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Estimating Exchange Rate Pass-Through to Consumer Prices in India: Application of an Extended IS-LM-AS Model

Yu Hsing

Abstract

Applying an extended IS-LM-AS model, this paper finds that when the exchange rate rises 1 rupee per U.S. dollar, the CPI will increase by 0.6654 and that if the exchange rate rises 1%, the CPI will increase by 0.4237%. In addition, more money supply, more government deficit or borrowing, a higher crude oil price, a higher U.S. CPI, and a higher expected price will raise India's CPI. Hence, exchange rate pass-through (ERPT) to the consumer price is partial or incomplete.

Keywords: exchange rate pass-through, exchange rates, consumer prices, money supply, crude oil prices
JEL Codes: F31, F41

1. Introduction

Exchange rate pass-through (ERPT) to domestic prices has been studied extensively. It is especially a concerned subject as the exchange rate of the Indian rupee per U.S. dollar changed from a recent low of 41.3485 in 2007 to 68.3895 in 2018, indicating that the value of the Indian rupee declined 65.40% versus the U.S. dollar during 2007-2018. Such large depreciation of the Indian rupee is expected to raise import costs, wholesale prices, and consumer prices. Partly due to depreciation of the Indian rupee, the consumer price index rose from 67.985 to 149.816 or 120.37% during 2007-2018. It is an empirical question as to how much the increase in the consumer price index is attributable to depreciation of the Indian rupee.

To the author's knowledge, few of previous studies have applied and extended the IS-LM-AS model in studying ERPT to consumer prices in India. This paper differs from previous studies in several aspects. First, an extended IS-LM-AS model incorporating the exchange rate in the money demand and aggregate supply functions is employed. Second, in the aggregate supply function, external shocks represented by the exchange rate and the energy cost are considered. Third, comparative static analysis is employed to determine how exchange rate movements would affect the price level.

2. Literature Survey

Several recent studies have examined ERPT to prices for India and related countries. Based on a sample of 24 developing countries including India and applying the FMOLS and DOLS methods, Karim (2005) found that ERPT to import prices is heterogeneous among these countries. Long-run ERPT ranges from 0.7725 based on the FMOLS to 0.827 based on the DOLS. For India, long-run ERPT is estimated to be 0.55 using the FMOLS and 0.97 using the DOLS.

Bhattacharya, Patnaik and Shah (2008) evaluated ERPT to the CPI and WPI for India during 1997-2007. If the effect of monetary policy is considered, a 100% shock to the exchange rate leads to 11% increase in the CPI in one month and 20% increase in 2 years. A 100% shock to the exchange rate results in 12% increase in the WPI in one month and 1.3% increase in 2 years. The pass-through elasticity for the CPI and WPI is 3.7%-17% and 28.6%, respectively, in the long run. Commodity prices have moderate effects on the CPI and WPI whereas the effect of crude oil price on the CPI and WPI is trivial. Hence, ERPT to the CPI and WPI is incomplete in India.

Dash and Narasimhan (2011) applied the cointegration and error correction techniques to investigate ERPT to import and export prices in India. The results showed more than complete pass-through to import prices but partial pass-through to export prices, and long-run pass-through effects are greater than short-run pass-through effects. These results suggest that Indian importers have less bargaining power than Indian exporters and that there is risk of import-induced inflation.

Applying a simultaneous-equation model of demand and supply, Roy and Pyne (2011) studied ERPT to export prices in India during 1960-2000. They found that ERPT to India's export prices is high but incomplete and that the

magnitude of ERPT to export prices varies by product groups mainly due to export price markups and product differentiations.

Saha and Zhang (2013) evaluated ERPT for Australia, China and India using the VAR model during 1990-2011. They found that ERPT to consumer prices is less in China and India than in Australia, that depreciation of the yuan and rupee reduces import prices but causes domestic price inflation, and that external variables have little impact on domestic prices in China and India, but interest rates, producer prices and industrial production effect their domestic prices.

Yanamandra (2015) assessed ERPT to import prices in India during 2003M1-2013M3. He found support for more than complete ERPT to import prices in the short run and higher ERPT in the long run, suggesting the inertia impact of a rising price. A nonlinear relationship was also found regardless whether the rupee appreciates or depreciates or whether the rupee exchange rate has a large or small change.

