Exchange rate pass-through in India

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Abstract

We investigate the relationship between inflation and the exchange rate in the post reform period in India. We estimate the impact of a change in the nominal exchange rate on the wholesale and consumer price indexes from 1997 to 2007. We also explore the impact of changes in oil prices and commodity prices on inflation in India. We find there are cointegrating relationships, and setup an estimation strategy which is consistent with this fact. We find that there is significant, but incomplete, exchange rate pass through.
JEL Codes: C32, E31, E37, F31, O52.
Keywords: Exchange rate pass-through, inflation, distribution chain, VAR, India.

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1 Introduction

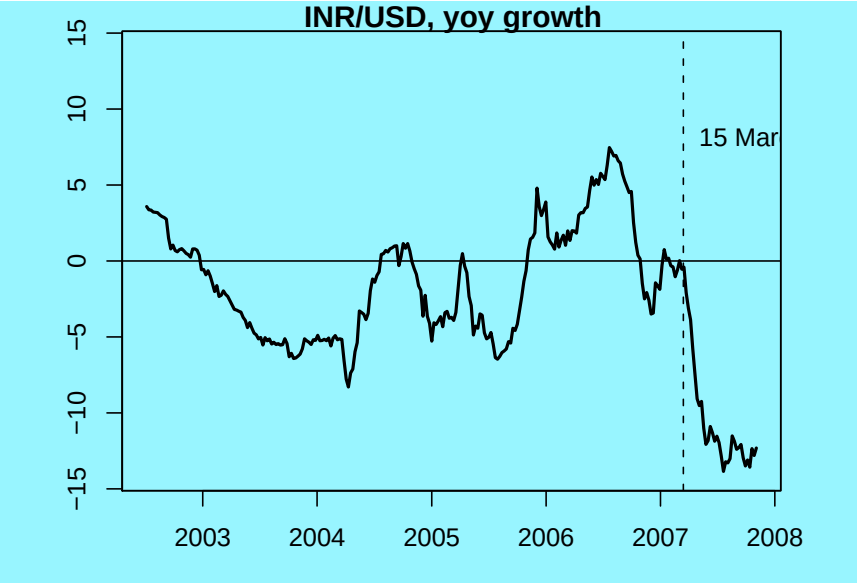
Exchange rate pass through (ERPT) is defined as the percentage change in domestic prices, which include consumer prices, producer prices, import prices and sometimes the prices set by domestic exporters, resulting from one-percent change in the exchange rate. The transmission mechanism of pass-through into domestic prices works in two stages. In the first stage, a depreciation of exchange rate increases prices of imported consumption and intermediate goods. However the effect is not confined only to import prices. In the second stage, it affects prices of domestically produced goods through supply and demand channels. The rise in intermediate goods prices increases costs of production and hence prices of domestically produced goods. On the other hand because of rise in import prices, demand shifts to domestically produced goods, leading to further increase in domestic prices. Thus the former effect is called the first-stage pass through, while the latter is referred to as the second-stage pass through. Moreover, passthrough can be 'complete' or 'incomplete'. If a one percent change in the exchange rate leads to a one percent change in prices, pass-through is said to be complete. If the impact on prices is smaller, this is said to be 'incomplete' pass-through.

The Indian rupee appreciated with respect to the US dollar since 2001. While most of the time the appreciation has been slow, sometimes there has been a sharp change in the exchange rate. For example, in April 2007, there was a 9 percent appreciation of the Indian rupee. This was followed by a sharp decline in inflation. This episode motivates an effort at measuring the extent to which the exchange rate appreciation was responsible for the decline in inflation. This paper explores the relationship between exchange rate movements and domestic prices in the recent decade. We focus our attention to the second-stage pass through, that is effect of exchange rate movements on producer or consumer prices. We attempt to answer the following questions:

- Does a change in the exchange rate have a significant effect on inflation?
- How large is the exchange rate pass-through?
- How much time does it take for a change in the exchange rate to impact on inflation?
- How long does the impact of a shock to exchange rates last?
- How do changes in oil prices affect inflation in India?
- How do changes in world commodity prices affect inflation in India?
- What are the implications for monetary policy in this context?

Since the degree and timing of pass-through are important for forecasting inflation and for setting monetary policy in response to inflation shocks, these questions are relevant for monetary policy formulation. Moreover, while there are several empirical studies on ERPT in the developed countries and some of the emerging markets like South-East Asia, Latin America and East-European Nations, the literature on India is limited.

Figure 1 Recent Indian exchange rate Movements



We adopt multivariate analysis taking into consideration the possibility of long run relationship existing among world prices, domestic prices and exchange rate. We find that exchange rate pass-through into domestic prices in India is moderate. The long run pass through elasticity for CPI is 3.7-17%, while that for WPI is 28.6%. If effects of monetary policy are not taken into consideration, 10% of the exchange rate shock passes into the CPI index in the next period. If the effect of monetary policy is considered, then pass through effect on CPI rises from 11% in the next period to 20% in two years followed by a 100% shock to exchange rate. The immediate effect on WPI followed by a 100% exchange rate shock is around 12% which falls in two years to 1.3%.

In section 2 we describe some stylized facts about the relation between prices, exchange rates and output in India. Section 3 describe the methodology adopted in the analysis. The next section 4 describes the data and results under different modelling framework. Section 5 presents the conclusions.

