How Well Does the IS-LM Model Fit in a Developing Economy: The Case of India

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Abstract The IS-LM model, as a vehicle for policy analysis, has a substantial influence on the policy makers and academicians. Like the developed countries, the IS-LM framework remains important for students to learn in the developing countries because of the benefits it offers in clarifying their thinking about the implications for practical policy issues. The main purpose of this study is to examine how well the dynamic properties of the estimated model of India match to the theoretical predictions of IS-LM model. The purpose is accomplished through Structural Vector Autoregressive (SVAR) model by estimating variance decompositions and impulse response functions. Our model explicitly accounts for the variables included in core macroeconomic models developed in the Keynesian flavour and specifies identification scheme, which capture some features of the developing economies in general. Our findings support the advocates of the IS-LM model most often compared to critics of the model.

Keywords: Structural vector autoregressive model, identification, adverse supply shock, IS shock, money demand shock, money supply shock

JEL Classifications: E12, E30, E50

Introduction

The IS-LM model, as a vehicle for policy analysis, has a substantial influence on the policy makers and academicians. The framework remains a vital didactic element of most macroeconomics texts. Mankiw (1990, p. 1645) notes that “[t]he IS-LM model, augmented by the Phillips curve, continues to provide the best way to interpret discussions of economic policy in the press and among policy makers.” Robert Solow (1997), Blanchard (1997) and Blinder (1997) more recently expressed similar views to those of Mankiw. They explicitly mentioned the IS-LM model as a core of practical macroeconomics that we should all believe. Gali (1992, p. 737) concludes that the US data seem to support the empirical relevance of IS-LM Phillips curve paradigm.

Like the developed countries, the IS-LM framework remains important for students to learn in the developing countries because of the benefits it offers in clarifying their thinking about the implications for practical policy issues. The main purpose of this study is to examine how well the dynamic properties of the estimated model of India match to the theoretical predictions of IS-LM model. India, which shares many features with other developing countries, is unique in many ways and provides a standard case of such an investigation. India shares the
following features with other developing countries: First, the Indian economy faces adverse supply shocks most frequently like the other developing countries. Second, most of the economic activities are in the hands of less educated peasantry, which make the role of expectations negligible. Third, the capital market is very much underdeveloped and confined to a small number of investors. Fourth, domestic tax base is underdeveloped and that the budget deficit is financed through government borrowing from the banking system. Fifth, the financial system has a dual structure, which consists of the official banking system or the organized money market and the unorganized money market. But Indian socio-political environment is relatively stable compared to other developing countries, which makes the case for India a strong one.

If the evidence from this study supports stylized predictions of those theories, economists and academicians in developing countries would then feel more comfortable to assess policy initiatives under different institutional settings. The purpose is accomplished through Structural Vector Autoregressive (SVAR) model by estimating variance decompositions and impulse response functions. Our model explicitly accounts for the variables included in core macroeconomic models developed in the Keynesian flavour and specifies identification scheme, which capture some features of the developing economies in general.

The Model and Methodology

Two types of shocks can capture real and monetary shocks of an economy. These are demand shocks and supply shocks. Demand shocks include IS shock, money supply shock and money demand shock. Any demand side shock which shifts the IS or LM curve also shifts the aggregate demand curve in the same direction. Supply shocks include productivity, energy or oil and technology shock.

The IS-LM model predicts that IS shocks will lead to an increase output, interest rate and money stock. Contractionary money supply shocks will lead to an initial decline in output, increase in interest rate and decrease in money stock. On the other hand, money demand shocks raise interest rate and money stock. We should remember that one of the assumptions of IS-LM model is that price level is given and thus does not change in response to demand shocks. Advocates of supply side, however, allowed movement of price due to favorable or adverse supply shocks. Adverse supply shocks will decrease output, increase price, either increase or decrease interest rate and, increase or decrease money stock.

The predictions cited above are first round of effects. There may be second round of effects, third round of effects and so on. For example, will output increase instantaneously due to IS shock? It will take time for production to respond to increased demand. Over time an increase in output leads to an increase in money demand. This puts an upward pressure on interest rate and hence leads to lower investment and lower output. Therefore, after an initial increase, output starts to decline. On the other hand, when central bank adopts a contractionary monetary policy, initially interest rises sharply. But over time higher interest rate leads to lower investment and hence a lower output. Then lower output leads to lower money demand and ultimately creates a downward pressure on interest rate. In fact, the dynamic responses of different variables to a shock depend on a diversity of transmission mechanisms developed into the economy. Moreover, the intensity of various shocks depends on interest rate sensitivity and income sensitivity of money demand.
This study uses Structural Vector Auto Regressive (SVAR) model, which is a useful tool to analyze the macroeconomic response of an economy to specific shocks. Compared to large-scale macroeconomic models, SVAR requires a minimum number of identifying restrictions in order to separate the movements of the model’s variables into parts due to underlying shocks. For the general approach, as it is has been used in some important works, see for example Sims (1986), and Gali (1992).

