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Macroeconomic Determinants of Exchange Rate Pass-Through in India?

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Abstract

This paper examines the evolution of exchange rate pass-through (ERPT) into India's consumer price index (CPI) at the aggregate level over the period 1980Q1-2006Q4. It also investigates whether the extent of exchange rate pass-through is impacted by common macro fundamentals such as inflation and exchange rate volatility. Finally, the paper also tests for possible asymmetries of ERPT during periods of depreciation versus appreciation.

Keywords: Exchange rate pass-though (ERPT), Exchange rate volatility, India, Inflation.

JEL classification: *E31, F31, F41, O53.*

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1. Introduction

While India has been one of the fastest growing economies in the world over the last decade, policymakers are constantly vigilant about signs of overheating and consequent build-up of inflationary pressures in the economy. This paper focuses narrowly on the question of whether exchange rate pass-through (ERPT) into India's consumer price index (CPI) has changed over the period 1980Q1-2006Q4 and its possible macroeconomic determinants.

Section 2 develops the empirical framework to be estimated and discusses the data to be used and preliminary time series tests for stationarity. Section 3 undertakes the dynamic estimates of India's exchange rate pass-through over time. Section 4 investigates whether ERPT is endogenous to certain macro variables, including inflation and exchange rate volatility. Section 5 also examines whether there are asymmetries in ERPT, i.e. does the extent of pass-through differ during periods of appreciation versus depreciation? The final section concludes the paper.

2. Data and Methodology

2.1 Empirical Framework

We consider exchange rate pass-through using the bilateral-US dollar exchange rate. Specifically, following Ghosh and Rajan (2007), the extent of exchange rate pass-through into India's aggregate CPI is estimated for the bilateral USD rates as follows.

$$\ln(CPI)^{India} = \alpha_0 + \alpha_1 \ln(E_{US}^{India}) + \alpha_2 \ln(PPI/CPI)^{US} + \alpha_3 \ln(IP)^{India} + \varepsilon_t \qquad (1)$$

where: E_{US}^{India} is the bilateral exchange rate defined as the number of units of the Indian rupee per unit of the US dollar. We control for shifts in aggregate demand in India by using the overall industrial production index of India (quarterly GDP data for India was not available). For cost conditions in the exporting nation we use the PPI in the US. For an alternate specification we use the US CPI. The ERPT elasticity is given by the co-efficient α_1. If α_1 =1 then we have complete pass-through, while if α_1 < 1 we have less than full pass-through.

We also estimate ERPT for India's nominal effective exchange rate (NEER). Here we use the world CPI as a proxy for overall or the rest of the world's exporters' costs.

$$\ln(CPI)^{India} = \delta_0 + \delta_1 \ln(NEER)^{India} + \delta_2 \ln(CPI)^{World} + \delta_3 \ln(IP)^{India} + \upsilon_t \qquad (2)$$

2.2 Data and Stationarity Tests

Data on India's CPI, bilateral dollar exchange rate, US PPI, and India's IP, world CPI are sourced from the *International Financial Statistics*. NEER data is taken from the *Reserve Bank of India* (RBI). All variables are seasonally adjusted by using the Census X-12 methodology. The data spans from 1980Q1-2006Q4.

In order to ascertain to what degree the variables share univariate integration properties we start by conducting tests for stationarity in the variables in eqs. (1) and (2) using both the augmented Dickey-Fuller (ADF) test as well as the Phillip-Perron test (Table 1a). Both tests fail to reject the null hypothesis of unit root in the variables in their level form, suggesting that they are stationary in their first differenced form. Given that the variables are *I(1)* we next test for co-integration among the variables both in eqs. (1)

and (2) using the methodology developed by Johansen and Juselius (1990). Evidence of co-integration among variables rules out the possibility of the estimated relationship being spurious. The Johansen procedure involves identification of rank of a *m* by *m* matrix $\prod$ with the following specification:

$$\Delta X_t = \delta + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \prod X_{t-k} + \varepsilon_t \qquad (3)$$

X_t is a column vector of the m variables. Γ and $\prod$ represent coefficient matrices. Δ is a difference operator. *k* denotes the lag length. δ is a constant. If $\prod$ has zero rank, there is no linear combination of the variables, i.e. the variables are non-cointegrated. If the rank r of $\prod$ is greater than zero then the variables in eq. (1) are co-integrated. The results for co-integration for ERPT are shown in Table 1(b). The results indicate the presence of a co-integrating relationship for most cases.

