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Monetary policy transmission in an emerging market setting

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Abstract

Some emerging economies have a relatively ineffective monetary policy transmission owing to weaknesses in the domestic financial system and the presence of a large and segmented informal sector. At the same time, small open economies can have a substantial monetary policy transmission through the exchange rate channel. In order to understand this setting, we explore a unified treatment of monetary policy transmission and exchange-rate pass-through. The results for an emerging market, India, suggest that the most effective mechanism through which monetary policy impacts inflation runs through the exchange rate.

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Keywords: Monetary policy transmission; Exchange rate pass-through;

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1 Introduction

While emerging economies are increasingly integrated with the world economy through trade and financial flows, there are unique policy challenges in monetary policy primarily owing to underdeveloped financial markets and institutions (Hammond et al., 2009). With a well functioning financial system, changes in the policy rate have a substantial influence upon aggregate demand and thus on the price level (Gerlash and Smets, 1995; Ramaswami and Slok, 1998; Mojon and Peersman, 2001; Smets and Wouters, 2002; Ganev et al., 2002; Norris and Floerkemeir, 2006).

In developing countries, the lack of a capable financial system hampers this channel. While there is substantial variation in financial development across developing countries (Dorrucci et al., 2009), three features are often found. The first is an underdeveloped bond market. Through this, the transmission of changes in the short term policy rate to other points on the yield curve tends to be weak (Moreno, 2008).

The second issue is that of the banking system. Low levels of competition, resource pre-emption for deficit financing, and public sector ownership inhibit the extent to which changes in the policy rate rapidly affect deposit rates and lending rates. High costs of information processing, evaluating projects and monitoring borrowers induce banks to maintain persistently high levels of bank reserves (Agenor and Aynaoui, 2010). Small values for the stock of bank lending to the private sector, relative to GDP, imply that even when bank lending rates do change, the impact upon aggregate demand is small.

In addition to the small formal financial system there is the large informal sector in most developing countries. The size of this sector, and the nature of its linkages with the formal financial system, has important consequences for monetary policy transmission. When the central bank raises rates, the monetary policy transmission tends to be weak because this does not directly affect informal finance, and also because on the margin there are borrowers who switch to borrowing from the informal system in response to higher interest rates in the formal financial system.

Studies of the monetary policy transmission in emerging economies have primarily explored specific channels of transmission (Jha and Mohanty, 1995; Fung, 2002; Wu et al., 2007). Some studies have also assessed the relative performance of various channels (Cushman and Zha, 1997; Disyatat and Vongsinsirikul, 2003; Golenelli and Rovelli, 2006; Catao and Pagan, 2010; Singh and Kalirajan, 2007; Aleem, 2010), while others focus on the financial strength of the economy (Elbourn and Hann, 2006). A recent contribution to this literature, Mishra et al. (2010), finds strong evidence of a weak monetary policy transmission in emerging economies.

In a small open economy, the exchange rate offers an additional transmission channel for monetary policy (Adolfson, 2001). When the central bank raises rates, this yields a currency appreciation, through which tradeables become cheaper. In addition, there is an indirect effect upon inflation through expenditure switching away from domestically produced goods. These two factors come together in the 'exchange rate pass-through' (ERPT), the percentage change in domestic prices resulting from a one percent change in the exchange rate.

The extent of pass-through influences the choice of the optimal monetary policy strategy in an open economy framework (Devereux, 2001; Adolfson, 2001; Smets and Wouters, 2002; Monacelli, 2005). When pass-through is incomplete, the exchange rate channel becomes less effective and the brunt of the adjustment has to be borne by the interest rate channel. Conversely, when the conventional monetary policy transmission through the bond market and the banking system is weak, a greater burden of adjustment is borne by the exchange rate channel. The interest rate channel of monetary policy requires transmission of shocks to short term policy rate to the long term yield curve. Empirically, it has been found that this transmission mechanism is weak in emerging markets (Moreno, 2008). In addition, Saxena (2008) finds that nine out of thirteen Asian and Latin American emerging economies opt foreign exchange intervention to complement their conduct of monetary policy.

This reasoning suggests linking the two literatures – on the monetary policy transmission and on exchange-rate pass-through – into a unified approach. Smets and Wouters (2002); Zorzi et al. (2007); Ito and Sato (2008) provide insights into the inter-linkages between pass through and monetary policy. Smets and Wouters (2002) find that incomplete exchange rate pass-through for both import and domestic prices in the Euro zone reduce the effectiveness of the exchange rate channel of monetary policy. On the other hand Zorzi et al. (2007); Ito and Sato (2008) assess the magnitude of exchange rate pass-through in a set of emerging economies and East Asian counties assuming endogeneity between exchange rate and other monetary policy instruments. Taking into account the impact of interest rate shocks on the exchange rate, Zorzi et al. (2007) find a larger pass-through for emerging markets in general compared to developed countries. Ito and Sato (2008) find a larger pass-through to import prices compared to domestic prices in the crisis-hit East Asian countries.