Let us consider the following SVAR model with M variables and p lags:

\[
Y_t' B + Y_{t-1}' \Gamma_1 + Y_{t-2}' \Gamma_2 + \ldots + Y_{t-p}' \Gamma_p = \varepsilon_t'
\]

where, \( Y \) is an \( M \times 1 \) vector of variables, \( B \) is an \( M \times M \) nonsingular matrix, \( \Gamma \)'s are \( M \times M \) matrices, and \( \varepsilon \) is an \( M \times 1 \) vector of structural disturbances. Each column of the co-efficient matrices is the vector of coefficients in a particular equation while each row applies to a particular variable.

Assumptions about \( \varepsilon_t \):

A1: \( E(\varepsilon_t) = 0 \)

A2: \( E (\varepsilon_t \varepsilon_t') = \begin{bmatrix}
\text{Var}(\xi_1) & 0 & \ldots & 0 \\
0 & \text{Var}(\xi_2) & \ldots & 0 \\
0 & 0 & \ldots & 0 \\
0 & 0 & \ldots & \text{Var}(\xi_M)
\end{bmatrix} = \Omega \)

The assumption (A2) arises from the belief that structural shocks originate from independent sources. The solution of the above system in VAR form:

\[
Y_t' = - Y_{t-1}' \Gamma_1 B^{-1} - Y_{t-2}' \Gamma_2 B^{-1} - \ldots - Y_{t-p}' \Gamma_p B^{-1} + \varepsilon_t' B^{-1}
\]

\[
= Y_{t-1}' \Pi_1 + Y_{t-2}' \Pi_2 + \ldots + Y_{t-p}' \Pi_p + \varepsilon_t'
\]

where, \(-\Gamma_i B^{-1} = \Pi_i\) \( (i = 1 \ldots p) \) and \( \varepsilon_t' = \varepsilon_t' B^{-1} \)

It follows from the assumptions about \( \varepsilon_t \), that:

B1: \( E(\varepsilon_t) = E (B^{-1} \varepsilon_t) = 0 \)

B2: \( E (\varepsilon_t \varepsilon_t') = E (B^{-1} \varepsilon_t \varepsilon_t' B^{-1}) = B^{-1} \Omega B^{-1} = \Sigma \)

Since reduced form errors are correlated, \( \Sigma \) is not a diagonal matrix. The relationship between \( \Sigma \) and \( \Omega \) is:

\[
B^{-1} \Omega B^{-1} = \Sigma
\]

\[
\Rightarrow \quad \Omega = B' \Sigma B
\]
Given the structural form (1), we can deduce the reduced form (2) uniquely since $B$ is non-singular. But given the reduced form i.e. $\Pi_i$ and $\Sigma$, we cannot always deduce uniquely the structural form. If a reduced form has two or more structural forms associated with it, the structures are said to be observationally equivalent. If we can deduce a unique structural form, given the reduced form, by imposing restrictions then the model is said to be identified.

To identify the structural model from a reduced form VAR it is necessary to impose $(M^2 - M)/2 + M$ restrictions on the structural parameters. In each equation, each contemporaneous variable has a coefficient of one. This normalization is a necessary scaling of the equation, which is equivalent to putting one variable on the left-hand side of an equation. So we need $(M^2 - M)/2$ restrictions to be imposed on the system. It is notable that traditional simultaneous equation approach requires stronger a priori restrictions on $B$ matrix than SVAR approach; see Leeper, Sims and Zha (1996) for specific details on this issue. Our main objective is to restrict the system in such a way that i) we can recover the structural shocks (the $\xi_t$s) from reduced form innovations, and ii) we can preserve the assumed error structure concerning the independence of various $\xi_t$ shocks.

