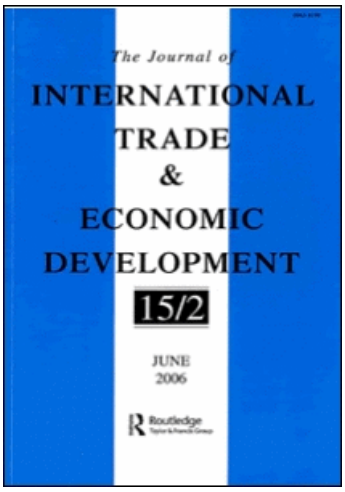

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How High is Exchange Rate Pass-Through in India? Has it Changed over Time?

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ABSTRACT *Concerns about relatively high degrees of exchange rate pass-through in a number of emerging economies have contributed to a fear of floating. Despite the obvious policy relevance of this issue there is hardly any existing literature that has examined aggregate CPI pass-through for India, which has been liberalizing its economy since 1991. This paper estimates exchange rate pass-through (ERPT) at the aggregate level into India's CPI for the period 1980Q1–2005Q3. We also analyze whether exchange rate pass-through in India has changed over time, particular since 1991, which was the beginning of the country's economic liberalization program.*

KEY WORDS: Exchange rate pass-though, fear of floating, India, inflation, NEER

Introduction

One of the perennial concerns for liberalizing economies such as India is the extent of pass-through of currency changes into domestic inflation. Concerns about relatively high degrees of exchange rate pass-through in a number of emerging economies have contributed to a fear of floating (Goldfajn & Olivares, 2001). Despite the obvious policy relevance of this issue, there is hardly any existing literature examining aggregate CPI pass-through for India, which has been liberalizing its economy since 1991. This paper fills this void in the literature by estimating pass-through for India from 1980 to 2005. We also analyze whether exchange rate pass-through in India has changed over time, particularly since 1991, which was the beginning of the country's economic liberalization program.

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The paper is organized as follows. The next section presents the empirical framework and estimation equation to be used. The section after presents the data and the results for the estimates of exchange rate pass-through for India. The final section concludes the paper.

Empirical Framework

We consider the law of one price in absolute terms. A commodity Y that is exported by country B to country A.

$$P_Y^A = E_B^A P_Y^B \tag{1}$$

where E_B^A is the exchange rate between the two nations defined as A's currency over B's currency, while P_Y^A, P_Y^B are prices of the exportable Y in each nation's domestic currency respectively. Taking total differentials of equation (1) we have,

$$\mathrm{d}P_Y^A = \mathrm{d}E_B^A + \mathrm{d}P_Y^B \tag{2}$$

If $\mathrm{d}P_Y^B = 0$ then the change in exchange rate is fully transmitted into A's import prices and there is full exchange rate pass-through. However, if $\mathrm{d}P_Y^B \neq 0$ then the change in the exchange rate is not fully transmitted into A's currency price of good Y and we have a case of incomplete pass-through.

In order to operationalize equation (2) it needs to be augmented by proper control variables. The primary control variables are the cost conditions in the exporting nation's market and demand conditions in the importing nation's market. We consider exchange rate pass-through using both the bilateral – US dollar exchange rate as well as the nominal effective exchange rates (NEER). Specifically, the extent of exchange rate pass-through into India's aggregate CPI is estimated for the bilateral USD rates and the NEER as follows.

$$\ln(CPI)^{India} = \alpha_0 + \alpha_1 \ln(E_{US}^{India}) + \alpha_2 \ln(PPI)^{US} + \alpha_3 \ln(IP)^{India} + \varepsilon_t \tag{3}$$

$$\ln(CPI)^{India} = \delta_0 + \delta_1 \ln(NEER)^{India} + \delta_2 \ln(CPI)^{World} + \delta_3 \ln(IP)^{India} + \varepsilon_t \tag{4}$$

Note that we control for shifts in aggregate demand in India by using the overall industrial production index of India (quarterly GDP data for India were not available). For cost conditions in the exporting nation we use two alternate measures, namely the US PPI and the CPI in equation (3), while for estimation of the NEER pass-through equation (4) we use the aggregate CPI of the world to proxy for cost conditions of the exporters. The exchange rate pass-through elasticity is given by the coefficient $\alpha_1 = 1$ then we have

complete exchange rate pass-through, while if $\alpha_1 < 1$ we have less than full pass-through.