2 Questions

In 2007, specifically in the month of March, the bilateral rupee dollar rate has shown a sharp appreciation after a period of slow appreciation since 2001. This is depicted by Figure 1. At the same time, both overall WPI and the WPI for manufacturing showed a sharp decline, which is depicted by Figure 2.

During the same period, we find a decline in crude oil prices while the WPI of fuel was stable owing to administered pricing (Figure 3).

Figure 2 Recent Indian WPI Changes

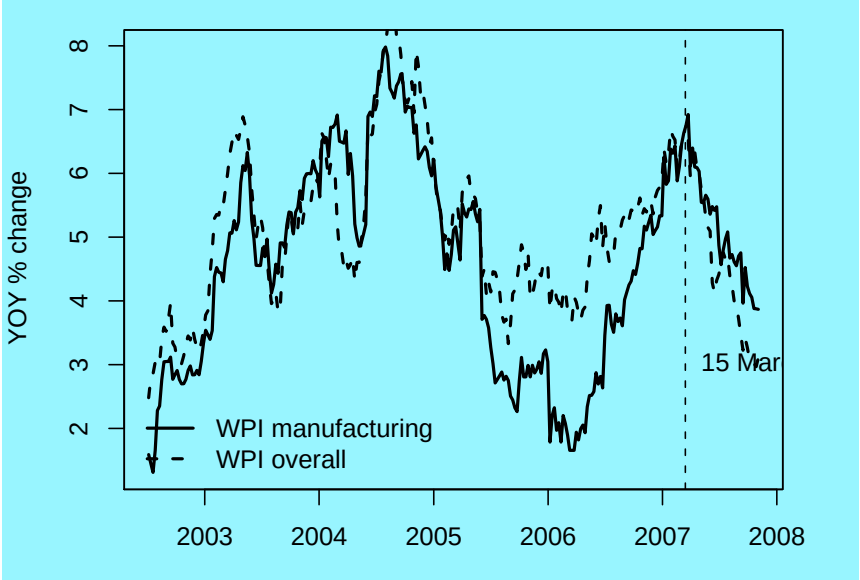
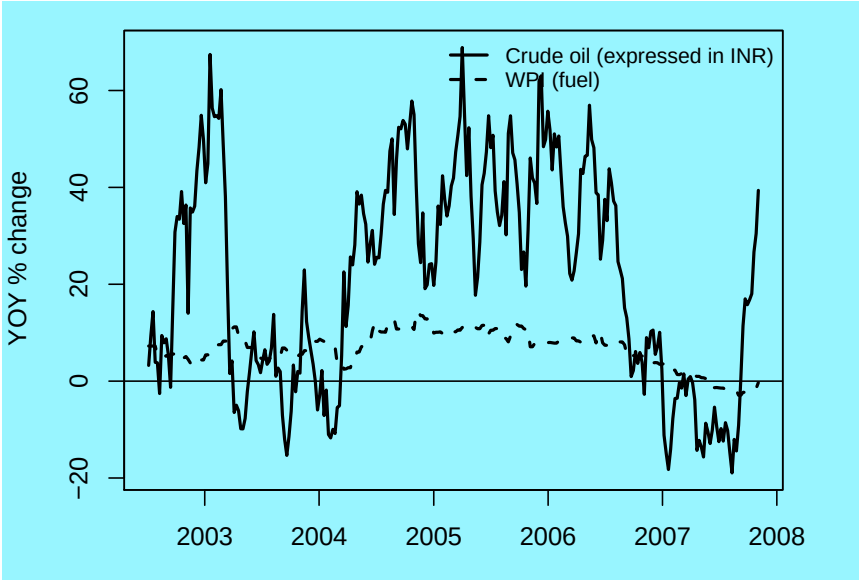


Figure 3 Oil Price Movements



These observations immediately raise questions about the extent, timing and duration of responsiveness of domestic prices to exchange rate movements in India. There is a growing body of research on ERPT in India that estimates extent of pass-through into domestic prices, attempts to determine macro and microeconomic factors that affect the extent of ERPT, and attempts to find structural break in ERPT (Khundrakpam, 2007 and Ghosh and Rajan, 2007). Both studies consistently show low degree of pass through with no sign of changing degree of pass-through in the post-reform periods.

Khundrakpam estimated exchange rate pass-through into the wholesale price index in India using monthly data for 1991:8-2005:3. Given that data does not reveal existence of any long-run co-integrating relation between prices and exchange rate, he investigates the effect of an exogenous change in exchange rate on domestic prices controlling for other factors such as demand condition of the importing country, the price of the exporting country, food-price shock which are also exogenous to the system. He finds that degree of pass-through in India is low. A 10% change in exchange rate increases final prices by 0.6-0.9% only. Incorporating dummies for direction of exchange rate change, he also finds that pass-through coefficients are higher for appreciation than depreciation. Finally rolling regression technique reveals no declining trend of ERPT. Increase in import penetration, lowering import tariff associated to liberalization and increased inflation persistence have been conjectured as plausible reasons for non-declining ERPT in India.

Ghosh and Rajan explore the relation of CPI and exchange rate in India using bivariate error correction mechanism assuming home demand condition and foreign prices exogenous to the system. They found that 100% change in exchange leads to 40-50% change in CPI. Using split sample technique, they did not find any significant change in ERPT between pre and post reform periods.