Since our main purpose is to examine how well the dynamic properties of the estimated models of India match to the theoretical predictions of IS-LM model, our model includes variables like output ($y$) and price ($p$), money stock ($m$) and interest rate ($r$). The reasons for including these variables are: (a) basic macroeconomic models developed in the Keynesian flavour include these variables; (b) theoretical predictions discussed above involve dynamic interactions among these variables. So the $Y$-vector is

$$Y' = [y, p, r, m]$$

where

- $y$: Log of real GDP,
- $p$: Log of consumer price index,
- $r$: Nominal interest rate$^3$, and
- $m$: Log of nominal broad money stock M2.

Matrix of contemporaneous coefficients $B$ is:

$$
\begin{bmatrix}
1 & \beta_{12} & \beta_{13} & \beta_{14} \\
\beta_{21} & 1 & \beta_{23} & \beta_{24} \\
\beta_{31} & \beta_{32} & 1 & \beta_{34} \\
\beta_{41} & \beta_{42} & \beta_{43} & 1
\end{bmatrix}
$$

We need $(4^2 - 4)/2 = 6$ restrictions to identify the structural system. Following are the restrictions:

Restrictions (1), (2), and (3)

We have already discussed that price is influenced by supply shocks not by demand shocks. India experienced sudden increase in price level particularly in the early 1970s because of flood, drought, oil price shock and other unforeseen adverse supply shocks that developing countries face most often. Therefore, we can assume that in the developing countries price is not contemporaneously influenced by other variables in the system but by the adverse supply shocks. It imposes three restrictions on the price equation.$^4$
\[ \beta_{12} = 0, \beta_{32} = 0, \beta_{42} = 0 \]

**Restrictions (4) and (5)**

Since output and prices are not observed by the central bank immediately, it can only adjust interest rate immediately to changes in money stock. This imposes two restrictions on the interest rate equation:

\[ \beta_{13} = 0, \beta_{23} = 0 \]

**Restriction (6)**

Following the tradition, it is assumed that money demand depends on the level of transactions and the interest rate. In the developing countries it is hard to measure overall level of transactions. However, it is reasonable to assume that transactions are proportional to nominal income. Therefore, it is assumed that \( y_t \) and \( p_t \) effect \( m_t \) with the same magnitude and same sign. By imposing a symmetric restriction on the money equation, we get the desired money demand function. That restriction is:

\[ \beta_{14} = \beta_{24} \]

Under this structure, contemporaneous relations among variables and the innovations are:

\[
\begin{bmatrix}
y_t & p_t & r_t & m_t \\
\end{bmatrix}
\begin{bmatrix}
1 & 0 & 0 & \beta_{14} \\
\beta_{21} & 1 & 0 & \beta_{14} \\
\beta_{31} & 0 & 1 & \beta_{34} \\
\beta_{41} & 0 & \beta_{43} & 1 \\
\end{bmatrix}
\begin{bmatrix}
\xi_{yt} & \xi_{pt} & \xi_{rt} & \xi_{mt} \\
\end{bmatrix}
\]

The above-mentioned identification scheme capture a wide range of interrelationships among the variables involved based on traditional economic theory. How well does the identification scheme capture standard theoretical predictions with regards to developing countries is an empirical issue.

A system’s reaction to shock in one of the variables can best be explained by a VAR model. Impulse response functions capture dynamic properties of a VAR model. The moving average representation of equation (2) is:

\[ Y_t = \Phi(L)e_t \]

where \( [I - \Pi(L)]^{-1} = \Phi(L) \) and \( L \) is the lag operator.

Expanding and taking transpose in both sides we get

\[ Y'_t = e'_t \phi_0 + e'_{t+1} \phi_1 + e'_{t+2} \phi_2 + \ldots + e'_{t+p} \phi_p + \ldots + \]

Using the relationship between reduced form error and structural form error \( e'_t = \varepsilon'_t B^{-1} \), we can represent \( Y_t \) as a linear combination of current and past structural shocks.
\[
Y_t' = \epsilon_t' B^{-1} \phi_0 + \epsilon_t' B^{-1} \phi_1 + \epsilon_t' B^{-1} \phi_2 + \ldots + \epsilon_t' B^{-1} \phi_p + \ldots
\]  (5)

Alternatively,

\[
Y_t' = \epsilon_t' \psi_0 + \epsilon_t' \psi_1 + \epsilon_t' \psi_2 + \ldots + \epsilon_t' \psi_p + \ldots
\]  (6)

where, \(B^{-1} \phi_i = \psi_i\) \(i = 1\ldots p\)

Each \(\psi_i\) is an \(M \times M\) matrix of parameters derived from the structural model. The coefficients of \(\psi_i\) can be used to generate the effect of \(\xi_{1t}, \xi_{2t}, \xi_{3t}, \ldots\) shocks on the entire time paths of \(y_{1t}, y_{2t}, y_{3t}, \ldots\) sequences. So the response of \(y_1\) to a unit shock in \(y_1\) is thus given by \(\psi_{11}(0), \psi_{11}(1), \psi_{11}(2), \psi_{11}(3), \ldots\) which is called impulse response function. We have \(M^2\) sets of such impulse response functions.