3. Evolution of ERPT Elasticities

We next obtain ERPT elasticities by using the dynamic OLS (DOLS) method developed by Stock and Watson (1993). This procedure involves regressing any variable with the regressors itself but also the leads and lags of the first differences of the regressors. By including the lagged and lead values of the changes in the regressors it corrects for potential simultaneity bias and small sample bias among the regressors.

3.1 Point Estimates

The empirical estimating version of eq. (1) is:

$$\ln(CPI)_t^{India} = B' X_t + \sum_{j=-1}^{j=+1} \eta_j \Delta \ln(E_{US}^{India})_{t-j} + \sum_{j=-1}^{j=+1} \lambda_j \Delta \ln(PPI^{USA})_{t-j} + \sum_{j=-1}^{j=+1} \gamma_j \Delta \ln(IP^{INdia})_{t-j} + \zeta_t \quad (4)$$

where: $B = [\alpha_0, \alpha_1, \alpha_2, \alpha_3]'$, $X = [(1, \ln(E_{US}^{India}), \ln(PPI^{USA}), \ln(IP^{India})]$.

We use the same methodology for eq. (2) as well. The results shown in Table 2 use upto one period lag and lead of variables. For the USD, we find ERPT of 45 percent when we use the US PPI as exporter's costs while the elasticity is 49 percent when US CPI is used. For India's NEER we do not find any evidence of ERPT.

3.2 Recursive Estimates

Since we are interested in how and why ERPT elasticities in India change over time we undertake dynamic estimations of ERPT using the recursive least squares methodology. This methodology adds one data point to the sample and plots the estimates over the time. The recursive ERPT elasticities for USD and NEER are shown in Figures 1 and 2, respectively. For India's NEER, ERPT elasticities are also plotted, albeit insignificant. The initial fluctuation in ERPT elasticities is due to lack of sufficient data points in estimation. In both cases we do not find any evidence of declining pass-through over time. This is at odds with the findings for industrial countries which seems to suggest that ERPT has been declining over time (see Campa and Goldberg, 2005).

4. Macroeconomic Factors Affecting ERPT

Having estimated the evolution of ERPT, we next explore its possible macroeconomic determinants.

Following Taylor (2000), it is generally believed that ERPT rates are endogenous to a nation's monetary policy and monetary stability, i.e. the more stable is a country's monetary policy and the lower its inflation the lower will be the extent of ERPT. This thesis has been confirmed by Gagnon and Ihrig (2004) using macro level data for industrial countries as well as by Choudri and Hakura (2006), and others. In related work, Devereux and Engel (2003) argues that if exporters set their prices in the currency of the country that has stable monetary policy (i.e. local currency pricing as opposed to producer currency pricing) then ERPT into import prices in local currency terms will be low for countries with low monetary and exchange rate variability.

While the impact of monetary policy variability on ERPT is generally accepted, the impact of exchange rate variability is less certain. For instance, Froot and Klemperer (1989) contend that ERPT is low when nominal exchange rate volatility is high and exporters try to preserve market share. They view exchange rate volatility as temporary fluctuations in exchange rates in any one direction. So exporters absorb these shocks in their mark-ups and profit margins.

With this as background and given the lack of evidence of ERPT in India's NEER, we limit our focus on ERPT using the bilateral US dollar rate. We test for the role of these macroeconomic variables by regressing the time varying ERPT elasticities obtained from the recursive estimations on money supply growth, inflation rates and exchange rate volatility.

$$\hat{\alpha}_1^i = \delta' x_t \tag{6}$$

where $\delta = [\delta_0, \delta_1, \delta_2,]$, x_t=*[money supply growth, lagged inflation rate, exchange rate volatility]*. For money supply growth we used the percentage rate of change of M2 and for inflation rate we use percentage change of CPI. We capture exchange rate volatility by using a moving average standard deviation of the exchange rate series, $V = \left[(1/m) \sum_{i=1}^{m} (\log E_{t+i-1} - \log E_{t+i-2})^2 \right]^{1/2}$ with $m = 4$ is the number of lags and E = exchange rate (using US dollars). We use the percentage change in CPI as a proxy for inflation.