The contribution of this paper lies in a unified treatment of exchange rate pass-through and the monetary policy transmission. This permits an assessment of the effectiveness of the two alternative paths through which changes in the short rate impact upon the economy. A Structural Vector Error Correction Model (SVECM) model is used, which identifies the long-run and short-run relationships and the adjustment mechanism. This structural model enables us to identify structural shocks affecting different variables.

Many emerging markets have made relatively little progress in financial sector development, which is reflected in a small financial system with infirmities of the banking system and bond market. Most emerging markets have, however, made substantial progress in removing tariff and non-tariff barriers to international trade, and to developing the infrastructure of transportation and communications through which international trade can be achieved at minimal transactions costs. In countries where trade liberalisation has run ahead of financial liberalisation, the traditional channels of monetary policy transmission (through the domestic financial system) might be relatively ineffective, but the channel through the exchange rate pass-through might be relatively important.

The empirical analysis for India, a country with weak financial development but high trade integration, shows such relationships. The parameter estimates show that the policy rate has a negligible impact on output: the null of zero-effect cannot be rejected. At the same time, changes in the policy rate affect the exchange rate, and evidence of a significant exchange rate pass-through is observed. This evidence thus suggests that in India, the exchange rate is a channel that can influence prices; the policy rate can influence prices through the impact of the policy rate on the exchange rate.

The remainder of this paper is organised as follows. Sections 2 and 3 describe the model and the dataset used for the study. Section 4 discusses the results of the baseline model and performs robustness checks and section 6 concludes.

2 Estimation strategy

The mainstream strategy for analysing exchange rate pass-through is a multivariate time-series analysis of six variables: output, oil price, import price, domestic price, exchange rate and short-term nominal interest rate (McCarthy, 1999; Smets and Wouters, 2002; Ito and Sato, 2008). In such analyses, emerging markets are treated as small open economies where domestic variables are endogenous to the system and are affected by exogenous world variables, but not vice versa.

The ordering of variables in the exchange rate pass-through and monetary policy literature is subject to the characteristics of the country/region under consideration and the problem explored. For example, Kim and Roubini (2000) present an open economy model for industrialised countries in a non-recursive structural framework. In their model, the policy rate, which is ordered first, is affected contemporaneously by shocks to money demand, the world price of oil and the exchange rate. The exchange rate is ordered last in the list which responds instantaneously to all other shocks. These shocks are ordered as following: money demand, CPI index, IIP, world price of oil and U.S. Federal Funds Rate. This model captures the characteristics of a large open economy with fully floating exchange rates where authorities have independence over monetary policy. Incorporating world variables in the endogenous system implies that although, these variables are not affected by shocks to the home country variables contemporaneously, they are affected with a lag. For a model of an emerging economy like India, which is a small open economy (in the sense that it can not affect prices in the world market), world variables are incorporated in the set exogenous variables.

In contrast to Kim and Roubini (2000), the pass-through literature dominated by McCarthy (1999) and its downstream literature follows recursive structural VAR models with Choleski orthogonalisation. The order of the variables in these models is the following: oil price inflation, output gap, exchange rate, import price inflation, wholesale and consumer price inflation. This formulation again captures the floating nature of the exchange rate which immediately responds to supply and demand side shocks to the economy. In a country with an intermediate exchange rate regime, the above described ordering may not be appropriate. Ito and Sato (2008) augmented this framework with a monetary policy variable preceded by exchange rate to allow for monetary policy shock.

To determine the ordering of the variables, we assume that the exchange rate bears the first impact of external shocks such as a change in foreign prices or interest rates. The impact on the domestic price index and income is through the interest rate channel, with imported inflation coming directly from exchange rates. Since oil price is largely administered in India, we do not include this variable in our model. The different ordering of variables in our model aims to capture the characteristics of the Indian economy. The underlying rationale for the ordering is as follows: shocks to world variables (U.S. policy rate and inflation), which are purely exogenous to the system (home variables can not affect the world variables even with a lag) immediately affect the exchange rate. This is followed by the interest rate affecting output and thereby the domestic price. The exchange rate can also have an immediate effect on prices via import prices. Thus, domestic prices are ordered last in the model, which contemporaneously respond to all shocks in the system (McCarthy, 1999).

To capture both the short-run and the long-run relationships in the model we estimate a Vector Error Correcting Model (VECM). The standard monetary policy-pass-through literature deals with I(1) variables by estimating a structural VAR model in first differences (McCarthy, 1999; Ito and Sato, 2008). However, this approach leads to loss of information concerning the long-term relationships between the series and a mis-specification if the series are cointegrated (Hafer and Jansen, 1991). Since cointegration tests detect that series in this analysis are cointegrated, we estimate the model using a Vector Error Correction Model. In the VECM, variables adjust to their long-run relationship. The structure of the model is:

$$\Delta y_t = \mu + \alpha\beta' y_{t-p} + A_1 \Delta y_{t-1} + ... + A_{p-1} \Delta y_{t-p+1} + \delta X_t + u_t \tag{1}$$

where,

$$y_t = \begin{bmatrix} e_t \\ i_t \\ Y_t \\ P_t^I \end{bmatrix}, \quad X_t = \begin{bmatrix} P_t^{\text{US}} \\ i_t^{\text{US}} \end{bmatrix},$$

Here y_t denotes a vector of endogenous variables that includes the exchange rate e_t, the interest rate i_t, output Y_t and the price index P_t^I. The vector of exogenous variables X_t includes the U.S. interest rate i_t^{US} and the U.S. producer price index P_t^{US}.