Variance decomposition allocates each variable’s forecast error variance to the individual shocks. The forecast error can be written following the previous development as:

\[
Y_t' - E_{t-n} Y_t' = \sum_{i=0}^{n-1} \epsilon_{t-i} \psi_i
\]  (7)

where, \(E_{t-n} Y_t'\) is the expected value of \(Y_t'\) based on the entire information available at time \(t-n\). It is possible to decompose the \(n\)-step ahead forecast error variance of \(y\) series due to each one of the shocks \(\xi_{yt}, \xi_{pt}, \xi_{rt}, \xi_{nt}\).

### Data and Stationarity of Data

The data used in this study are taken from the IMF, *International Financial Statistics (IFS)* CD-ROM- supplemented by IMF, IFS Yearbook. Quarterly observations comprising the period 1967:Q1-2001:Q4 are used to estimate the model.

Price: The Consumer Price Index (CPI) is used. It is the cost of acquiring a fixed basket of goods and services by the average consumer.

Interest rate: The bank rate (discount rate) is used for the nominal interest rate variable. The bank rate is the main instrument that central bank uses to conduct monetary policy. It is the rate of interest that the central bank charges on short term loans to financial institutions. It is seen as the trendsetter for other short-term interest rates.

GDP: Real GDP is used as a measure of aggregate economic activity. Real GDP is computed by deflating the nominal GDP by the Consumer Price Index.

Money: Broad Money (M2) is used as money stock. In developing countries broad money relation is more stable and gives better forecast than narrow money. The question of stationarity of data comes next. The answer to this question involves an assessment of the trade-off between the loss of efficiency and loss of information. A SVAR model specified with levels, when time series are nonstationary, will generate estimates that may be spurious. On the other hand, a SVAR model specified with differences, when series are nonstationary will generate estimates that are efficient but will ignore potential long run relationships. Doan (2000) recommend against differencing even if the variable contains a unit root because it throws away information concerning the co-movement of variables. Fuller (1976,
Theorem 8.5.1) shows that differencing produces no gain in asymptotic efficiency in an autoregression, even if it is appropriate. Sims (1988) and Christiano-Eichenbaum (1990) were on the sides of skeptics on the importance of these tests. Following Doan, Fuller, Sims, and Christiano-Eichenbaum, no unit root tests are conducted and the present study uses levels rather than differences of the variables involved.

**Empirical Evidence**

We begin the analysis of the results with estimating contemporaneous coefficients. A two-step procedure is used to estimate the structural VAR model. First, the reduced form VAR, with sufficient lag length, is estimated by OLS method. Next a sufficient number of restrictions are imposed on $B$ and $\Omega$ to identify the parameters. Finally Broyden, Fletcher, Goldfarb, Shanno (BFGS) method estimates the model.

Identification scheme, stated in the previous section, postulates that the output equation allows output innovations to depend on innovations in price, interest rate and money. Price equation is autonomous and no other innovations but price innovations can influence it contemporaneously. The money supply equation allows money innovations to depend on innovations in interest rate alone. The money demand equation allows money innovations to depend on innovations in interest rate, price and output with the latter two having symmetric effects.

The estimated relationships among the contemporaneous coefficients are listed in Table 1. P-values are given in parentheses below the coefficients. The estimated coefficients of the money supply equation have reasonable economic interpretations. The coefficients are of the expected signs. The sign of the $m$ coefficient is particularly interesting because it indicates how the bank rate responds to a change in the monetary aggregate. Suppose there is an increase in the monetary aggregate. If the central bank believes that such an increase will lead to a rise in future inflation, it will tend to increase the bank rate in order to offset the rising money stock. The relationship between interest rate and monetary aggregate is therefore expected to be positive in this policy reaction function. Interest rate semi-elasticity of money supply in India is 4.02. In the money demand function the relationship between output and money demand is expected to be positive. Because when consumer income rises, the demand for goods and services will rise which, in turn, increase their demand for money so that they can actually purchase more goods and services. This coefficient will give income elasticity of money demand. Since consumer is willing to hold less money when cost of holding money (interest rate) increases, the relationship between interest rate and money demand is negative. This means that money demand equation has reasonable interpretation in India. Income elasticity of money demand in India is elastic, which is true for all developing countries. Interest rate semi-elasticity of money demand is 0.123. The output equation can also be given good economic interpretations.