Unlike these existing studies, we adopt the framework of multivariate analysis. Our approach is motivated by the fact that single equation estimation method does not take into account potential endogeneity problem among domestic prices and exchange rate. Again focusing only on the endogeneity of domestic prices and exchange rate does not consider the effects of shocks in the world market that may affect exchange rate and hence domestic prices.

The multivariate analysis of ERPT started with pioneering work of McCarthy (1999). He analyzed the relationship between exchange rate and inflation in a recursive VAR framework for industrialized countries incorporating a distribution chain of pricing that follows from import prices to producers and consumer prices. Similar methodology has been followed to investigate exchange rate pass-through into domestic prices in several countries and regions (Bhundia, 2002; Leigh and Rossi, 2002; Gueorguiev, 2003; Belaisch, 2003; Zorzi, Hahn and Sanchez, 2007).

However these approach does not capture the potential long run relationship among variables. In order to incorporate this feature, Kiptui, Ndolo and Kaminchia (2005) proposes error-correction mechanism in estimating ERPT for Keneya.

In order to explore the potential long run relation among domestic and world prices and exchange rate, we investigate ERPT under the Vector Error Correction Mechanism which captures co-integrating relations in a multivariate framework.[1] We incorporate money supply and interest rate in the system to investigate implications of monetary policy for ERPT.

3 Methodology

We estimate a VAR model in the first difference of the variables to capture effect of exchange rate movements on inflation, which is measured as the first difference of the log of prices. Since this model is not able to incorporate the potential long run relation among the variables we propose to apply the Vector Error Correction Method.

3.1 Vector Autoregression Analysis

The model is based on McCarthy, (1999). This model includes exchange rate, wholesale and consumer prices in a recursive VAR framework. An exogenous supply shock is proxied by oil prices and a demand shock by the gap between actual and potential output. In this model the ordering starts with an exogenous variable, world oil prices, and ends with consumer prices, on which all shocks are expected to have an impact. The estimation equations are:

$$\pi_t^{\text{oil}} = \alpha_1 \pi_{t-1}^{\text{oil}} + \alpha_2 \pi_{t-2}^{\text{oil}} + ... + \alpha_p \pi_{t-p}^{\text{oil}} + \epsilon_t^{\text{oil}} \quad (1)$$

$$Y_t = \beta_1 \Delta Y_{t-1} + \beta_2 \Delta Y_{t-2} + ... + \beta_p \Delta Y_{t-p} + \beta_3 \epsilon_t^{\text{oil}} + \beta_4 \epsilon_t^{Y} \quad (2)$$

$$\Delta e_t = \gamma_1 \Delta e_{t-1} + \gamma_2 \Delta e_{t-2} + ... + \gamma_p \Delta e_{t-p} + \gamma_3 \epsilon_t^{\text{oil}} + \gamma_4 \epsilon_t^{Y} + \gamma_5 \epsilon_t^{e} \quad (3)$$

$$\pi_t^{\text{index}} = \delta_1 \pi_{t-1}^{\text{index}} + \delta_2 \pi_{t-2}^{\text{index}} + ... + \delta_p \pi_{t-p}^{\text{index}} + \delta_3 \epsilon_t^{\text{oil}} + \delta_4 \epsilon_t^{Y} + \delta_5 \epsilon_t^{e} + \epsilon_t^{index} \quad (4)$$

where Δ is the first difference operator, ϵ is the innovation in the superscript variable, Y is the output gap in industrial production and π is the inflation measured by a particular index like the WPI or the CPI and in oil. Given the ordering of variables, structural shocks are identified using a Cholesky decomposition.

[1] Ito, Sasaki and Sato,(2005) also followed a single equation estimation technique. Goldfajan and Werlang (2000) explore the relationship between exchange rate depreciations and inflation in a panel study based on single equation estimation technique using a sample of 71 countries in the period 1980-1998. Choudhri and Hakura (2006) attempts to identify factors affecting the size of ERPT in industrialized economies; while Hahn (2007) estimates ERPT in sectoral prices for Euro area.

3.2 Vector Error Correction Mechanism

The VECM is a mechanism where the variables adjust to their existing long-run relationship. It explains how long-term error explains the movement in the short term. The general structure of our model estimated by the VECM method is the following:

$$\Delta y_t = \mu + \alpha\beta^{'} y_{t-1} + A_1 \Delta y_{t-1} + ... + A_{p-1}\Delta y_{t-p+1} + \epsilon_t$$

where

$$y_t = \begin{bmatrix} P_t^{W/O} \\ Y_t \\ e_t \\ m_t \\ P_t^{\text{index}} \end{bmatrix}$$

This y_t denotes the vector of variables under consideration,

Here $P_t^{W/O}$ denotes index of either world commodity prices or crude oil prices, m_t denotes monetary policy variable which is either real money supply or interest rate and P_t^{index} denotes a price index.

Also α denotes the vector of adjustment parameter, β is the co-integrating vector and $A_i, i = 1, ..p-1$ are the short run impact parameters. The parameters of the model are estimated in the log-linear form using Johansen (1988) MLE technique.