Applying the VAR model, Mendali and Das (2017) studied ERPT to the wholesale price index (WPI) in India. They found that if the rupee depreciates 10%, the WPI would rise 0.011% after 1 month, and 0.01197% after 6 months, and the cumulative ERPT is 0.07% after 1 month and converges at 0.06%. Increasing oil prices and WPI are the 2 main factors of price increase. Hence, the findings reduce the concern of price instability due to a flexible exchange rate system.

Based on a sample of 19 high and middle countries including India, Dilla, Achsani and Anggraeni (2017) examined whether the adoption of inflation targeting (IT) would affect ERPT to the consumer price. The results are mixed. For India, before the adoption of IT, ERPT to consumer prices increases 0.010 and 0.028 in the short and run long; and after the adoption of IT, ERPT to consumer prices increases 0.014 and 0.032 in the short and long run. Hence, after the adoption of IT, ERPT to prices does not decline. However, ERPT to consumer prices declines for Indonesia and Thailand after the adoption of IT in the short and long run.

Studying ERPT in selected Asian countries including India, Soon, Baharumshah, and Wohar (2018) found that there is evidence of ERPT to the consumer price once inflation volatility is greater than 4.17. The degree of ERPT varies due to low and high inflation volatility in non-inflation and inflation targeting countries.

Using a sample of 47 countries including India, Ha, Stocker and Yilmazkuday (2019) revealed that ERPT to inflation differs among countries over time depending on the factors causing exchange rate changes and country characters. Countries pursuing credible inflation targets and flexible exchange rate systems tend to have smaller pass-through ratios. A higher degree of central bank independence helps to stabilize inflation and make the exchange rate as a cushion against external shocks.

Examining ERPT for selected Asian countries including India during 1995.Q1-2016.Q4 and applying the nonlinear ARDL technique, Kassi, Sun, Ding, Rathnayake and Assamoi (2019) showed that there is an asymmetric ERPT to prices in Asian developing countries in the short run and in Asian emerging countries in the short and long run, that ERPT is higher for appreciation than depreciation in the long run, and that there is evidence of downward rigid price and weak competition. They also indicated that ERPT has not decreased in these Asian countries in the long run. If a currency appreciates (depreciates) 1%, the consumer price would decline 0.9% (rise 0.5%) in the long run. ERPT is higher in emerging Asian countries with lower inflation and price volatility than in developing Asian countries.

3. The Model

Suppose that aggregate expenditures are a function of real income, government taxes, government spending, the real interest rate and the real exchange rate, that real money demand is determined by the nominal interest rate, real income and the nominal exchange rate, and that the price level is characterized by an augmented expectations supply function where the price level is affected by the expected price level, the output gap, the nominal exchange rate, and the energy cost. Extending the IS-LM-AS model (Romer, 2006), we have:

$$Y = f[Y, T, G, R - \pi^e, \varepsilon(P^*/P)] \quad (1)$$

$$M/P = g(R, Y, \varepsilon) \quad (2)$$

$$P = h(P^e, Y - Y^*, \varepsilon, E) \quad (3)$$

where
Y = real GDP in India,
T = government taxes,
G = government spending,
R = the nominal interest rate,
π^e = the expected inflation rate,
ε = the nominal exchange rate,
P^* = the price level in the U.S.,
P = the price level in India,
M = the money supply,
P^e = the expected price level,
Y^* = potential real GDP, and
E = the energy cost.

Suppose that potential real GDP is a constant in the short run. Solving for the three endogenous variables (Y, R - π^e, and P) simultaneously, we can obtain the equilibrium price level as:

$$\bar{P} = \bar{P}(\varepsilon, M, G - T, E, P^*, P^e) \quad (4)$$

The determinant of the Jacobian is given by:

$$|J| = [-(1 - f_Y)g_R - f_R h_Y MP^{-2} + f_P g_R h_Y - f_R g_Y] > 0 \quad (5)$$

The partial derivative of the equilibrium P with respect to the nominal exchange rate can be expressed as:

$$\partial \bar{P}/\partial \varepsilon = [-g_R h_\varepsilon (1 - f_Y) - f_\varepsilon g_R h_Y - f_R g_Y h_\varepsilon + f_R g_\varepsilon h_Y]/|J| > 0 \text{ if } g_\varepsilon < 0$$

$$< \text{or} > 0 \text{ if } g_\varepsilon > 0. \quad (6)$$

The sign of the first three terms is positive whereas the sign of the last term depends on the sign of g_ε. The exchange rate may affect real money demand through the substitution effect and the wealth effect (Arango and Nadiri, 1981). If the substitution effect dominates the wealth effect, the sign in equation (6) would be positive. On the other hand, if the wealth effect dominates the substitution effect, the sign in equation (6) would be unclear.