Impulse response functions capture the dynamic properties of the model. The impulse response functions are depicted in Figure 1. Each column of graphs represents response of a single variable due to shocks in all the variables in the system. Response graphs in a given column all have the same scale with the maximum and minimum heights shown on any graph in the column noted at the left of each graph. The height of the graphs in a given column provides a visual measure of the relative contribution of shocks listed in the rows to explaining variance in the variable listed at the top (bottom) of the column. On the other hand, each row of graphs
represents response of all the variables in the system due to shock in a single variable. The black lines in the figure represent the impulse response functions, while the dashed lines correspond to the 95% upper and lower confidence bands about the point estimates of impulse response functions.\textsuperscript{11} The typical shocks whose effects we are about to discuss are one standard deviation unit in each equation of the system.

Before we analyze the dynamic properties of the model, we need to give a structural interpretation of the shocks related to each one of the equations. Shocks related to price equation are termed as “aggregate supply shocks”; shocks related to output equation are identified as “IS shocks” or “aggregate demand shocks”; shocks related to interest rate equation are identified as “money supply shocks”; and shocks related to money equation are identified as “money demand shocks”. In some literature shocks associated with $y$ are labeled as supply shocks, particularly in the long run models. But here aggregate supply is normalized on the price level. Therefore, it will be appropriate to call it “adverse supply shocks”.\textsuperscript{12} We look at the dynamic responses of the model to each type of shocks and compare them with the theoretical predictions of the IS-LM model.

*The IS Shocks*

The dynamic effects of one standard deviation IS shocks are summarized in row 1 of Figure 1. Responses of all the variables except price are consistent with theory. However, several aspects deserve attention. The first aspect is the strength of IS shocks and their initial impact on real GDP compared to other shocks. GDP rises by almost 1.5% in the quarter of the shock while the other shocks produce negative responses (see the first column of figure 1). But the effect on GDP is less persistent. The second aspect is the substantial permanent effect on price, nominal interest rate and the money stock. The assumption of sticky price does not work well. But our finding is consistent with an upward sloping supply curve, where IS shock will lead to an increase in price.

*The Supply Shocks*

The dynamic effects of one standard deviation supply shocks are summarized in row 2 of Figure 1. Aggregate supply equation is normalized on the price level. The results are largely consistent with theory. The initial impact on GDP is negative for up to 10 quarters. The positive effect on prices is substantial but vanishes during the 10\textsuperscript{th} quarter as expected. The interest rate rises and the money stock is positive though weak, but it is not inconsistent due to substantial positive movement of price.

*The Money Supply Shocks*

Money supply equation is normalized on the interest rate. The dynamic effects of one standard deviation contractionary money supply shocks are summarized in row 3 of Figure 1. The IS-LM predictions are captured well by the responses. The typical path of interest rate after the shock takes the form of an initial rise in interest rate followed by a gradual decline in that variable. We observe that output slowly declines over time. The largest decline is achieved at the 4\textsuperscript{th} quarter. Low liquidity initially drives the output level down by about 5 basic points. The response of price suggests that it is nearly unchanged for the first four quarters and so. Only after
that the price level seem to decline and “price effect” rather than “price puzzle” dominates. This is worth stressing, since in many countries evidence shows a positive impact on price. The opposite response of money and interest rate suggests that “liquidity effect” dominates. This is also worth stressing, since in many countries evidence shows a positive correlation between money and the interest rate responses. This statistical fact has been interpreted as evidence against the standard monetary transmission mechanism.

The Money Demand Shocks

The dynamic effects of one standard deviation money demand shocks are summarized in row 4 of Figure 1. As we would expect, money demand shocks will produce responses, which are qualitatively the mirror image of responses derived from money supply. But since the interest rate increases in both the cases, the effects of such shocks on real sector are similar. The IS-LM predictions are captured well by the responses.