The parameters of the model are estimated in the log-linear form following Johansen and Juselius (1990). β is the co-integrating vector, α is the vector of adjustment parameters, and $A_i, i = 1 \dots (p-1)$, are the cumulative long run impact parameters.

The expected sign of the long run elasticity of domestic prices with respect to the exchange rate is positive: Imported goods become more expensive when the exchange rate depreciates. This leads to a rise in demand for domestically produced goods through expenditure switching effects, and hence, prices of domestic goods increase. The expected sign of the long run elasticity of output with respect to the exchange rate is also positive because depreciation tends to increase demand for, and thus raise production of goods in import-competing industries. The signs of the long-run elasticities of the domestic price index and output with respect to the interest rate are expected to be negative, since contractionary monetary policy reduces economic activity putting downward pressure on prices.

Long-run elasticities depict the static relationships among the variables under study. If the exchange rate is hit by a shock amounting to a one percentage point at period t, the long-run elasticity of prices indicates the change in the price index at period t. This does not take into account the dynamic framework in which the impact of shocks on variables in the system transmits over time. To understand the dynamic effect of shocks to different variables, we analyse impulse responses. We estimate a structural model using the Choleski decomposition of the variance-covariance matrix of the reduced form VECM model.

We assume that any shock to the exchange rate contemporaneously affects all other variables, but other variables do not affect it instantaneously. The next variable in the ordering, i.e. interest rate, affects aggregate demand and the domestic price index contemporaneously but not the exchange rate. Similarly, the next variable, output, affects only the domestic price index contemporaneously while, the domestic price index does not affect any variable instantaneously. Thus, the shock structure underlying the structural VECM model is the following:

$$\begin{bmatrix} u_t^e \\ u_t^i \\ u_t^Y \\ u_t^{PI} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ b_e^i & 1 & 0 & 0 \\ b_e^Y & b_i^Y & 1 & 0 \\ b_e^{PI} & b_i^{PI} & b_Y^{PI} & 1 \end{bmatrix} \begin{bmatrix} \epsilon_t^e \\ \epsilon_t^i \\ \epsilon_t^Y \\ \epsilon_t^{PI} \end{bmatrix} \tag{2}$$

where u_t denotes the reduced form error and ϵ_t indicates the structural error. These impulse responses indicate how a unit shock to the causal variable, say, the interest rate at period t affects the response variable, say, the domestic price index, in each subsequent period $t + s, s = 1, 2, 3, \ldots$.

A positive shock to the exchange rate, i.e. a depreciation of the exchange rate, is expected to increase domestic price and output in the subsequent periods. A positive shock to the interest rate, i.e. a contractionary monetary shock, is expected to reduce output and price. A contractionary monetary shock via an increase in the interest rate tends to make the domestic currency more attractive. Hence, the exchange rate is expected to appreciate in the subsequent periods after a positive shock to the interest rate. In the reverse direction, the sign of the impact of a change the exchange rate on the interest rate depends on the monetary policy regime, and hence it is hard to anticipate what it might be.

3 The data

We construct a monthly dataset from 1997 to 2009. Our dataset for domestic variables is sourced from the Business Beacon database produced by the Centre for Monitoring Indian Economy (CMIE).

The price series chosen is the Wholesale Price Index (WPI). The nominal exchange rate is measured by the rupee dollar rate. The analysis of monetary policy transmission requires a careful choice of the interest rate. The interest rate should be able to capture the true nature of the monetary policy stance. In India, monetary policy instruments have been changing since the second half of the 1990s. The policy rate, and previously the bank rate is now represented by two rates; the repo rate and the reverse repo rate. However, the cash reserve ratio continues to be used as an instrument of monetary policy and hence policy rates do not fully represent the impact of liquidity changes. To capture the stance of monetary policy, affected by the various instruments that the Reserve Bank of India uses, we measure the policy interest rate by the 91 day treasury bill rate in the secondary market. This rate represents the combined effect of RBI's policy rates as well as the effect of liquidity changes resulting from changes in the cash reserve ratio, purchases of foreign currency and open market operations by RBI.

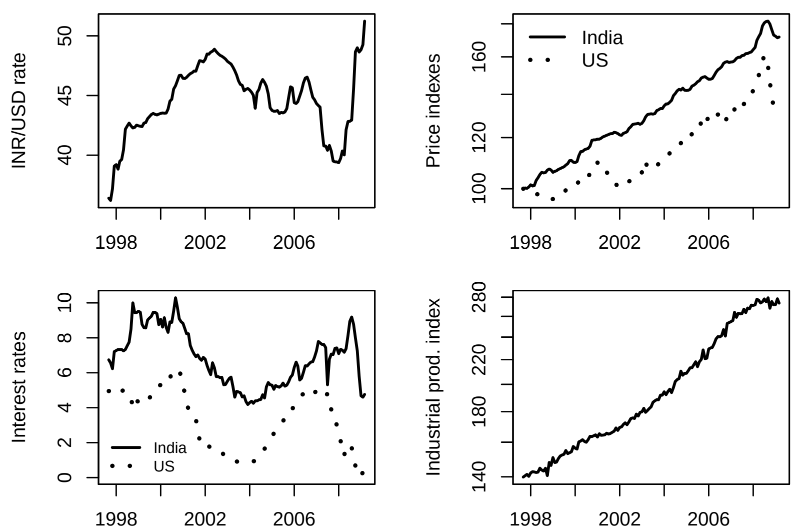
The Index of Industrial Production (IIP) is a proxy for output that is observed at a monthly frequency. All domestic variables, except the exchange rate and interest rates are seasonally adjusted.[1]