Empirics

Data

Data on India's CPI, bilateral dollar exchange rate, US CPI, US PPI, and India's index of industrial production are all sourced from *International Financial Statistics*. Data on India's NEER is taken from the *Reserve Bank of India*. All variables are seasonally adjusted by using the Census X-12 methodology. The data for India spans 1980Q1 – 2005Q3.

Exchange Rate Pass-Through: Entire Sample

We start by testing for the presence of unit root in the variables. We use both the augmented Dickey – Fuller and Phillip – Perron tests to detect for stationarity in the variables. The unit root test results are shown in Table 1(a).[1] The variables are found to be non-stationary in their level form, but were found to be stationary in their first-differenced form, i.e. they were I(1). Next we tested for cointegration among the variables in equation (3) using the Johansen and Juselius (1990) methodology. Cointegration among the variables enables us to run the regression in level form. The cointegration results are presented in Table 1(b). We test for cointegration for the entire sample period as well as for two sub-samples: 1980Q1 – 1990Q4 and 1992Q1 – 2005Q3. As Table 1(b) shows, here is evidence of the presence of a cointegration vector among the variables in the estimation equation for India. This confirms the presence of a long-run stable linear

Table 1(a). Unit root rest 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*
Lcpi	0.245	−3.455	−7.514	−3.455	0.572	−3.455	−7.584	−3.455
Lexrt	−0.441	−3.455	−6.915	−3.455	0.324	−3.454	−6.740	−3.455
Lneer	−2.109	−3.454	−10.497	−3.455	−2.259	−3.454	−10.495	−3.455
Lppiusa	−2.766	−3.455	−5.876	−3.455	−2.963	−3.454	−5.876	−3.455
Lcpiusa	−3.005	−3.455	−6.618	−3.455	−4.146	−3.454	−6.618	−3.455
Lipindia	−2.297	−3.455	−14.145	−3.455	−3.186	−3.454	−13.895	−3.455
Lcpiw	−0.190	−3.457	−2.428	−3.457	1.051	−3.454	−2.752	−3.455

*tests are conducted using the trend and intercept. Automatic lag length selection on the basis of AIC criteria.

Lcpi = consumer price index of India, *lexrt* = bilateral nominal rupee-dollar exchange rate, *lneer* = nominal effective exchange rate of India, *lppiusa* = producer price index of the US, *lcpi* = consumer price index of the US, *lipindia* = industrial production index of India. *Lcpiw* = aggregate consumer price index of the world.

Table 1(b). Cointegration results for India

		Trace statistic				*Maximum eigenvalue statistic*			
		r = 0	*r = 1*	*r = 2*	*r = 3*	*r = 0*	*r = 1*	*r = 2*	*r = 3*
Full-Sample	Spec.1	30.051	11.115	2.460	0.047	18.936	8.655	2.413	0.047
Full-Sample	Spec.2	48.391[a]	25.957	9.213	2.610	22.434	16.744	6.602	2.610
Full-Sample	Spec.3	65.714[a]	27.835	9.856	2.538	37.879[a]	17.979	7.317	2.538
1980Q1 – 1990Q4	Spec.1	63.054[a]	32.550[b]	13.835	0.933	30.503[a]	18.715	12.902	0.933
1980Q1 – 1990Q4	Spec.2	57.021[a]	26.631	7.603	0.153	30.390[a]	19.029	7.450	0.153
1980Q1 – 1990Q4	Spec.3	55.021[a]	26.985	9.084	4.139[d]	28.035[a]	17.902	4.945	4.139[d]
1992Q1 – 2005Q3	Spec.1	49.293[a]	21.063	6.306	1.334	28.230[a]	14.757	4.973	1.334
1992Q1 – 2005Q3	Spec.2	55.075[a]	27.296	10.933	3.051	27.779[a]	16.363	7.882	3.051
1992Q1 – 2005Q3	Spec.3	94.324[a]	49.480[b]	18.317[c]	0.592	44.844[a]	31.163[b]	17.726[c]	0.592
	5% critical value	47.856	29.797	15.495	3.841	27.584	21.132	14.265	3.841

r – denotes the number of cointegrating equations.

a – denotes presence of 1 cointegrating equation; b – denotes presence of 2 cointegrating equations; c – denotes presence of 3 cointegrating equations; d – denotes presence of 4 cointegrating equations.