The variance decompositions for series y are provided in Table 2. Demand side shocks explain most of the output variability not only in the short run but also in the long run in India as shown in the table. This part is also consistent with the Keynesian theories.

Open Economy Version of the Model

We can consider open economy version of the IS-LM model by including the exchange rate in the model. We define exchange rate as the domestic currency price of one unit of foreign exchange (i.e. US dollar). Given this definition, any exchange rate shock implies devaluation by the home country. Traditional IS-LM model (Dornbusch, Fischer and Startz 2001, p. 280) predicts that a real depreciation by the home country shifts the IS curve to the right and leads to a rise in income. By making a country’s exports cheaper and imports expensive, devaluation is said to stimulate the aggregate demand and thus, domestic production. In contrast to this conventional view, some recent studies, however, have argued that by raising the cost of imported inputs, devaluation contracts aggregate supply. If decrease in aggregate supply more than offsets the increase in aggregate demand, output eventually declines. Empirical literatures indicate that devaluation may affect output positively or negatively. Bahmani-Oskooee and Miteza (2003) conducted a literature survey on the effects of devaluation on domestic production and concluded that the impact is country specific, depends on model specification, and the estimation technique.

A change in the nominal exchange rate may not provide a complete picture of how much a country’s international competitiveness is changing. For example, effectiveness of nominal devaluation may be offset by an increase in domestic price level relative to foreign price level. The concept of real exchange rate is used to cope with this type of problem. Therefore, we include real exchange rate in the model. Now the Y-vector is

\[ Y' = [y, p, r, m, q] \]

where q: Log of real exchange rate.\textsuperscript{13}

Now, we need \((5^2 - 5)/2 = 10\) restrictions to identify the structural system. Identification scheme assumes that the output equation allows output innovations to depend on innovations in price, interest rate, money and real exchange rate. Price equation is autonomous and no other
innovations but price innovations can influence it contemporaneously. The money supply equation allows money innovations to depend on innovations in interest rate alone. The money demand equation allows money innovations to depend on innovations in interest rate, price and output with the latter two having symmetric effects. The real exchange rate equation allows real exchange rate innovations to depend on innovations in output, interest rate and money.

Under this structure, contemporaneous relations among variables and the innovations are:

\[
\begin{bmatrix}
1 & 0 & 0 & \beta_{14} & \beta_{15} \\
\beta_{21} & 1 & 0 & \beta_{14} & 0 \\
\beta_{31} & 0 & 1 & \beta_{34} & \beta_{35} \\
\beta_{41} & \beta_{43} & 1 & \beta_{45} \\
\beta_{51} & 0 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
y_t \\
p_t \\
r_t \\
m_t \\
q_t
\end{bmatrix}
= \begin{bmatrix}
\xi_{yt} \\
\xi_{pt} \\
\xi_{rt} \\
\xi_{mt} \\
\xi_{qt}
\end{bmatrix}
\]

The estimated relationships among the contemporaneous coefficients are listed in Table 3. Most of the coefficients are of the expected signs. The impulse response functions are depicted in Figure 2. The open economy version of IS-LM predictions is captured well by the responses. Dynamic responses of each variable to different shocks are more or less the same as the closed economy version at least qualitatively. The IS shock, adverse supply shock, money demand shock, and money supply shock exert almost the same dynamic effects on output, price, interest rate and money. But they are not as smooth as the closed economy version. The dynamic effects of one standard deviation real exchange rate shocks are summarized in row 5 of Figure 2. The responses of price, interest rate, and money suggest that they are nearly unchanged during the entire time horizon. The assumption of sticky price does work better than the closed economy responses. Specifically we want to investigate whether real exchange rate would affect real output. The response of output is positive but not strong. The typical path of GDP after the shock takes the form of an initial rise in Real GDP followed by a gradual decline. However it is always positive. Another important finding is that contractionary monetary policy leads to a currency appreciation and a decline in output in an open economy (see row 3 of Figure 2) that is quite consistent with theory.

The variance decompositions for series \( y \) are provided in Table 4. Demand side shocks including the real exchange rate shock again explain most of the output variability not only in the short run but also in the long run.

From the above discussion we see that responses are outstandingly consistent with IS-LM model in India. Our results do not give rise to either the “price puzzle” or the “exchange rate puzzle” and therefore no statistical fact against the standard monetary transmission mechanism.