Table 3 presents the results for ERPT of the bilateral US dollar rate where the ERPT elasticities are obtained using both the US PPI and CPI as proxies for the foreign exporter's costs. On trying various combinations of the three macro variables, we fail to find any statistically significant impact of money growth or lagged inflation rate on ERPT. However, exchange rate volatility is consistently found to have a negative impact on ERPT. This finding is robust to when we used various lagged structures of the independent variables.[1]

5. Are there Asymmetries in EPRT

The existing literature suggests that the response of exporters to exchange rate changes is often asymmetric, depending on whether the exchange rate appreciates or depreciates. A weakening of the destination market's currency causes the exporter to reduce its export price and keep the importing nation's product price more or less stable,

consequently implying lower ERPT. However, when the exporters' currency depreciates, exports become relatively cheaper in the destination market. This may create an incentive for exporters to maintain their export prices or, in some cases, even to reduce their own currency price and amplify the impact of their currency depreciation (so as to gain market share), leading to a higher ERPT (Madhavi 2002).

In order to test for EPRT during periods of depreciations and appreciations we construct two dummies:

D_t = 1 when $\Delta \ln E_{US}^{India}$ >0, 0 otherwise.

A_t = 1 when $\Delta \ln E_{US}^{India}$ <0, 0 otherwise.

We use an error-correction form of eq.(1) and interact the dummy variables with $\Delta \ln(E_{US}^{India})_t$.

$$\Delta \ln(CPI)_t^{India} = \beta_0 + \sum_{j=1}^{j=k} \phi_j \alpha_1 \ln(CPI)_{t-j}^{India} + \sum_{j=0}^{j=l} \eta_j \Delta \ln(E_{US}^{India})_{t-j} + \sum_{j=0}^{j=m} \lambda_j \Delta \ln(PPI)_{t-j}^{US} + \sum_{j=0}^{j=n} \gamma_j \Delta \ln(IP)_{t-j}^{India} + \sum_{j=1}^{r} \beta_j [\ln(P_i^B)_{t-1} - B' X_{t-1}] + \varepsilon_t \quad (5)$$

The results are shown in Table 4. An appreciation of the rupee against the USD leads to ERPT of 26 to 28 percent, while depreciations lead to ERPT of 12 percent. For NEER appreciations lead to ERPT of 15 percent and depreciations of 9 percent. The relatively lower EPRT into Indian CPI when the Rupee depreciates compared to when it appreciates, is consistent with the priors discussed previously.

6. Conclusion

This paper estimates the evolution of exchange rate pass-through into India's CPI for over the period 1980Q1 to 2006Q4 and its macroeconomic determinants. We find the exchange rate pass-through elasticity of the rupee-USD to be between 45 and 50 percent and quite stable over the period under consideration. Moreover we conducted dynamic ERPT elasticities using the Rupee-USD rate and examined the impact of common macroeconomic variables on the elasticities. We find that exchange rate volatility is the only variable that consistently has a negative effect on ERPT elasticities.

This is an important finding as one reason cited for the "fear of floating" is that small and open economies are relatively more susceptible to exchange rate pass-through effects into domestic prices. However, our results suggest that exchange rate pass through may be endogenous to the degree of flexibility of the exchange rate regime itself. Low exchange rate pass through implies that small and open economies may be less concerned about the potential inflationary consequences of exchange rate fluctuations, suggesting there is less reason to fear floating.

NOTES

1. We also tried with lags of the variables as well as volatility of money growth and inflation rate. The results were found to be insignificant other than exchange rate volatility. They are available on request.