4 Results

4.1 Data

We use monthly data from September, 1997 to October, 2007 in order to investigate ERPT in the post reform period.The exchange rate is the nominal rupee dollar (INR-USD) exchange rate. The price of oil is the world price of the Indian basket measured in Indian rupees. This data is sourced from IFS. Data on the world commodity price index are sourced from IFS. IIP is considered as a proxy for monthly GDP. The measure of real money supply is M3 adjusted for IIP. The interest rate is the average of the maximum and minimum of the treasury bill rate. All variables, except for exchange rate and interest rate are seasonally adjusted using ARIMA X(11). The output gap is measured as the deviation of the seasonally adjusted index of industrial production from its Hodrick-Prescott filtered trend. Inflation is measured by the WPI and the CPI.

4.2 Estimation

After deseasonalising all data is first taken in logs and then tested for stationarity using the DF-GLS, the ADF and the PP tests.

These three tests consistently show that all the series except for wholesale fuel prices and IIP gap are non-stationary in levels, but stationary in their first differences, that is, the series are $I(1)$. For fuel prices, only the PP is able to reject the null of unit root in the first difference of the series. However in our analysis, we assume that this series is $I(1)$. On the other hand IIP gap is marginally non-stationary in level for certain lags.

For estimating exchange rate pass through into the aggregate price level as well as inflation, we analyze a variety of specifications, taking into account the following issues. First, in order to investigate ERPT and impact of fuel prices in the CPI inflation in India, we follow the existing literature of recursive VAR analysis described in section 3.1. Second, since India has a large share of intermediate goods in imports, we explore ERPT in aggregate CPI index by incorporating world commodity price index instead of fuel prices. Next, we explore impact of money supply in this framework. Finally we investigate the effect of crude oil prices and resultant exchange rate movements in WPI index. For these last three specifications, we use VECM technique described in section 3.2. The specifications are summarized as follows:

Model 1: Recursive VAR Here, the variables considered are fuel price, CPI, Exchange rate and IIP gap. Prices are in the first difference of log, exchange rate is in its first difference, while IIP gap is in its level assuming that this series is stationary.

Model 2: VECM The variables considered are world commodity price index, CPI, exchange rate and IIP gap. All the variables are in logs.

Model 3: VECM This model is based on the specification of model 2 with real money supply included in it.

Model 4: VECM Variables considered are crude oil price, WPI, IIP gap, exchange rate and interest rate. All the variables are in log in level. Sine IIP gap can be considered as a stationary series, in this specification, we impose the condition that IIP gap is not co-integrated with other series in the long run.

For all the specifications, lag order selection tests are performed. We choose lag order following LR criterion for Model 2,3 and 4, while the number of lags in Model 1 is chosen by the AIC criterion.

For all the specifications 2,3 and 4, Johansen co-integration test shows that for each of these specifications, there exists one co-integration relation at 5% level. The results are shown in table 11.

The results are summarized in tables 1 and 2. Table 1 presents the long run relation of the price level with the relevant variables and the short run effect of exchange rate movement

Table 1 Long-run and Short-run pass-through

This table reports long-run relation of prices and other variables and the short run ERPT coefficients. The last row is the p-value of the estimation results. For instance p-value associated with the long run relation of CPI and other variables under Model 1 is 0.000 which says that coefficients in this relation are jointly significant. The p-vale of 0.47 associated with short run ERPT under this model says that the coefficient is significant at 10%.

Variables	Model 2		Model 3		Model 4	
	Lcpi		Lcpi		Lwpi	
	Long-run Relation	Short-run ERPT	Long-run Relation	Short-run ERPT	Long-run Relation	Short-run ERPT
Log of exchange Rate	0.037	0.101*	0.173	0.113*	0.286	0.136***
Log of crude oil price					0.187	
Log of world commodity price	0.262		0.247			
Log of IIP gap	- 2.805		-3.707			
Log of interest rate					- 0.067	
Log of real money supply			0.023			
Constant	3.718		3.049		3.51	
p-value	0.000	0.047	0.000	0.027	0.000	0.000

on it. We find that 1% increase in exchange rate causes 0.037-0.17% rise in CPI level in the long run, while the effect in the short run is 0.101-0.113%. We also find that WPI changes by 0.286% in the long run and by 0.136% in the short run due to 1% rise in exchange rate. The effect of 1% change in the world commodity prices on CPI is 0.247-0.262%, while 1% rise in the crude oil prices results in 0.187% increase in WPI. Moreover a 100% increase in real money supply causes 2.3% increase in CPI, while 100% rise in the interest rate reduces WPI by 6.7%.

Table 2 shows how different variables adjust to the long run relation. The number in the parentheses are the p-value of these coefficients. It shows that adjustment parameters for crude-oil price, world commodity prices for the model 3 and interest rate are not significant. This implies that these variables do not respond to the long-run equilibrium relation, hence these variables are weekly exogenous to the system.

4.3 Impulse response results

In conducting impulse response analysis, in the specification 1, we investigate orthogonalized impulse response given the ordering of variables. However, other specifications do not take into account ordering of variables, we explore impulse response as impact on a variable due to shock on another variable taking into account of its impact on other variables simultaneously.

Table 2 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 CPI under Model 2 is -0.041, saying that CPI adjusts by 4.1% as a response to any deviation from the long run relation. p-values are reported in the parentheses.