We use the U.S. PPI as a measure of world tradeables inflation.[2]. The monetary policy stance of the rest of the world is captured by the three-month

[1] For seasonal adjustment we use the X12ARIMA program of the U.S. Census Bureau. For further details, see http://www.mayin.org/cycle.in.

[2] The FRED database of the Federal Reserve Bank of St. Louis does not have seasonally adjusted data for the U.S. PPI. Statistical testing revealed that the seasonality of this series was unstable. Hence, we use non-seasonally adjusted U.S. PPI.

Figure 1 Exchange rate, prices, output and interest rates



treasury bill rate of the U.S. Both these series are from the FRED database.

Figure 1 shows the key variables. The price indexes of the two countries are re-based to 100 for the purpose of the graph. They show higher inflation in India, and the sharp fluctuations of prices in the Great Recession of 2008. Reflecting higher Indian inflation, the Indian short rate has been higher than that in the US at all times. The output series – the seasonally adjusted Indian IIP – shows a slowdown in growth in the Great Recession.

Since the choice of the estimation method depends on the level of integration of the series, we first test for stationarity. Tables 1 and 2 show unit root tests for all the series in their level and in first differences. All the variables, except the interest rate, are in logs. These tests suggest that the series of interest are non-stationary of order 1.

4 Empirical results

The Johansen co-integration rank tests based on both the trace test and the maximum eigenvalue test are reported in Table 3. The underlying VAR model specified with the endogenous variables in levels used for the VECM representation includes two lags. The lag-order selection tests are based on AIC, HQ, SC and FPE criteria. All the tests indicate a VAR model of the endogenous variables, i.e., exchange rate, interest rate, IIP and WPI in levels

Table 1 Unit root test in levels

The null hypothesis of the ADF test is that the series contains a unit root, with or without a drift against an alternate hypothesis of being a stationary series. The test statistics reported in the table below are for the lag-order that is found significant. In addition, results of the KPSS test are also shown.

Variables	Unit Root Test	
	ADF	KPSS
Log of IIP	0.35 (lag 1)	0.58
Log of WPI	-0.71 (lag 1)	2.85
Log of exchange rate	-2.56 (lag 1)	0.44
Interest rate	-1.85 (lag 0)	0.98
Log of U.S. PPI	-2.63 (lag 1)	2.6
U.S. interest rate	-1.2 (lag 1)	0.76

Table 2 Unit root tests in first differences

The null hypothesis of the ADF test is that the series contains a unit root, with or without a drift against an alternate hypothesis of being a stationary series. The test statistics reported in the table below are for the lag-order that is found significant. In addition, results of the KPSS test are also shown.

Variables	Unit Root Test	
	ADF	KPSS
Log of IIP	-11.94 (lag 1)	0.2
Log of WPI	-7.34 (lag 0)	0.03
Log of exchange rate	-7.17 (lag 0)	0.24
Interest rate	-10.32(lag 0)	0.1
Log of U.S. PPI	-7.83 (lag 0)	0.09
U.S. interest rate	-7.06 (lag 0)	0.18

Table 3 Johansen co-integration analysis

This table reports Johansen co-integration test statistics in the model with exchange rate, interest rate, IIP and WPI.

Cointegration Test	Rank order	test	10pct	5pct	1pct
Trace test					
	r <= 3	0.002	6.5	8.18	11.65
	r <= 2	13.242	15.66	17.95	23.52
	r <= 1	36.13	28.71	31.52	37.22
	r = 0	88.283	45.23	48.28	55.43
Maximum eigenvalue test					
	r <= 3	0.002	6.5	8.18	11.65
	r <= 2	13.24	12.91	14.9	19.19
	r <= 1	22.888	18.9	21.07	25.75
	r = 0	52.153	24.78	27.14	32.14

Table 4 Long run elasticities of WPI with respect to IIP, interest rate and exchange rate

This table reports long-run relation of price and other variables normalised with respect to WPI.

Variables	Log of WPI
Log of exchange rate	-0.199
Interest rate	0.006
Log of IIP	-0.357
Log of WPI	1

with 2 lags. Hence the VECM representation of the model includes one lag in differences.

The test statistics of Johansen co-integration test based on both the trace test and the maximum eigenvalue test suggest that there is one economically meaningful co-integration relation among endogenous variables at the 1 percent level of significance.[3] The estimated long-run relation between exchange rate, price level, IIP and interest rate is shown in Table 4.