4. Empirical Results

The data were collected from the International Monetary Fund, the World Economic Outlook, and OECD. The price level is represented by the consumer price index. The nominal exchange rate is measured as units of the rupee per U.S. dollar. The money supply is represented by the index for M3 money. Fiscal policy is measured as government borrowing as a percent of GDP. The crude oil price per barrel is selected to represent the energy cost. The U.S. consumer price index is chosen to represent the foreign price. The expected consumer price index is estimated as the average consumer price index of the past three years. The sample ranges from 1990 to 2018. The data for M3 money is not available before year 1990.

Figure 1 shows the scatter diagram between the CPI and the nominal exchange rate (EXR) during 1990-2018. They seemed to exhibit a positive relationship during the sample period. Figure 2 presents the scatter diagram between the CPI and M3 (M3M) money supply. They appeared to have a strong positive relationship.

Table 1 presents the estimated regression and related statistics. The GARCH process is employed in empirical estimation in order to correct for autoregressive conditional heteroskedasticity. The estimated coefficients in the conditional variance equation are significant at the 1% level. Approximately 99.78% of the change in the consumer price index can be explained by the six right-hand side variables. All the estimated coefficients are significant at the 1% level. The consumer price index in India is positively affected by the nominal exchange rate, M3 money, the borrowing-to-GDP ratio, the crude oil price, the U.S. price level, and the expected price level.

Figure 1. Scatter Diagram between the CPI and the Nominal Exchange Rate (EXR)

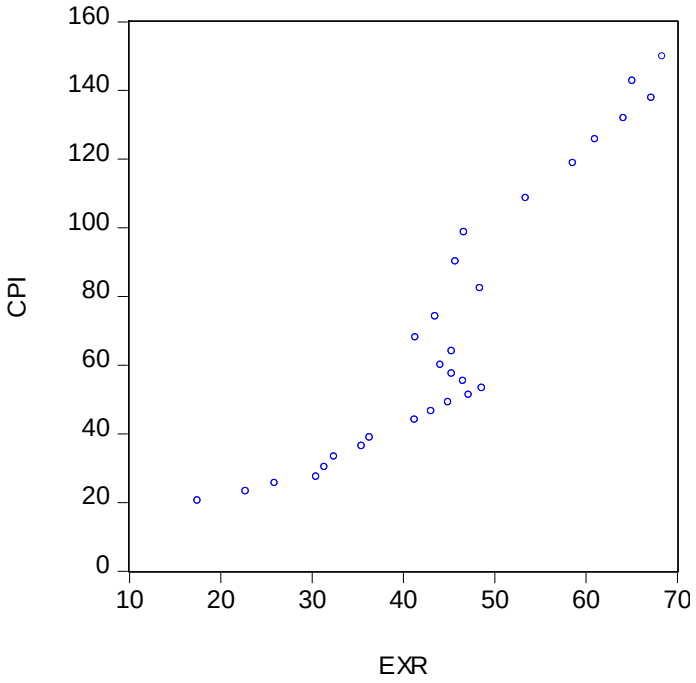
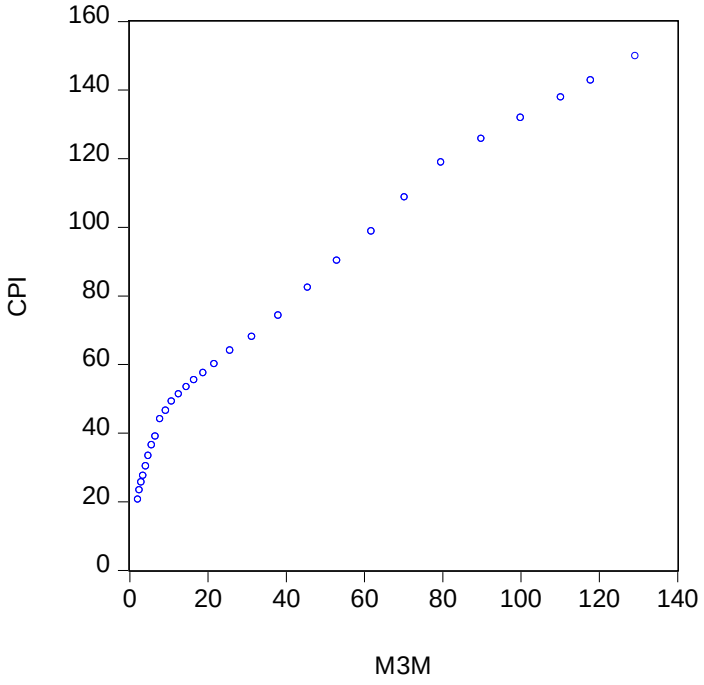