Variables	Model 2	Model 3	Model4
Log of crude oil price			0.307
			(0.106)
Log of world commodity price	0.232	0.205	
	(0.021)	(0.096)	
Log of wpi			-0.02
			(0.020)
Log of cpi	-0.041	0.016	
	(0.001)	(0.270)	
Log of exchange rate	-0.114	-0.105	-0.058
	(0.000)	(0.000)	(0.019)
Log of IIP gap	-0.039	-0.096	
	(0.166)	(0.003)	
Log of real money supply		0.085	
		(0.028)	
Log of interest rate			0.413
			(0.003)

The results are shown in Table 3. This shows % change in price levels due to 100% shock in different variables. The impulse response analysis shows that 100% increase in exchange rate leads to 12% rise in WPI in the next period, while after two years, the effect is 1.3%. Again 100% increase in exchange rate leads to 10.2-11.5% increase in CPI in the next period, while after two years, the effect is 6.8-20%. We also find that 100% increase in depreciation has a cumulative effect of 2.5% after two years on the CPI inflation.

Figures 4 depicts impulse response of CPI inflation to an unit shock to the exchange rate. It shows that CPI inflation increases immediately followed by a positive shock to the exchange rate. However it dies down in the long run. The Figures 5 and 6 respectively depict cumulative effect on CPI inflation due a unit shock to exchange rate change and fuel price inflation. We find that fuel price inflation has negligible effect on CPI inflation. This finding is consistent with the fact that fuel prices are administered in India.

Figure 7 shows the response of CPI in the aggregate level followed by 1% shock to exchange rate and world commodity price under the Model 2 when impact of money supply is not considered. It shows that exchange rate shock has a sharp positive effect on CPI immediately, but eventually it falls, although does not die down. World commodity price shock has a positive effect on CPI in the long run.

Figure 8 shows impulse response analysis for aggregate CPI when monetary policy is taken into consideration.

Again, a 100% change in real money supply raises CPI by 4.5% in the next period and in

Table 3 Impulse Response Results for Prices (Due to 100% Shock)

Variables	Model 1		Model 2		Model 3		Model 4	
	CPI inflation Cumulative Effect		CPI		CPI		WPI	
	Next Period	2 years Ahead	Next Period	2 years Ahead	Next Period	2 years Ahead	Next Period	2 years Ahead
First difference of exchange rate	1.3	2.5						
Exchange rate			10.2	6.8	11.5	20.4	12	1.3
Crude oil price							1.1	5.4
World commodity price			-0.23	5.55	-0.0233	4.651		
Real money supply					4.51	20.78		
Interest rate							0.8	-0.8

Figure 4 Impulse Response of CPI Inflation to a Unit Shock to Exchange Rate

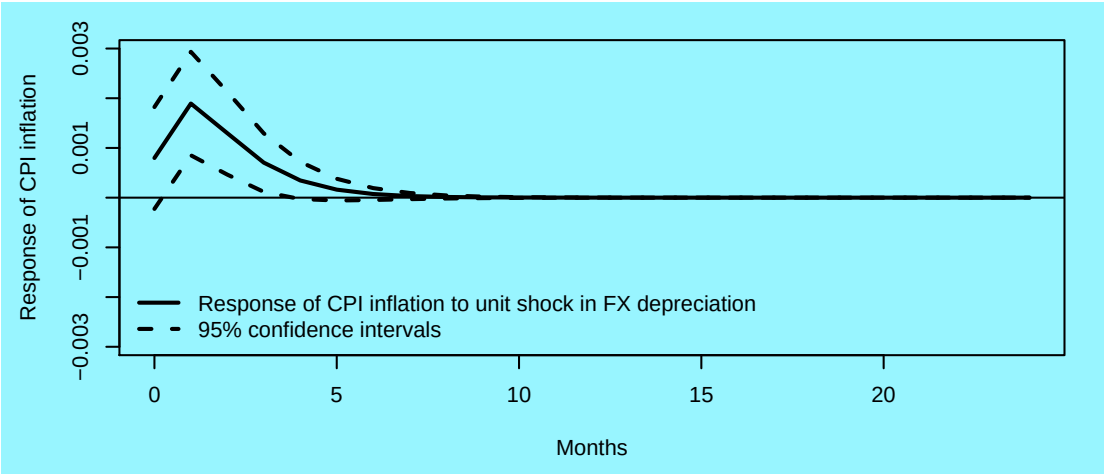


Figure 5 Cumulative Impulse Response of CPI Inflation to a Unit Shock to Exchange Rate and Fuel Price Inflation