[3]The trace and max-eigen value tests indicate existence of two cointegrating vectors at 5% level of significance. We have examined our VECM model with two cointigating relationships. However, these two long run equilibrium relations are not economically meaningful. For instance, at the 5% level of significance, among two cointegrating relationships, one is between exchange rate, IIP and WPI, while the other is between interest rate, IIP and WPI. But the first relation indicates that in the long run, price is negatively affected by exchange rate and IIP in the first equilibrium relation, whereas in the second, it is negatively affected by interest rate and IIP.

Table 5 Adjustment parameters

This table reports the adjustment parameters of a series that reveals how the series respond to the long run relationship. The adjustment parameter of WPI in the co-integration relation is -0.031, saying that WPI adjusts by 3.1% as a response to a 100% deviation from the long run relation. Here *** implies significance level is less than 0.1%, while ** implies 0.1% significance level. Also * and . implies 1% and 5% level of significance respectively.

Variables	Adjustment parameter
Log of exchange rate	0.035*
Log of interest rate	2.243***
Log of IIP	-0.012
Log of WPI	0.034***

The estimated relation suggests that in the long run, a 1 percent increase (depreciation) in the exchange rate raises WPI by a 0.2 percent. Also, a 1 percent rise in interest rate yields a 0.01 percent reduction in WPI while, a 1 percent increase in interest rate has a negligible impact on the IIP in the long run.

As an example, consider a situation where WPI inflation was at 5 per cent and the exchange rate was at Rs.48. If a 6 per cent appreciation took place, to Rs.45 to the dollar, WPI inflation goes down to 3.8 percent [(5 - (0.2 * 6)) percent] in the long run. Similarly, when there is a 1 percent rise in the interest rate (from 5 to 6 percent), WPI inflation (5 percent before shock) falls to 4.99 percent (5 - 0.01 percent) in the long run. The long-run impact of the exchange rate on IIP is negative. In other words, depreciation does not increase net export and output; however this impact is marginally significant.

Table 5 shows how different variables adjust to the long run relation. It shows that the interest rate responds to a deviation from the long-run equilibrium relation faster than any other variable. Also, the adjustment parameter for IIP is not significant. This implies that IIP is weakly exogenous to the system. This is consistent with the broad picture of IIP being weakly influenced by monetary policy.

Figure 2 shows the impulse responses to an exchange rate shock and monetary shock for a horizon of up to twenty four months, that is, two years after the shock. In each graph, we plot the Choleski orthogonalised impulse responses with a 95 percent confidence band.

The chain of relationships visible through these plots runs as follows. When

Figure 2 Impulse response analysis with Choleski orthogonal shock structure

This graph shows response of different variables to one percent shock to exchange rate and interest rate.

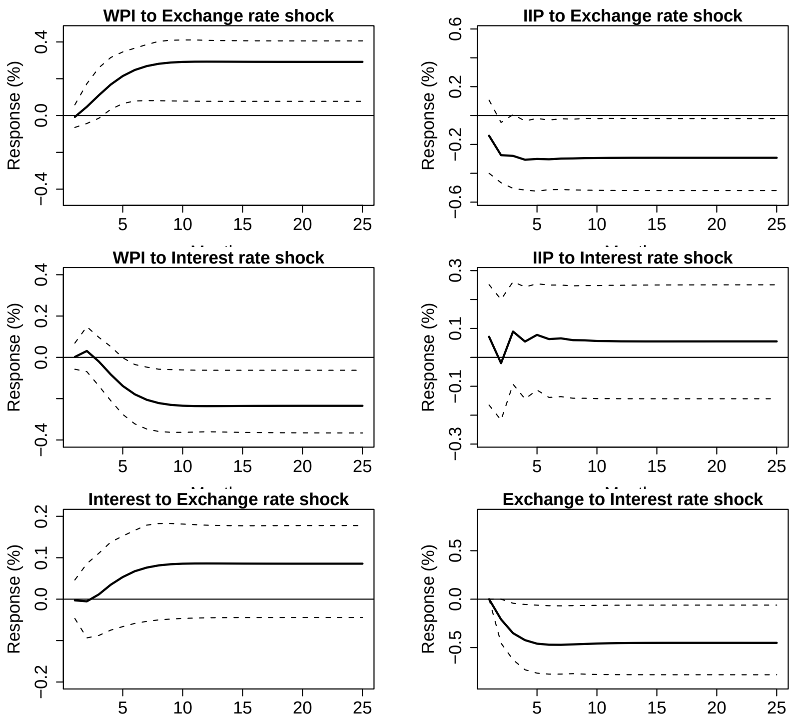


Table 6 FEVD analysis

	Horizon	Exchange rate	Interest Rate	IIP	WPI
FEVD for	1	100	0	0	0
Exchange Rate	5	94.94	2.74	0.05	2.27
	10	93.53	3.43	0.03	3.01
FEVD for	1	0.01	99.99	0	0
Interest rate	5	0.58	91.65	3.7	4.07
	10	2.61	77.7	5.62	14.07
FEVD for	1	1.42	0.37	98.21	0
IIP	5	8.84	0.56	87.97	2.63
	10	10.5	0.54	85.92	3.05
FEVD for	1	0.03	0	1.35	98.62
WPI	5	9.8	3.02	14.14	73.04
	10	25.55	14.07	20.44	39.94

an interest rate hike takes place, it has no direct impact upon output. However, it has an impact upon the exchange rate (the exchange rate appreciates). Changes in the exchange rate have an impact upon inflation: exchange rate appreciation is associated with a decline in prices. Putting these together, there is a statistically significant impact of an interest rate hike upon inflation.