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Table 1(a): Unit root test results

	ADF stat. Levels	5% critical value	ADF stat. 1st difference	5% critical value		P-P stat. Levels	5% critical value	P-P stat. 1st difference	5% critical value
LCPIINDI	-0.049	-3.453	-7.712	-3.453	LIMPR	0.331	-3.453	-7.747	-3.453
LEXRT	-0.326	-3.453	-7.277	-3.453	LEXRT	0.197	-3.452	-7.106	-3.453
LNEER	-2.140	-3.454	-10.614	-3.454	LNEER	-2.290	-3.454	-10.612	-3.454
LIPINDIA	-2.311	-3.453	-14.168	-3.453	LIPINDIA	-3.216	-3.453	-13.911	-3.453
LPPIUSA	-2.625	-3.453	-6.520	-3.453	LPPIUSA	-2.511	-3.452	-6.397	-3.453
LCPIUSUA	-2.825	-3.453	-6.856	-3.453	LCPIUSUA	-4.221	-3.452	-6.833	-3.453
LCPIWORLD	-0.182	-3.455	-2.493	-3.455	LCPIWORLD	0.921	-3.453	-2.817	-3.453

L denotes log operator, while Δ denotes first-difference. EXRT = USD-bilateral rate; NEER = India's nominal effective exchange rate; IPINDIA = industrial production index of India; PPIUSA = US PPI; CPIUSA = US CPI; CPIWORLD = world CPI.

Table 1(b): Johansen Co-integration results

	Trace statistic				Maximum Eigenvalue statistic			
	r=0	r=1	r=2	r=3	r=0	r=1	r=2	r=3
Specification 1*	37.019	14.291	4.805	0.475	22.728	9.486	4.330	0.475
Specification 2	48.706	19.196	6.295	0.561	29.510	12.900	5.735	0.561
Specification 3	65.720	27.621	7.067	2.710	38.100	20.553	4.357	2.710
5% critical value	47.856	29.797	15.495	3.841	27.584	21.132	14.265	3.841

*Specification 1 uses US PPI; Specification 2 uses US CPI as foreign exporter's cost; Specification 3 is for India's NEER.

Table 2: Dynamic OLS (DOLS)

	Specification 1	Specification 2	Specification 3
C	0.228	0.929	**0.468***
	0.446	0.612	0.269
LEXRT	**0.446*****	**0.485*****	
	0.026	0.040	
LNEER			0.033
			0.037
LPPIUSA	-0.139		
	0.145		
LCPIUSA		**-0.427***	
		0.231	
LCPIWORLD			**0.352*****
			0.038
LIPINDIA	**0.721*****	**0.830*****	**0.516*****
	0.062	0.075	0.075
$\Delta LEXRT_{(t-1)}$	**-0.274*****	**-0.261*****	0.013
	0.084	0.077	0.026
$\Delta LEXRT_{(t+1)}$	**0.155****	**0.226*****	**0.071****
	0.072	0.071	0.034
$\Delta LPPIUSA_{(t-1)}$	0.014	-0.779	**-1.465*****
	0.228	0.643	0.356
$\Delta LPPIUSA_{(t+1)}$	-0.234	**-2.501*****	-0.395
	0.213	0.777	0.384
$\Delta LIP_{(t-1)}$	-0.055	-0.072	**-0.226***
	0.124	0.113	0.130
$\Delta LIP_{(t+1)}$	**0.381*****	**0.438*****	0.176
	0.081	0.072	0.107
Adj. R^2	0.998	0.998	0.997

Terms below co-efficient denote standard errors. *, **,*** indicates significance at the 10%, 5%, 1% levels. L denotes log operator, while Δ denotes first-difference. L denotes log operator, while Δ denotes first-difference. EXRT = USD-bilateral rate; NEER = India's nominal effective exchange rate; IPINDIA = industrial production index of India; PPIUSA = US PPI; CPIUSA = US CPI; CPIWORLD = world CPI.