The cointegration tests are preformed at a lag length of 4. The sensitivity of the tests to different lag lengths is also performed and is found to be insensitive to the lag length.

relationship among the variables. As such, we run the regression in levels. The results are shown in Table 2.

We find exchange rate pass-through elasticity into India's CPI for the entire sample period (1980 – 2005) to be 43 per cent when we use the US PPI as a measure of foreign costs, while the elasticity is 41 per cent when we use the US CPI. This implies that a 1 per cent change in the rupee – dollar rate will lead to around 0.4 per cent increase in the CPI of India. We also estimated pass-through elasticity from India's NEER into the CPI. Here we find a statistically insignificant coefficient for the NEER, implying lack of any evidence of pass-through.

We also examined short-run pass-through of exchange rate changes into India's CPI by using the error correction (ECM) forms of equations (3) and (4):

$$\Delta \ln(CPI)_t^{India} = \beta_0 + \beta_1 (ECM)_{t-1} + \beta_2 \Delta \ln(E_{US}^{India})_t + \beta_3 \Delta \ln(PPI)_t^{US} + \beta_4 \Delta \ln (IP)_t^{India} + \beta_5 \Delta \ln(CPI)_{t-1}^{India} + \varepsilon_t \quad (5)$$

$$\Delta \ln(CPI)_t^{India} = \gamma_0 + \beta_1 (ECM)_{t-1} + \gamma_2 \Delta \ln (NEER)_t^{India} + \gamma_3 \Delta \ln(CPI)_t^{W} + \gamma_4 \Delta \ln (IP)_t^{India} + \gamma_5 \Delta \ln(CPI)_{t-1}^{India} + \varepsilon_t \quad (6)$$

Table 2. Level regression results for India

	Full-Sample			*1980Q1–1990Q4*			*1992Q1–2005Q3*		
	Spec.1	*Spec.2*	*Spec.3*	*Spec.4*	*Spec.5*	*Spec.6*	*Spec.7*	*Spec.8*	*Spec.9*
C	−0.149	−0.661	−0.069	−1.242	**−3.032*****	0.634	1.012	0.098	**0.518*****
	0.555	0.536	0.258	1.031	0.579	1.136	0.715	1.263	0.309
Lexrt	**0.432*****	**0.410*****		**0.368*****	0.019		**0.381*****	**0.497*****	
	0.030	0.052		0.136	0.107		0.065	0.067	
Lneer			0.064			0.154			−0.103
			0.047			0.138			0.070
Lppiusa	−0.036			0.296			−0.393		
	0.167			0.268			0.205		
Lcpiusa		0.149			**1.115*****			−0.167	
		0.202			0.236			0.452	
Lcpiw			**0.313*****			**0.518*****			**0.468*****
			0.04			0.087			0.158
Lip	**0.712*****	**0.656*****	**0.634*****	**0.658*****	**0.477*****	0.176	**0.860*****	**0.738*****	**0.519*****
	0.059	0.066	0.076	0.134	0.086	0.215	0.089	0.162	0.162
Adj. R^2	0.998	0.998	0.998	0.985	0.993	0.992	0.993	0.992	0.983
N	103	103	103	44	44	44	55	55	55

Terms below coefficients denote standard errors. ***, **,*indicate statistical significance at 1%, 5%, and 10%, respectively.

The ECM results are shown in Table 3. The error-correction term suggests that any deviation from the long-run equilibrium relationship is adjusted by about 13 to 12 per cent in the short-run. The short-run exchange rate pass-through elasticity is found to be 10 and 9 per cent, respectively, for the two specifications over the entire sample period. For the NEER we once again do not find any significant pass-through.

Exchange Rate Pass-Through Pre and Post Liberalization

Since the Indian economy undertook a set of market-oriented reforms following the balance of payments crisis in 1991 we re-estimated exchange rate pass-through for two sub-periods, namely 1980Q1 – 1990Q4 and 1992Ql – 2005Q3.[2] For the pre-liberalization period we find an exchange rate pass-through elasticity of 37 per cent when we use US PPI, while we do not find any significant pass-through when we use the US CPI as a control. This is consistent with the general literature that finds relatively lower pass-through into CPI.

For India's NEER, once again we do not find any significant pass-through. For the post-liberalization period, the pass-through elasticities for specifications using the US PPI and CPI are 38 and 50 per cent, respectively, while for NEER there is no evidence of pass-through. These results indicate that, at the macro level, there is evidence of a slightly higher exchange rate pass-through for the post-liberalization era, which is consistent with greater openness of the country to external influences. However, the ECM results reveal no evidence of short-run pass-through for either the bilateral USD-rupee rate or the NEER for either of the two sub-samples (compared with about 10 per cent for the entire period using the bilateral USD – rupee rate).