The results of forecast error variance decomposition analysis complement the results from the impulse response analysis. Table 6 reports the FEVD results. The FEVD analysis for the WPI shows that five months out, a shock to the exchange rate contributes a 9.8 percent variation to the WPI series, while the interest rate has only a 3.02 percent contribution. After ten months the contribution of exchange rate rises to 25.55 percent, while that of interest rate is only 14.07 percent.

The exchange rate has a contribution to the variation in IIP of 8.84 percent and 10.5 percent in the five months and ten months ahead in the forecast horizon respectively. The contribution of interest rate in the variation of IIP is lower compared to the exchange rate and it falls over time. The interest rate contributes to only 0.56 percent to the variation in IIP at five months ahead in the forecast horizon. This falls to 0.54 percent after ten months. Interestingly, the first row in Table 6 shows that the interest rate has a higher contribution to the variation in exchange rate compared to IIP and WPI.

We also find that U.S. producer price changes have a significant impact on WPI inflation. An increase in the U.S. producer price index by 1 percent raises WPI by 0.1 percent. We also find that a 1 percent U.S. interest rate hike reduces WPI by 0.001 percent. These coefficients are highly statistically significant.

5 Robustness checks

5.1 Alternative specifications

The specification of the shock structure in our main model is based on the argument put forward in the ERPT literature for emerging markets that macroeconomic variables have little explanatory power for exchange rates in the short to medium run (Zorzi et al., 2007). We re-estimate the model with three alternative identification schemes to assess the sensitivity of our baseline results with respect to the shock structure specification.

The first alternative specification is based on our original ordering of variables with an orthogonalised shock structure. This specification scheme assumes that a shock to any variable at period t affects only that variable in period t and no other variables. The second alternative model follows an ordering of variables where the interest rate is the first variable followed by the exchange rate, IIP and WPI. Given the ordering, Choleski orthogonalisation is applied to the model. This alternative model allows for a contemporaneous response of the exchange rate to changes in the monetary policy instrument. This represents a scenario where a rise in the interest rate makes domestic currency more attractive, causing the exchange rate to appreciate contemporaneously.

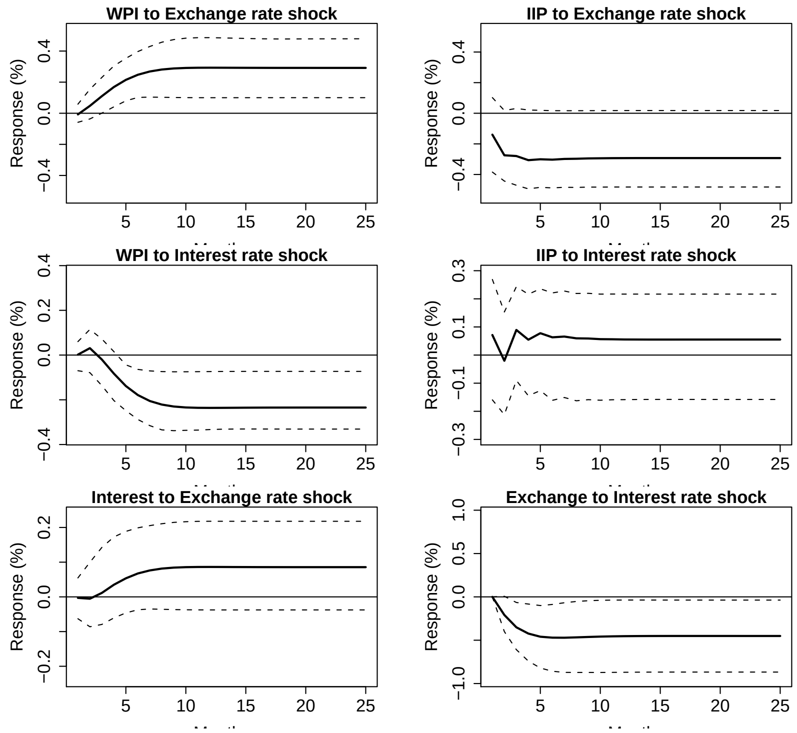
The third specification follows the standard ordering of variables of the pass-through literature. In this specification, the crude oil price is followed by IIP which is followed by the exchange rate, the interest rate and finally the WPI.

The results under the first two alternative identification schemes and the third model are in general, very similar to those of our base line model. However the response of exchange rate to interest rate shock is not significant when the interest rate affects the exchange rate contemporaneously. This can be seen in the impulse responses shown in figures 3,4 and 5.