Figure 1: Recursive OLS estimates USD ERPT elasticities into India's CPI

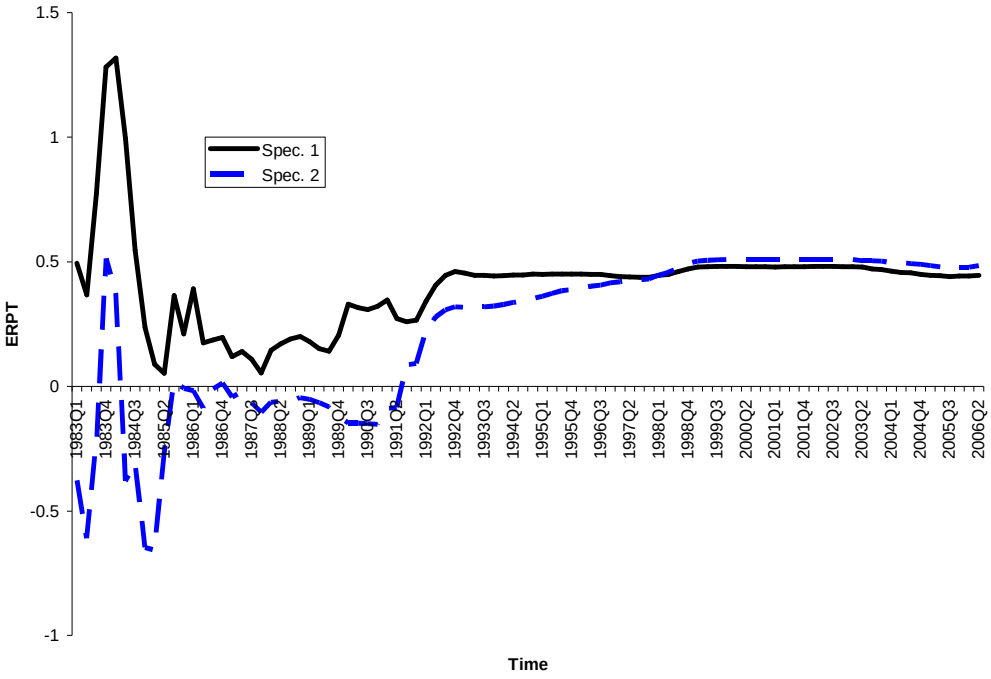

Figure 2: Recursive OLS estimates NEER ERPT elasticities into India's CPI

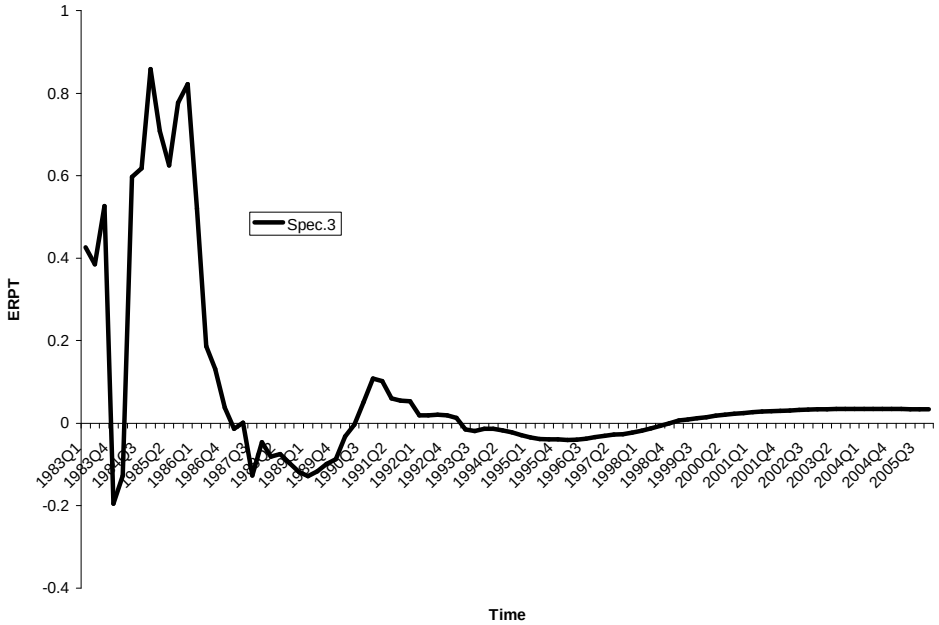

Table 3a: Effect of Macro variables on Recursive ERPT elasticities of US dollar: US PPI as Foreign Exporters' Costs