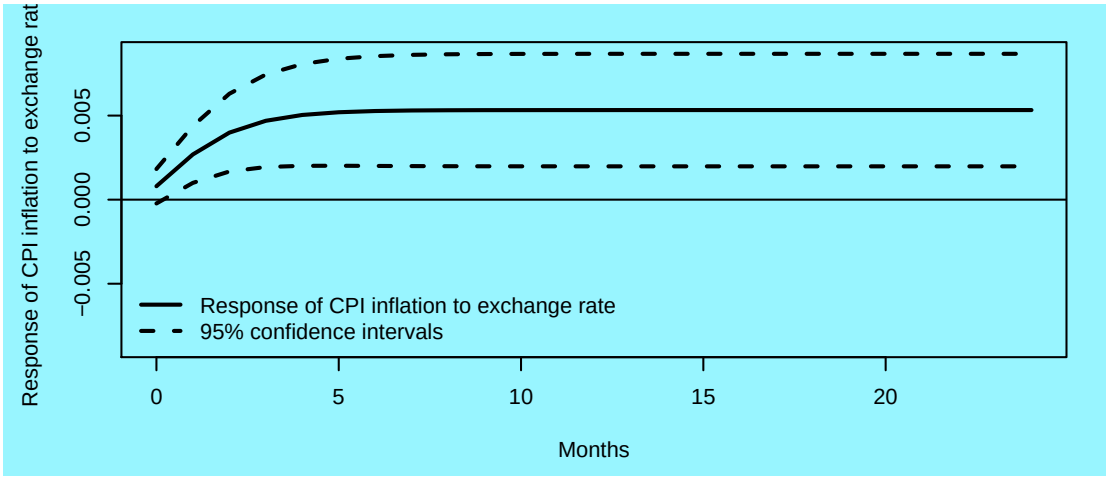


Figure 6 Cumulative Impulse Response of CPI Inflation to a Unit Shock to Exchange Rate and Fuel Price Inflation

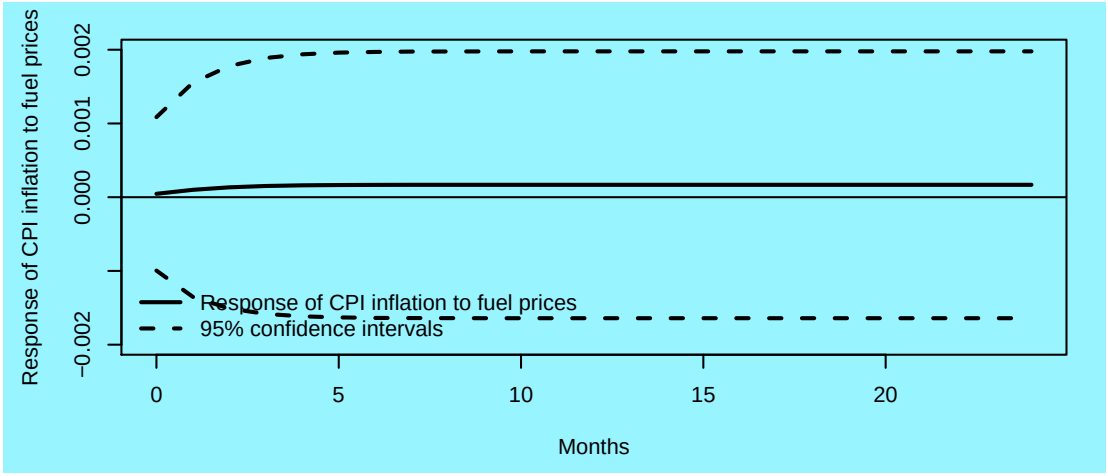


Figure 7 Impulse Response of CPI to 1 Percent Shock to Exchange Rate and World Commodity Price

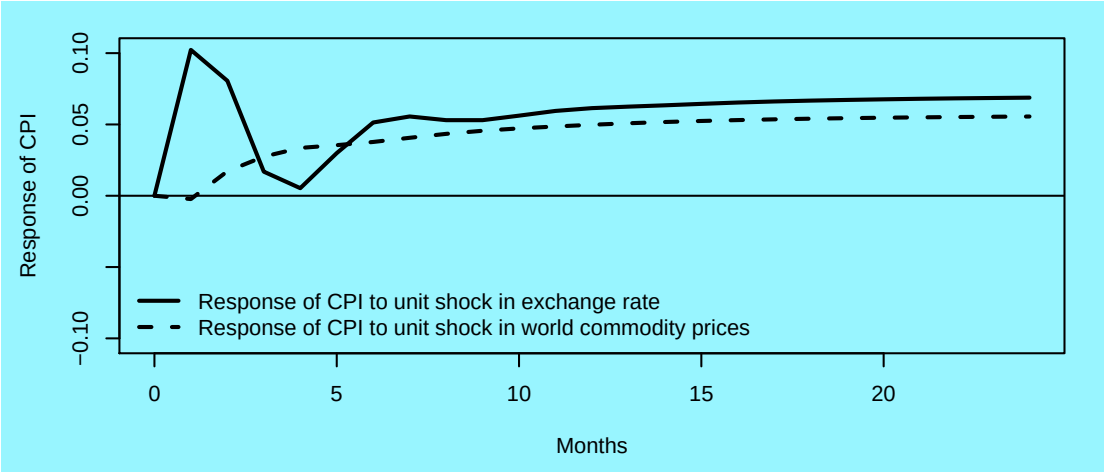


Figure 8 Impulse Response of CPI to 1 Percent Shock to Exchange Rate, World Commodity Price and Money Supply