**Summary and Conclusion**

The main purpose of this paper has been to examine how well the dynamic properties of the estimated model of India match to the theoretical predictions of IS-LM model. The purpose is accomplished through Structural Vector Autoregressive (SVAR) model by estimating variance decompositions and impulse response functions. Several conclusions emerge from a synopsis of the impulse responses and variance decompositions discussed:
Our findings support the advocates of the IS-LM model most often compared to critics of the model. The price response gives a strong hint as to why the IS-LM model may become less reliable as we focus on medium to long run. However, the response of price due to shock in money supply indicates that sticky price assumption is not a bad approximation of reality at least in the short run. Demand side shocks are stronger than supply side shocks in output determination. One important finding is that contractionary monetary policy leads to currency appreciation. It will worsen the trade balance and finally output will decline. This finding has a significant policy implication. The policy maker should be aware of the potential consequences of a restrictive policy while one of the main objectives of central bank is to achieve economic growth. Such a policy can be adopted only if long run benefits of monetary contraction overwhelmingly outweigh cost of output loss.

Footnotes

* The author would like to express sincere gratitude to the editor and an anonymous referee for their insightful criticisms and valuable suggestions.


2. Our discussion so far, is limited to the order condition of identifying structural equation. There is also the rank condition of identification. According to Doan (2000, p.295), the simplest approach to check this condition in practice, is to look at the log likelihood value of the estimated model and the log likelihood value of an unrestricted model; for a just identified model those should be equal.

3. The nominal interest rate rather than the real interest rate seems to be more appropriate variable in developing countries. Because most of the activities in developing countries are in the hands of less educated persons, which make the role of expectations almost insignificant. Moreover, the real interest rates were negative most often in developing countries including India.

4. Keating (1992) used similar restrictions but this study fits these restrictions to the reality of developing economies.

5. Since both y and p are in logarithms, this restriction is a technical device, which makes money demand as a function of nominal output.


9. The SVAR is estimated with a lag length of four quarters. The lag lengths are determined by likelihood ratio test of Sims (1980a, p. 17) and also supplemented by Akaike Information Criterion and Bayesian Information Criterion. Three seasonal dummies and a constant are included.

10. See Press et. al. (1988) and Doan (2000, p. 213).

11. The two standard deviation bands are computed using Doan’s (2000, p. 397) Monte Carlo simulations employing 2500 random draws.

12. The oil price shock of 1973 is an outstanding example of adverse supply shock. See Blanchard and Fischer (1989, p. 520) for details.

13. The real exchange rate (Q) is defined as Q = S P*/ P, where S is nominal exchange rate, P is domestic price level and P* is foreign price level. Consumer Price Index is used to represent the price variable. The US price index is taken as foreign price level.

14. Extending the IS-MP-IA model (Romer, 2000), Hsing (2005), however, finds that output in Singapore is positively influenced by currency appreciation.

References:


Christiano, L. J. and M. Eichenbaum. 1990. “Unit Roots in Real GNP: Do We Know and Do We Care?” Carnegie-Rochester Conference Series on Public Policy, Unit Roots, Investment Measures and Other Essays, ed. Allan Meltzer, 32(0), 7-61.


Table 1: Results of Contemporaneous Coefficients (Closed Economy)

<table>
<thead>
<tr>
<th>Equation</th>
<th>Coefficients</th>
<th>Std. Error</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output:</td>
<td>$y_t = 0.076p_t + 0.066r_t - 0.339m_t = \xi_{yt}$</td>
<td>(0.724)</td>
<td>(0.071)</td>
</tr>
<tr>
<td>Price:</td>
<td>$p_t = \xi_{pt}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Money supply:</td>
<td>$r_t - 4.028m_t = \xi_{rt}$</td>
<td>(0.031)</td>
<td></td>
</tr>
<tr>
<td>Money Demand:</td>
<td>$m_t - 1.813y_t - 1.813p_t + 0.123r_t = \xi_{mnt}$</td>
<td>(0.031)</td>
<td>(0.031)</td>
</tr>
</tbody>
</table>

Table 2: Variance Decompositions for $y$ (Closed Economy)

