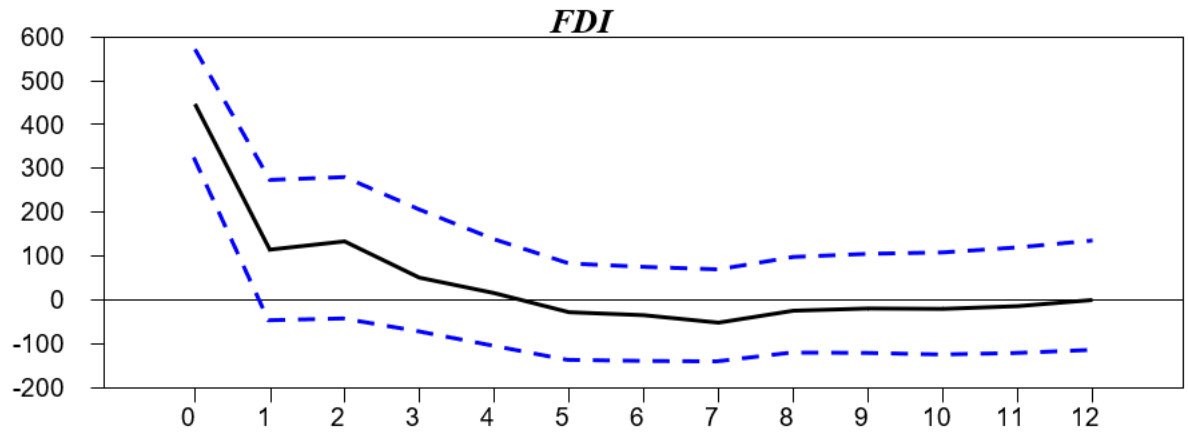

***Responses to Real Interest Rate Differential***



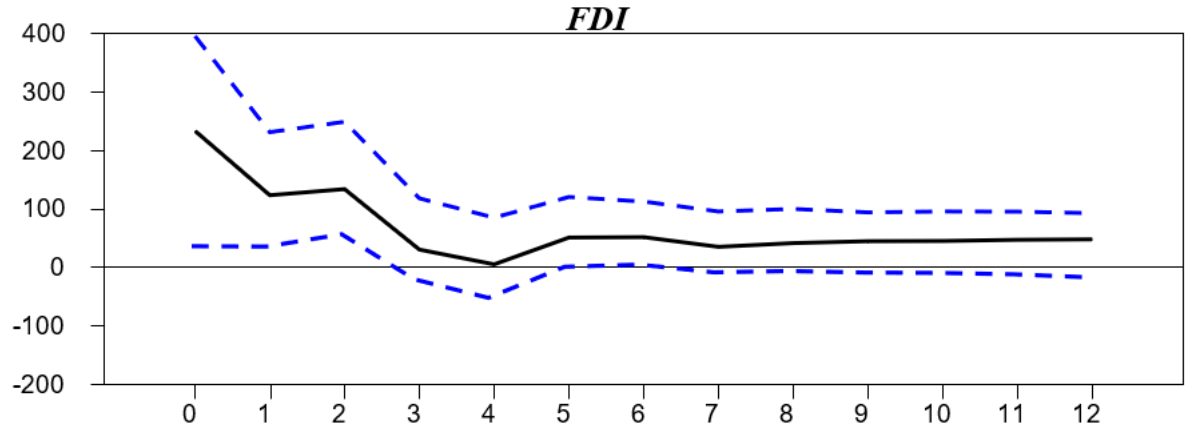

***Responses to Domestic Real Money Supply Growth***



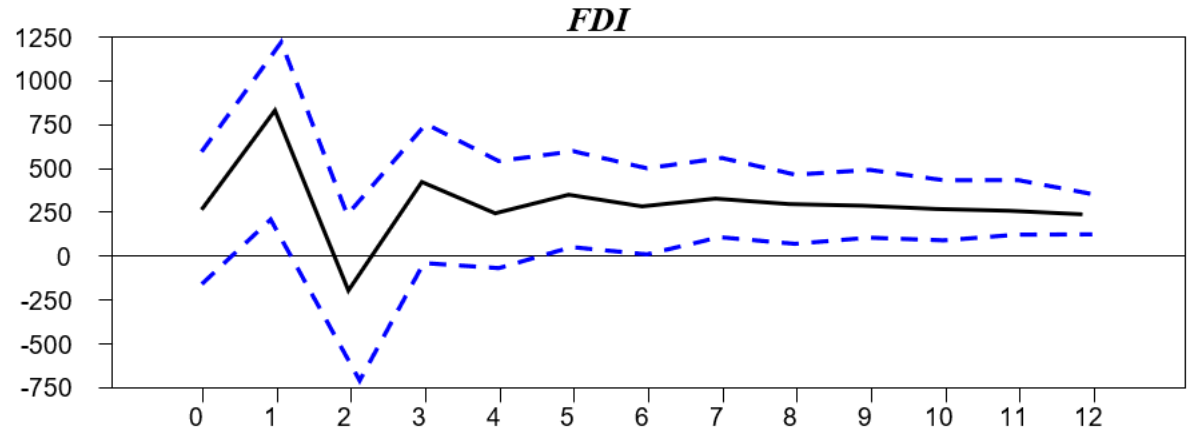

***Responses to Real Exchange Rate (REER)***



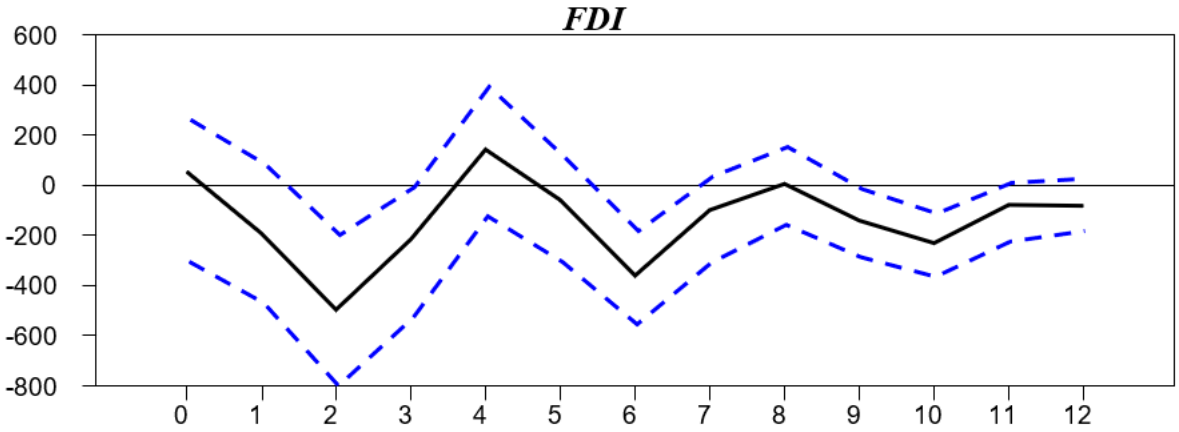

***Responses to Domestic Output Growth***




***Responses to Foreign Exchange Reserves to Import Ratio***




***Responses to Domestic Infrastructure***




***Responses to Domestic Fiscal Deficit to GDP Ratio***

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