Exchange Rate Pass-Through over Time

It might well be argued that the liberalization program in India has not been a 0 or 1 situation. In other words, while Indian reforms were initiated in 1991, the reform program itself is an ongoing one characterized by gradualism (for instance, see Ahluwalia, 2002; Rajan & Sen, 2002). Accordingly, it may be more insightful to consider dynamic changes in exchange rate pass-through over time.[3]

To this end we perform dynamic estimates of exchange rate pass-through by using the Kalman-Filter methodology. This is a recursive methodology that essentially estimates equations (3) or (4) in a state space and then updates the chosen state variable (i.e. the exchange rate term here) in a dynamic model. In the second stage the exchange rate pass-through coefficient is specified as a random walk, called the state equation and is estimated dynamically over time. The Kalman-Filter exchange rate pass-through elasticities are shown in Figures 1 and 2. For pass-through of the bilateral nominal dollar – rupee rate into India's CPI we do not find any

Table 3. Error correction model results for India

	Full Sample			*1980Q1–1990Q4*			*1992Q1–2005Q3*		
C	**0.009*****	**0.008*****	**0.008*****	**0.010*****	**0.008*****	**0.011****	**0.011*****	**0.013****	**0.009*****
	0.003	0.003	0.002	0.003	0.003	0.005	0.004	0.006	0.002
$Ecm_{(t-1)}$	**−0.128*****	**−0.118*****	**−0.067*****	**−0.072***	**−0.151****	**−0.173*****	**−0.219****	**−0.201*****	**−0.113*****
	0.044	0.039	0.023	0.035	0.061	0.044	0.088	0.066	0.031
Δ*Lexrt*	**0.102*****	**0.096*****		0.037	0.034		0.099	0.114	
	0.025	0.027		0.033	0.041		0.062	0.070	
Δ*Lneer*			−0.009			−0.012			−0.012
			0.013			0.066			0.008
Δ*Lppiusa*	**−0.048**			0.069			−0.243		
	0.104			0.119			0.189		
Δ*Lcpiusa*						0.149			−0.587
		0.169			0.165			0.618	
Δ*Lcpiw*			**0.164****			0.027			**0.274*****
			0.067			0.074			0.068
Δ*Lip*	0.082	0.076	0.029	0.037	0.071	0.027	0.041	0.014	−0.068
	0.055	0.055	0.056	0.067	0.060	0.043	0.091	0.084	0.089
$\Delta Lcpi_{(t-1)}$	**0.362*****	**0360*****	**0.281*****	**0.463*****	**0.481*****	**0.436*****	**0.275****	**0.312****	0.168
	0.090	0.074	0.077	0.108	0.111	0.143	0.103	0.087	0.105
Adj. R^2	0.245	0.247	0.235	0.139	0.213	0.297	0.156	0.146	0.195
D-W	2.029	2.05	2.059	2.052	1.999	2.194	1.953	2.018	1.873
F-stat	**7.486*****	**7.547*****	**7.129*****	**2.319***	**3.217****	**4.463*****	**2.961****	**2.809****	**3.570*****

Terms below coefficients denote stands errors, ***,**,*indicate statistical significance at 1%, 5%, and 10%, respectively.
Δ denotes first-differenced operator.