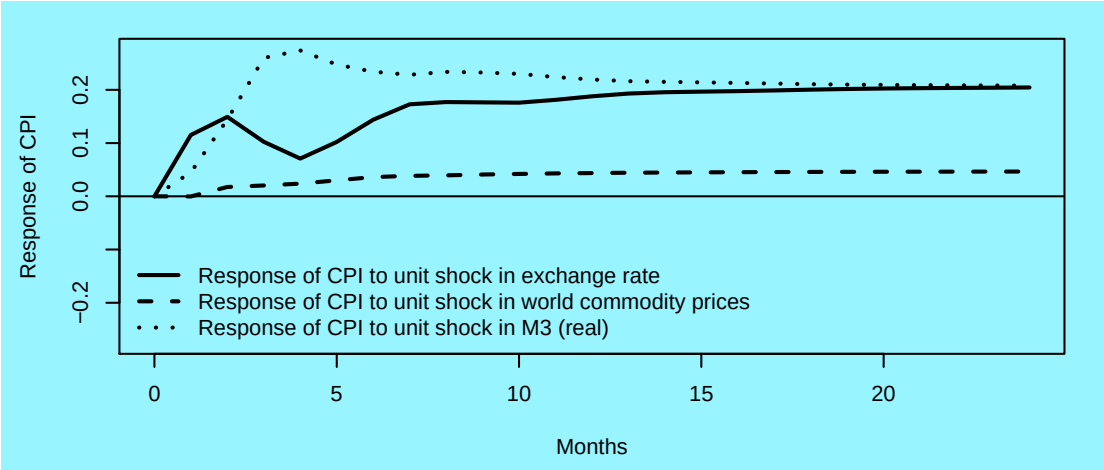
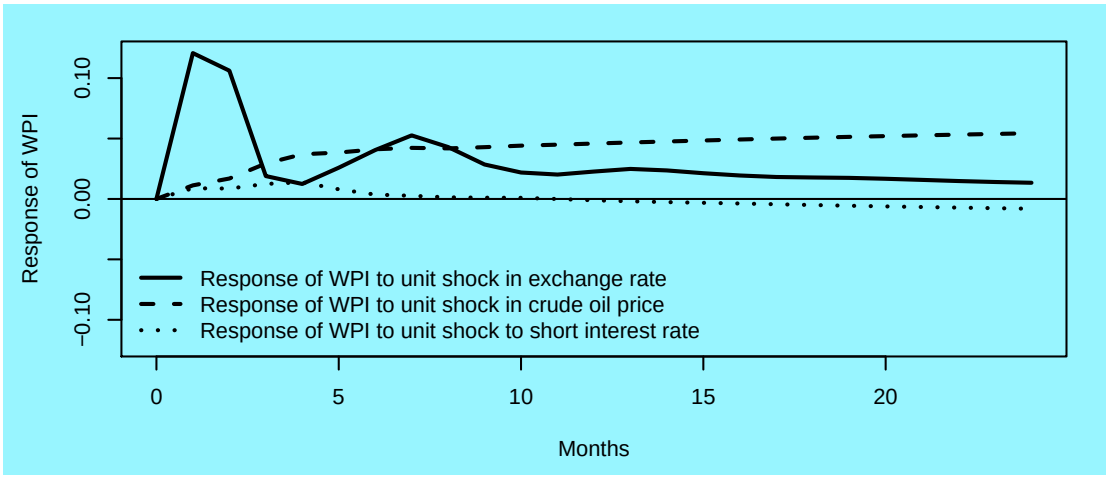


Figure 9 Impulse Response of WPI to 1 Percent Shock to Exchange Rate, Crude Oil Price and Interest Rate



two years, the effect is 20.7%. An increase in interest shows an immediate positive effect on WPI, but after two years the whole sale prices fall by -0.8% following a 100% increase in interest rate. These effects are on aggregate CPI and WPI.

An unanticipated change in the world commodity prices has an immediate negative effect on CPI but after two years it rises by 4.65-5.55% following a 100% shock in the world commodity prices. Moreover a 100% change in the crude oil prices leads to 5.4% change in WPI in the long run.

Figure 9 shows impacts on WPI due to one percent shock to exchange rate, crude oil peice and interest rate.

4.4 Variance decomposition results

The variance decomposition analysis is shown in the Table 4. It shows that exchange rate explains 0.9-7% variation in aggregate CPI and 1.6% variation in WPI in the long run, whereas the change in exchange rate explains 14% of variation in CPI inflation in the long run. Crude oil price explains most of the variations - around 50% of WPI.

5 Conclusions

This paper investigates the relationship between inflation and exchange rate in the post reform period in India. It finds that exchange rate pass-through into domestic prices in India is moderate. The long run pass through elasticity for CPI is 3.7-17%, while that for WPI is 28.6%. If effects of monetary policy are not taken into consideration, 10% of

Table 4 Variance Decomposition Results

Variables	Model 1		Model 2		Model 3		Model 4	
	CPI inflation		CPI		CPI		WPI	
	Next Period	2 years Ahead	Next Period	2 years Ahead	Next Period	2 years Ahead	Next Period	2 years Ahead
First Difference of exchange rate	0.0189	0.150						
Exchange rate				0.009		.074736		0.016
Crude oil price								0.522
World commodity price				0.076		0.050		
Real money supply						0.189		
Interest rate								0.006

exchange rate shock passes into the CPI index in the next period and falls to 6.8% after two years. If the effect of monetary policy is considered, then pass through effect on CPI rises from 11% in the next period to 20% in two years followed by a 100% shock to exchange rate. The immediate effect on WPI followed by a 100% exchange rate shock is around 12% which falls in two years to 1.3%.

Our finding are in line with the existing studies on ERPT estimates for India which find incomplete pass through for India. We also find that while crude oil price and world commodity price have moderate effects on WPI and CPI respectively, effect of fuel price on CPI is negligible. This finding is consistent with the fact that fuel prices are administered in India.