The results of the forecast variance decomposition analysis under these alternative models are also similar to our benchmark model. Table 7 presents results of the FEVD analysis for orthoginalised shock. Table 8 shows results of the FEVD analysis of the model where the interest rate precedes the exchange rate. The results of FEVD analysis for the model with oil prices are

Figure 3 Impulse response analysis with orthogonal shock structure

This graph shows response of different variables to one percent shock to exchange rate and interest rate.



depicted in Table 9. The results of the VECM analysis of this model are in the Appendix.

5.2 Choice of price index

As an alternate measure of price index, we use CPI (industrial workers). However, we do not find any significant impact of exchange rate and interest rate on domestic price index. Moreover, the direction of the impact of the exchange rate on CPI is wrong. These findings support the fact that CPI consists of a large share of non-tradeables and hence the effect of a shock to the exchange rate on this price index via tradeable prices is low.

Figure 4 Impulse response analysis for alternative ordering of variables

This graph shows response of different variables to one percent shock to exchange rate and interest rate.

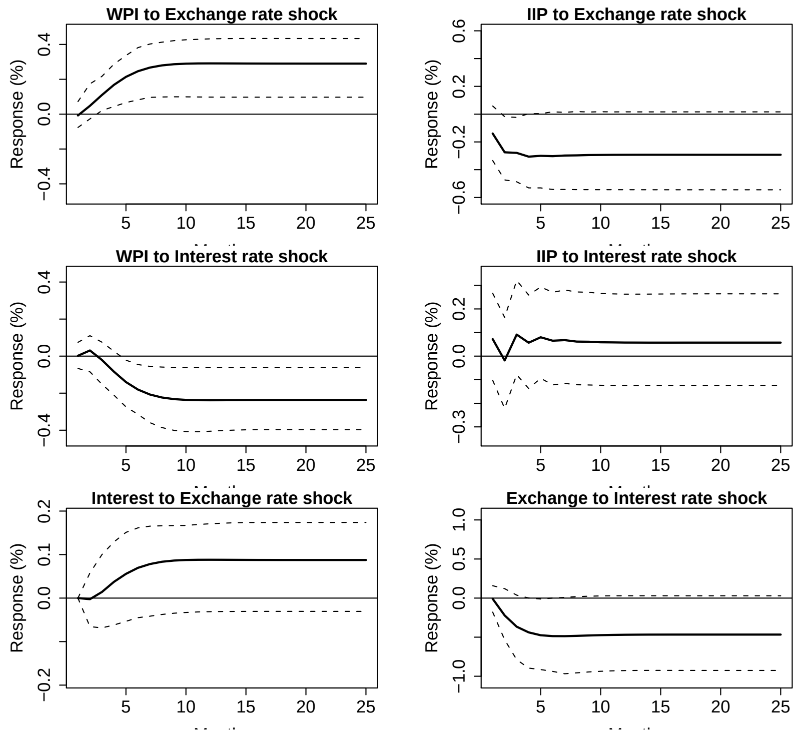


Table 7 FEVD analysis

	Horizon	Exchange rate	Interest Rate	IIP	WPI
FEVD for	1	100	0	0	0
Exchange Rate	5	94.77	2.78	0.15	2.3
	10	93.35	3.47	0.13	3.05
FEVD for	1	0	100	0	0
Interest rate	5	0.99	90.16	4.69	4.15
	10	3.61	74.45	7.84	14.1
FEVD for	1	0	0	100	0
IIP	5	4.32	0.13	92.69	2.85
	10	5.29	0.09	91.27	3.35
FEVD for	1	0	0	0	100
WPI	5	12.88	3.66	8.98	74.48
	10	29.85	15.36	15.87	38.93

Figure 5 Impulse response analysis for the model with oil price

This graph shows response of different variables to one percent shock to exchange rate, interest rate and oil price.