Figure 2. Scatter Diagram between the CPI and the M3 Money (M3M)



Specifically, if the exchange rate rises 1, the CPI will increase by 0.6654. If M3 rises 1, India's CPI will increase by 0.6306. A 1 percentage point increase in the government borrowing-to-GDP ratio will cause the CPI to rise by 0.2831. A US$1 increase in the crude oil price will increase the CPI by 0.1421. When U.S. CPI rises 1, India's CPI will increase by 0.1397. If the expected price rises 1, India's CPI will increase by 0.0673.

Table 1. Estimated Regression of the CPI in India

Variable	Coefficient	Probability
Intercept	-7.8093	0.0000
Exchange rate	0.6654	0.0000
M3 money	0.6306	0.0000
Government borrowing/GDP ratio	0.2831	0.0000
Crude oil price	0.1421	0.0000
Foreign price	0.1397	0.0000
Expected price	0.0673	0.0000
R-squared	0.9978	
Adjusted R-squared	0.9973	
Akaike information criterion	3.5913	
Schwarz criterion	4.0156	
Sample period	1990-2018	
Number of observations	29	

Notes:
The CPI is the consumer price index.
The exchange rate is measured as units of the Indian rupee per U.S. dollar.

The variables in the estimated regression in Table 1 have a linear relationship. The coefficient represents the slope. The elasticity in the linear regression can be calculated based on the formula $\beta(X/Y)$, where β is the estimated coefficient or the slope, Y is the dependent variable, and X is the independent variable. The elasticity of the CPI with respect to the exchange rate is found to be 0.4237 at the means, suggesting that if the rupee depreciates 1%, India's CPI will increase by 0.4237%. Hence, percent increase in the CPI is less than percent increase in the exchange rate, and exchange rate pass-through is partial or incomplete. Possible reasons for partial exchange rate pass-through are that exporters selling products to India may absorb part of the price increase in order to maintain the market share and that retailers may absorb part of the price increase in order to prevent sales from declining. The elasticity of the CPI with respect to M3 money is estimated to be 0.3385 at the means, suggesting that if M3 money rises 1%, the CPI will increase by 0.3385%. Hence, expansionary monetary policy such as more money supply tends to raise the consumer price index. The elasticity of the CPI with respect to the crude oil price is found to be 0.0956 at the means, suggesting that a 1% increase in the crude oil price tends to raise the CPI by 0.0956%.

5. Summary and Conclusions

This paper has examined ERPT to consumer prices in India based on an extended IS-LM-AS model. In the simultaneous-equation model, the equilibrium consumer price index is determined by the nominal exchange rate, M3 money supply, and government borrowing as a percent of GDP, the crude oil price, the U.S. consumer price index, and the expected consumer price index. Depreciation of the rupee, more M3 money, more government borrowing as a percent of GDP, a higher crude oil price, a higher U.S. consumer price index, and a higher expected consumer price index tend to cause India's consumer price index to rise. Exchange rate pass-through to consumer prices in India is confirmed but is partial or incomplete.

There are several policy implications. First, Rupee depreciation causes the consumer price to rise. Although ERPT to the consumer price is partial, chronicle depreciation of the rupee tends to continue raising the consumer price and reduce household wealth and consumption spending. Second, the consumer price index is also affected by the money supply. Hence, the authorities may need to make sure that the growth rate of the money supply is consistent with the growth rate of real GDP in order to avoid relatively high inflation. The adoption of flexible inflation targeting in 2015 seems to have reduced relatively high inflation rates in recent years. Third, external shocks such as the crude oil price and the U.S. consumer prices tend to affect India's domestic prices. The government may need to monitor changes in these prices in order to measure their impacts on India's domestic price level.

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Author

Yu Hsing, Ph.D.
Joseph H. Miller Endowed Professor in Business, Professor of Economics, Department of Management & Business Administration, College of Business, Southeastern Louisiana University, Hammond, Louisiana 70402, USA, yhsing@selu.edu