C	**0.427*** **	**0.422*** **	**0.483*** **	**0.418*** **	**0.470*** **	**0.467*** **	**0.457*** **
	0.037	0.041	0.058	0.035	0.045	0.047	0.038
Money growth	0.002			0.001	0.004		0.003
	0.008			0.008	0.008		0.008
Inflation rate$_{(t-1)}$		0.006		0.006		0.010	0.010
		0.013		0.012		0.013	0.013
USD volatility			**-1.746****		**-1.796****	**-1.867****	**-1.901****
			0.688		0.727	0.795	0.823
Adj. R^2	-0.010	-0.009	0.006	-0.019	-0.003	-0.001	-0.011

Terms below co-efficient denote standard errors. *, **,*** indicates significance at the 10%, 5%, 1% levels.

Table 3b: Effect of Macro variables on Recursive ERPT elasticities of US dollar: US CPI as Foreign Exporters' Costs

C	**0.296*** **	**0.312*** **	**0.335*** **	**0.315*** **	**0.336*** **	**0.349*** **	**0.348*** **
	0.028	0.029	0.033	0.030	0.033	0.032	0.032
Money growth	-0.002			-0.001	0.000		0.001
	0.003			0.003	0.003		0.003
Inflation rate$_{(t-1)}$		-0.012		-0.012		-0.009	-0.009
		0.008		0.008		0.007	0.008
USD volatility			**-1.667*** **		**-1.665*** **	**-1.562*** **	**-1.568*** **
			0.553		0.556	0.565	0.564
Adj. R^2	-0.008	0.018	0.087	0.009	0.078	0.092	0.083

Terms below co-efficient denote standard errors. *, **,*** indicates significance at the 10%, 5%, 1% levels.

Table 4: ERPT during Appreciation versus Depreciation

	Spec. 1		Spec. 2		Spec.3	
C	**0.012*** **	**0.009*** **	**0.010*** **	**0.007*** **	**0.010*** **	**0.007*** **
	0.003	0.003	0.003	0.002	0.002	0.002
$ECM_{(t-1)}$	**-0.124*** **	**-0.125*** **	**-0.116*** **	**-0.115*** **	**-0.076*** **	**-0.073*** **
	0.045	0.045	0.039	0.038	0.022	0.023
APPR_EXRT	**0.278*** **		**0.253** **		**0.154***	
	0.098		0.100		0.092	
DEPR_EXRT		**0.115*** **		**0.106*** **		**0.088*** **
		0.027		0.029		0.025
$\Delta(LPPIUSA)_t$	-0.040	-0.023				
	0.101	0.093				
$\Delta(LCPIUSA)_t$			0.230	0.201		
			0.163	0.161		
$\Delta(LCPIWORLD)_t$					**0.145** **	**0.140** **
					0.065	0.062
$\Delta(LIPINDIA)_t$	0.063	0.081	0.056	0.073	0.027	0.039
	0.051	0.055	0.052	0.054	0.054	0.056
$\Delta LCPI_{(t-1)}$	**0.359*** **	**0.365*** **	**0.352*** **	**0.355*** **	**0.276*** **	**0.278*** **
	0.091	0.089	0.069	0.073	0.075	0.078
Adj. R^2	0.190	0.242	0.203	0.249	0.243	0.282
F-stat.	**5.871*** **	**7.653*** **	**6.311*** **	**7.899*** **	**7.625*** **	**9.094*** **

Terms below co-efficient denote standard errors. *, **,*** indicates significance at the 10%, 5%, 1%. levels. L denotes log operator, while Δ denotes first-difference. EXRT = USD-bilateral rate; NEER = India's nominal effective exchange rate; IPINDIA = industrial production index of India; PPIUSA = US PPI; CPIUSA = US CPI; CPIWORLD = world CPI. APPR_EXRT denotes the extent of appreciation during appreciation periods, zero otherwise; DEPR_EXRT denotes the extent of depreciation during appreciation periods, zero otherwise.