Table 5 DF-GLS Unit Root Test Results: variables in Level

Variables	DF-GLS		
	Ng-Perron (Lag)	SC (Lag)	MAIC (Lag)
Log of crude oil price	-3.920	-2.230	-2.063
Log of fuel price	-3.382	-1.294	-1.294
Log of world commodity price	-1.924	-1.250	-1.250
Log of WPI	-2.841	-2.896	-2.335
Log of CPI	-2.286	-2.591	-2.286
Log of exchange rate	-0.593	-0.026	-0.026
Log of IIP gap	-3.123	-4.608	-3.613
Log of Real money supply	-1.315	-1.225	-1.072
Log of interest rate		-1.338	-1.338

Table 6 ADF Unit Root Test Results: variables in Level

Variables	ADF		
	Ng-Perron (Lag)	SC (Lag)	MAIC (Lag)
Log of crude oil price	-1.599	0.032	0.095
Log of fuel price	-2.205	-1.427	-1.427
Log of world commodity price	-0.359	0.837	0.837
Log of WPI	-0.009	-0.779	-0.236
Log of CPI	1.426	-1.835	1.426
Log of exchange rate	-1.193	-2.891	-2.891
Log of IIP gap	-3.144	-4.919	-3.710
Log of real money supply	-0.488	-1.490	-1.546
Log of interest rate	-1.394	-1.270	-1.270

6 Appendix

In this appendix, unit root tests and co-integration test results are presented.

The critical values at 1%, 5% and 10% under ADF and PP tests are -3.503, -2.889 and -2.579 respectively. The critical value at 1% significance level under DF-GLS test is -3.555. Here *, ** and *** imply that the null of unit root is rejected at 10%, 5% and 1% levels respectively.

Table 7 PPerron Unit Root Test Results: variables in Level

Variables	PP		
	Ng-Perron (Lag)	SC (Lag)	MAIC (Lag)
Log of crude oil price	-0.237	-0.083	-0.050
Log of fuel price	-1.115	-1.273	-1.273
Log of world commodity price	0.596	0.846	0.846
Log of WPI	-0.494	-0.488	-0.492
Log of CPI	-1.537	-1.671	-1.537
Log of exchange rate	-2.682	-2.669	-2.669
Log of IIP gap	-9.159	-8.200	-8.491
Log of real money supply	-1.530	-1.247	-1.318
Log of interest rate	-1.259	-1.344	-1.344

Table 8 DF-GLS Unit Root Test Results: variables in First Difference

Variables	DF-GLS		
	Ng-Perron (Lag)	SC (Lag)	MAIC (Lag)
First Difference of log of crude oil price	-2.832**	-7.120***	-2.457
First Difference of log of fuel price	-1.001	-1.432	-0.772
First Difference of log of world commodity price	-3.260**	-5.381***	-2.508
First Difference of log of WPI	-2.026	-5.197***	-1.791
First Difference of log of CPI	-5.634***	-7.897***	-6.600***
First Difference of log of exchange rate	-2.416	-5.404***	-2.416
First Difference of log of IIP gap	-3.190**	-11.291***	-3.038**
First Difference of log of real money supply	-3.032**	-10.267***	-2.863**
First Difference of log of interest rate		-7.528***	-3.272**

Table 9 ADF Unit Root Test Results: variables in First Difference

Variables	ADF		
	Ng-Perron (Lag)	SC (Lag)	MAIC (Lag)
First Difference of log of crude oil price	-3.973***	-8.035***	-2.743 *
First Difference of log of fuel price	-1.871	-2.571*	-1.553
First Difference of log of world commodity price	-3.802***	-7.644***	-2.679*
First Difference of log of WPI	-3.852***	-8.411***	-2.786*
First Difference of log of CPI	-5.538***	-7.747***	-6.284***
First Difference of log of exchange rate	-2.350	-6.169***	-2.350
First Difference of log of IIP gap	-3.545***	-11.650***	-3.986***
First Difference of log of real money supply	-2.552*	-10.195***	-2.929**
First Difference of log of interest rate	-11.882***	-8.851***	-2.722*

Table 10 PPerron Unit Root Test Results: variables in First Difference

Variables	PP		
	Ng-Perron (Lag)	SC (Lag)	MAIC (Lag)
First Difference of log of crude oil price	-10.774***	-10.644***	-10.708***
First Difference of log of fuel price	-8.958***	-8.446***	-8.846***
First Difference of log of world commodity price	-10.476***	-10.186***	-10.410***
First Difference of log of WPI	-8.238***	-8.454***	-8.231***
First Difference of log of CPI	-7.472***	-7.477***	-7.358***
First Difference of log of exchange rate	-7.075***	-6.975***	-7.075***
First Difference of log of IIP gap	-28.804***	-20.784***	-29.685***
First Difference of log of real money supply	-17.768***	-17.122***	-17.554***
First Difference of log of interest rate	-11.985***	-11.888***	-11.931***

Table 11 Johansen test for co-integration

Maximum Rank	Trace Statistics					
	Model 2	5% Critical Value	Model 3	5% Critical Value	Model 4	5% Critical Value
0	70.4745	47.21	76.1218	68.52	74.2842	68.52
1	28.1892**	29.68	43.7583**	47.21	41.8060**	47.21
2	10.7472	15.41	25.7647	29.68	19.1298	29.68
3	3.5869	3.76	12.5059	15.41	6.3306	15.41
4			2.5584	3.76	0.5760	3.76
5						

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