<table>
<thead>
<tr>
<th>Step</th>
<th>Std Error</th>
<th>Explained by innovations in</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>IS</td>
</tr>
<tr>
<td>1</td>
<td>0.024287</td>
<td>50.835</td>
</tr>
<tr>
<td>2</td>
<td>0.031166</td>
<td>46.079</td>
</tr>
<tr>
<td>4</td>
<td>0.043421</td>
<td>37.833</td>
</tr>
<tr>
<td>6</td>
<td>0.048077</td>
<td>32.493</td>
</tr>
<tr>
<td>8</td>
<td>0.051264</td>
<td>28.981</td>
</tr>
<tr>
<td>10</td>
<td>0.052285</td>
<td>27.879</td>
</tr>
<tr>
<td>12</td>
<td>0.053929</td>
<td>26.211</td>
</tr>
<tr>
<td>14</td>
<td>0.05629</td>
<td>24.19</td>
</tr>
<tr>
<td>16</td>
<td>0.058569</td>
<td>22.88</td>
</tr>
<tr>
<td>18</td>
<td>0.060305</td>
<td>22.542</td>
</tr>
<tr>
<td>20</td>
<td>0.061575</td>
<td>22.761</td>
</tr>
</tbody>
</table>
Table 3: Results of Contemporaneous Coefficients (Open Economy)

<table>
<thead>
<tr>
<th></th>
<th>Output:</th>
<th>Price:</th>
<th>Money supply:</th>
<th>Money Demand: mₜ-3.833yₜ -3.833pₜ +1.142rₜ = ξₘₜ</th>
<th>Real exchange rate: qₜ-1.03yₜ -0.813rₜ +0.123qₜ = ξₚₜ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>yₜ= 0.623pₜ + 0.059rₜ - 0.709mₜ - 0.569qₜ = ξₚₜ</td>
<td>pₜ = ξₚₜ</td>
<td>rₜ - 3.345mₜ = ξₘₜ</td>
<td>(0.093) (0.093) (0.058)</td>
<td>(0.031) (0.031) (0.028)</td>
</tr>
<tr>
<td></td>
<td>(0.724)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.071)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.079)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.047)</td>
<td></td>
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</tr>
</tbody>
</table>

Table 4: Variance Decompositions for y (Open Economy)

<table>
<thead>
<tr>
<th>Step</th>
<th>Std Error</th>
<th>IS</th>
<th>Supply</th>
<th>Money Supply</th>
<th>Money demand</th>
<th>Real exchange rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.025182</td>
<td>96.124</td>
<td>2.024</td>
<td>0.012</td>
<td>0.816</td>
<td>1.032</td>
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<tr>
<td>2</td>
<td>0.034081</td>
<td>95.002</td>
<td>2.213</td>
<td>1.455</td>
<td>0.045</td>
<td>1.284</td>
</tr>
<tr>
<td>4</td>
<td>0.039519</td>
<td>90.865</td>
<td>2.783</td>
<td>4.758</td>
<td>0.148</td>
<td>1.447</td>
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<tr>
<td>6</td>
<td>0.042847</td>
<td>78.302</td>
<td>10.930</td>
<td>7.073</td>
<td>0.339</td>
<td>3.356</td>
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<tr>
<td>8</td>
<td>0.044634</td>
<td>73.135</td>
<td>10.277</td>
<td>8.935</td>
<td>0.333</td>
<td>7.321</td>
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<tr>
<td>10</td>
<td>0.046376</td>
<td>68.194</td>
<td>10.101</td>
<td>10.204</td>
<td>0.367</td>
<td>11.134</td>
</tr>
<tr>
<td>12</td>
<td>0.048414</td>
<td>62.642</td>
<td>13.937</td>
<td>10.939</td>
<td>0.382</td>
<td>12.100</td>
</tr>
<tr>
<td>14</td>
<td>0.050414</td>
<td>57.924</td>
<td>17.965</td>
<td>11.524</td>
<td>0.500</td>
<td>12.088</td>
</tr>
<tr>
<td>16</td>
<td>0.052486</td>
<td>53.866</td>
<td>22.005</td>
<td>11.876</td>
<td>0.737</td>
<td>11.516</td>
</tr>
<tr>
<td>18</td>
<td>0.054003</td>
<td>51.467</td>
<td>23.768</td>
<td>12.380</td>
<td>1.170</td>
<td>11.215</td>
</tr>
<tr>
<td>20</td>
<td>0.055108</td>
<td>49.854</td>
<td>24.322</td>
<td>12.936</td>
<td>1.786</td>
<td>11.101</td>
</tr>
</tbody>
</table>
Figure 1: Impulse Response Functions of India (Closed Economy)
Figure 2: Impulse Response Functions of India (Open Economy)

Impulse responses

- IS shock
- Supply shock
- Money supply shock
- Money demand shock
- Real exchange rate shock