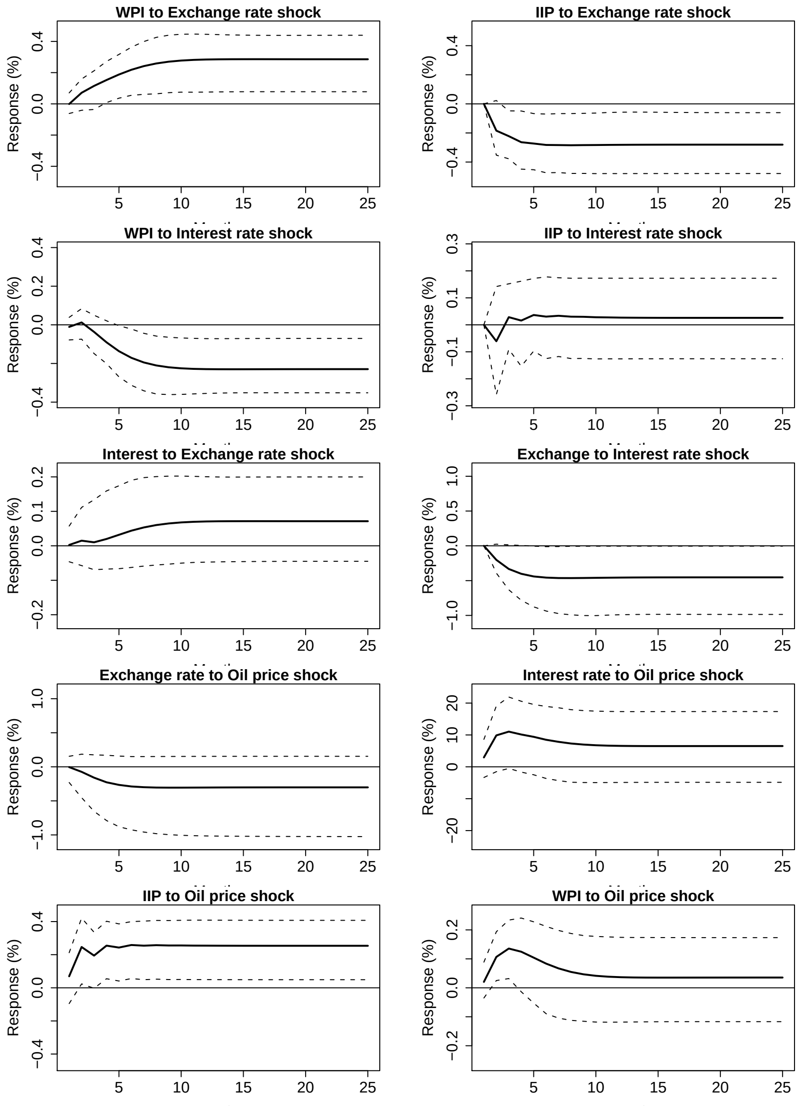


Table 8 FEVD analysis

	Horizon	Interest rate	Exchange Rate	IIP	WPI
FEVD for	1	100	0	0	0
Interest rate	5	91.58	0.64	3.7	4.07
	10	77.55	2.76	5.62	14.07
FEVD for	1	0.01	99.99	0	0
Exchange Rate	5	2.96	94.72	0.05	2.27
	10	3.68	93.28	0.03	3.01
FEVD for	1	0.38	1.41	98.21	0
IIP	5	0.58	8.81	87.97	2.63
	10	0.57	10.47	85.92	3.05
FEVD for	1	0	0.03	1.35	98.62
WPI	5	3.09	9.73	14.14	73.04
	10	14.33	25.29	20.44	39.94

Table 9 FEVD analysis

	Horizon	Oil price	IIP	Exchange rate	Interest Rate	WPI
FEVD for	1	100	0	0	0	0
Oil price	5	86.95	0.14	12.5	0.12	0.29
	10	83.68	0.26	15.15	0.19	0.71
FEVD for	1	0.37	99.63	0	0	0
IIP	5	5.63	84.76	5.62	0.15	3.84
	10	7.06	79.91	7.98	0.14	4.91
FEVD for	1	0	1.23	98.77	0	0
Exchange rate	5	0.74	0.6	93.69	2.46	2.51
	10	1.2	0.6	91.62	3.11	3.47
FEVD for	1	0.53	0.1	0	99.36	0
Interest rate	5	5.49	3.81	0.23	87.87	2.6
	10	4.9	5.88	1.33	77.77	10.12
FEVD for	1	0.26	0.85	0	0.07	98.81
WPI	5	6.32	9.68	8.6	3.17	72.23
	10	4.41	16.03	23.52	14.02	14.02

6 Conclusions

This paper finds that the monetary policy transmission mechanism in India, an emerging economy, is weak. This result agrees with that found in other low income countries that have a weak and small financial sector (Mishra et al., 2010). In India we find evidence of incomplete, but statistically significant, exchange rate pass though. This finding agrees with the existing studies on exchange rate pass-through in India (Ghosh and Rajan, 2007; Khundrakpam, 2007). Although, low exchange rate pass-through is generally observed in low-inflation countries, however, there can be other factors which reduce pass through in domestic prices. For instance, the pricing-to-market behaviour by producers in the exporting countries or the high share of non-traded commodities in the country's domestic price index may result in low exchange rate pass-through. We also find that changes in interest rates do not affect aggregate demand implying the absence of inflation-output trade-off. However, given a strong, though incomplete exchange rate pass-through, interest rates can impact inflation through the exchange rate.

7 Appendix: Results of VECM analysis of the model with oil price

Table 10 Long run elasticities of WPI with respect to oil price, IIP, exchange rate and interest rate

This table reports long-run relation of price and other variables normalised with respect to WPI.

Variables	Log of WPI
Log of oil price	-0.004
Log of IIP	-0.372
Log of exchange rate	-0.191
Interest rate	0.005
Log of WPI	1

Table 11 Adjustment parameters

This table reports the adjustment parameters of a series that reveals how the series respond to the long run relationship. The adjustment parameter of WPI in the co-integration relation is -0.031, saying that WPI adjusts by 3.1% as a response to a 100% deviation from the long run relation. Here *** implies significance level is less than 0.1%, while ** implies 0.1% significance level. Also * and . implies 1% and 5% level of significance respectively.

Variables	Adjustment parameter
Log of oil price	0.0045.
Log of IIP	-5e-04
Log of exchange rate	8e-04*
Log of interest rate	0.0376**
Log of WPI	6e-04***

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