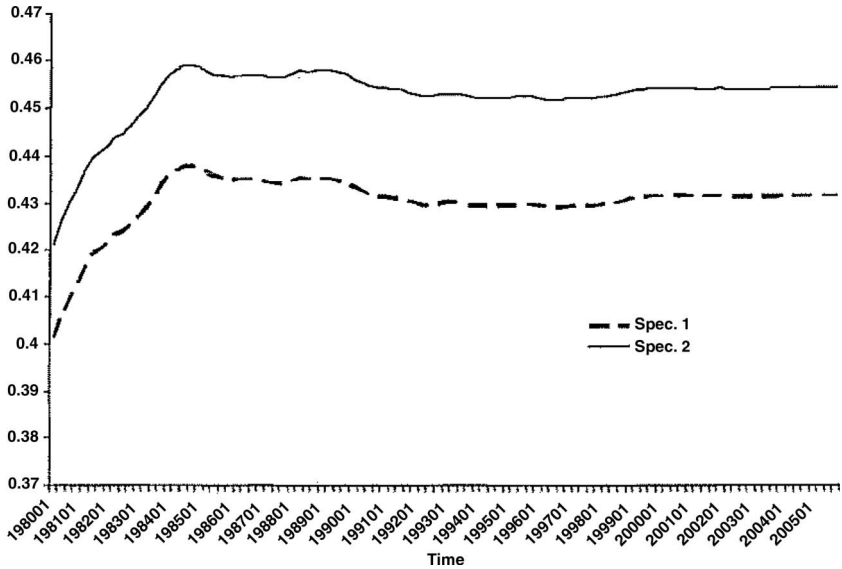

Figure 1. Kalman-filter exchange rate pass-through estimates of India's CPI

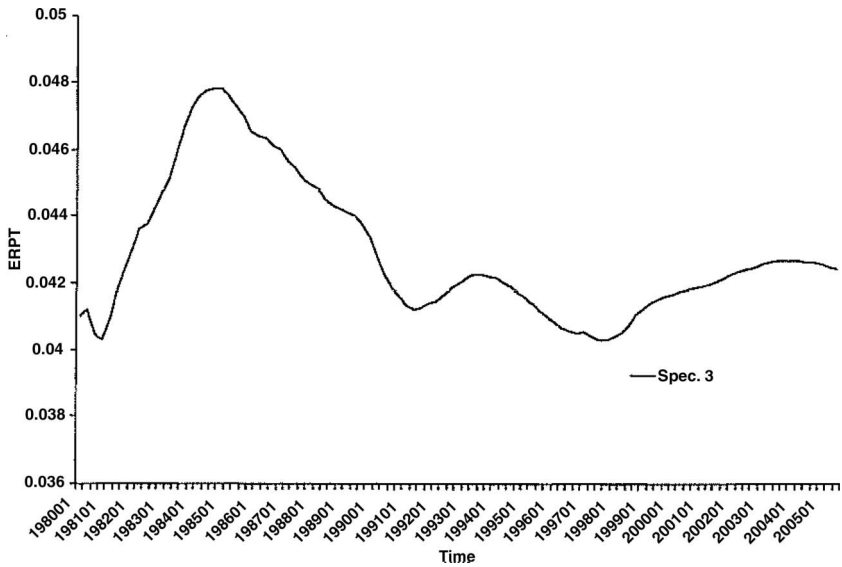

Figure 2. Kalman-filter exchange rate pass-through estimates into India's CPI

evidence of changing rates of pass-through over time. Using NEER, we find a slightly declining exchange rate pass-through in the 1990s, although insignificant as found earlier.

Conclusion

This paper has estimated exchange rate pass-through into India's CPI for over the period 1980Q1 to 2005Q3. We find the exchange rate pass-through elasticity of the bilateral exchange rate of the Indian rupee with the USD to be about 40 per cent for the entire period in the long run, while it is inevitably smaller in the short run (10 per cent). For India's NEER, however, we do not find any evidence of significant pass-through even in the long-run. This suggests that as far as 'importing inflation from abroad' is concerned, gyrations in the bilateral rupee–dollar rate have been more important then fluctuations in India's NEER. This may rationalize the seeming greater emphasis by the Reserve Bank of India (RBI) on ensuring stability of the Indian rupee vis-à-vis the US dollar in recent times (see Cavoli & Rajan, 2007, and references cited within). We also estimated exchange rate pass-through both before and after the introduction of economic reforms in India in 1991. Our results suggest some evidence of a slightly higher pass-through for the post-liberalization era, which is consistent with greater openness of the country to external influences.

Future research in estimating exchange rate pass-through in India should focus on estimating it for both aggregate import (export) prices as well as for disaggregate import (export) prices at the industry level subject to the availability of data.

Notes

[1] Given the data is of quarterly frequency, for purposes of sensitivity analysis we also tested for unit roots at seasonal frequencies – lag lengths of 4 and 8. The results were largely unaffected.

[2] We excluded 1991 as this was the crisis period (India suffering a balance of payment crisis in June 1991). However, we tried various cut-off dates but the results were largely unchanged.

[3] Recent literature on pass-through has focused on declining pass-through across the world. For details see (Campa & Goldberg, 2005; Frankel *et al*., 2005; Taylor, 2000 and the review by Ghosh & Rajan, 2007).

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