CHAPTER 9

Food Inflation in India: What Role for Monetary Policy?

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Persistent and elevated food inflation has presented challenges for monetary management in India. While it is a widely held view that central banks should only respond to changes in underlying core inflation and second-round effects on core inflation from commodity price shocks, there is growing evidence that the dynamics of food price inflation are very different in emerging market economies. Ignoring it in monetary policy action may lead to policy mistakes. As former Reserve Bank of India (RBI) governor Duvvuri Subbarao pointed out: "If food inflation is higher, as is typically the case in many low-income countries including India, then we would be underestimating inflationary pressures on a systemic basis. That would mislead policy prescriptions."[1]

India is not unique in the nontrivial role food price shocks play in shaping inflation shocks. Food price inflation shocks in emerging market economies are more volatile and persistent than in advanced economies, and are propagated strongly into nonfood inflation (Walsh 2011). They also tend to have stronger and longer-lasting effects on inflation in economies with high food shares in their consumption baskets and in economies with less firmly anchored expectations (IMF 2011a). Accordingly, excluding commodity-price inflation in economies where food and fuel represent a large share of household expenditure, and where commodity price changes affect core inflation through second-round effects, may not be appropriate (Catão and Chang 2010; Walsh 2011). Anand and Prasad (2010) also conclude that in an environment of credit-constrained consumers, a narrow policy focus on nonfood inflation can lead to suboptimal outcomes.

In this chapter we estimate the second-round effects of food price inflation and investigate their importance for monetary policy formulation in India. To do that, we document why second-round effects may have nontrivial consequences for monetary policy formation in emerging market economies. Then we carry out econometric analysis investigating the importance of these second-round effects in India. Lastly, we develop and estimate a suitable dynamic stochastic general equilibrium model that builds on a stylized gap model in which each variable is expressed in terms of its deviation from equilibrium; in other words in "gap" terms.[2]

[1] Comments made at the meeting of the Central Bank Governance Group in Basel, May 9, 2011.
[2] See for example, Berg, Karam, and Laxton (2006a, 2006b).

This is tailored to India's fundamentals so that various aspects of monetary policy transmission there can be studied.

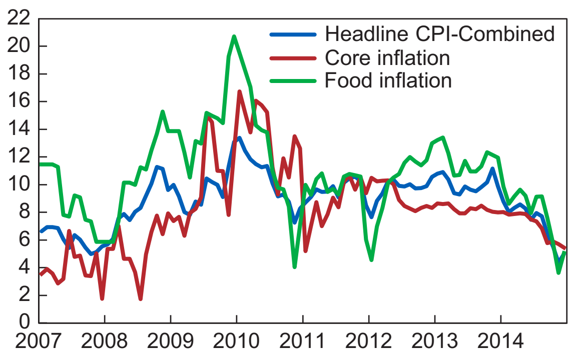
RECENT INFLATION DYNAMICS IN INDIA: THE ROLE OF FOOD INFLATION

High and persistent inflation remains a key macroeconomic challenge in India. Elevated inflation has coincided with the growth slowdown of recent years, distinguishing India from other major emerging market economies. Among the several factors that contributed to this were food inflation feeding quickly into wages and core inflation; entrenched inflation expectations; cost-push shocks from binding sector-specific supply constraints (particularly in agriculture, energy, and transportation); the pass-through from a weaker rupee; and ongoing energy price increases (Figures 9.1 and 9.2). However, food inflation has played an important role in shaping inflation dynamics in India because of the following factors: (1) the share of food expenditure in total household expenditure is high; (2) inflation expectations are anchored by food inflation; and (3) inflation expectations, anchored by food inflation, feed into wages (Figures 9.1 and 9.2).

In India, as in other emerging markets, the share of food expenditure in total household expenditure is much higher than in advanced economies (Table 9.1). Correspondingly, the weight on food in the consumer price index (CPI) basket is also high. In the CPI-Combined index, the weight on food, beverages, and tobacco is 49.7 percent.

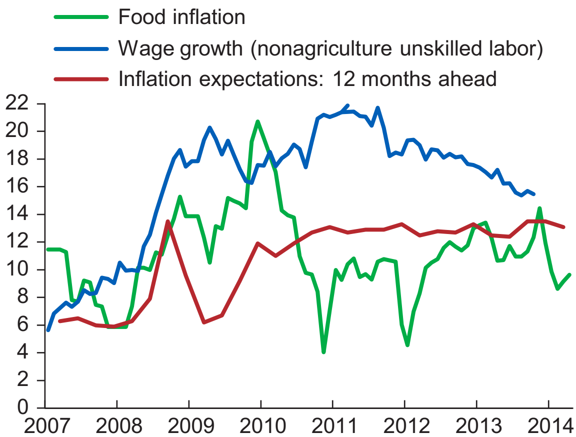
Food inflation also appears to play a pivotal role in informing inflation expectations. The RBI's inflation expectations survey of households suggests that general price expectations are more consistently aligned with food price expectations than with any other product groups. The share of households expecting headline

Figure 9.1. Inflation in India, 2011–14
(Percent, year-over-year)



Sources: Haver Analytics; and IMF staff calculations.

Figure 9.2. Role of Food Inflation in India
(Percent, year-over-year)



Sources: CEIC; Haver Analytics; and IMF staff calculations.

TABLE 9.1

Share of Food Expenditure in Total Household Expenditure *(Percent)*

Emerging Markets		Advanced Economies	
Indonesia	53.0	Japan	14.7
Vietnam	49.8	Germany	11.5
India	48.8	Australia	10.8
China	36.7	Canada	9.3
Russia	33.2	United Kingdom	8.8
Malaysia	28.0	United States	5.7
Average	41.6	Average	10.1

Sources: CEIC; household surveys; U.S. Department of Agriculture, Economic Research Service, International Food Consumption Patterns Dataset; and authors' calculations.
Note: Data for emerging markets for 2005; data for advanced economies for 2006. Expenditure on food includes expenditure on food consumed at home only and does not include expenditure on beverages and tobacco.

CPI inflation to move in coherence with food inflation has averaged about 90 percent in recent years. In December 2012, for example, more than 95 percent of the respondents appeared to have been influenced by expected changes in food prices for arriving at general price expectations, suggesting that they consider food prices to be very important when they think about price dynamics.

Wage growth accelerated during 2009–13, and both agricultural and nonagricultural wages have been on sustained growth trajectories since about 2005. Real wage growth has also been significantly positive. Admittedly, several factors contributed to this. Of them, the Mahatma Gandhi National Rural Employment Guarantee Act scheme stands out. Although it has undoubtedly benefited inclusiveness and enhanced the socioeconomic position of India's rural population, it also probably buttressed inflation pressures during 2010–13. The scheme has not

only set a floor on many rural wages and strengthened the bargaining position of the rural labor force, but has also tied up wage growth indexation to retail inflation, reinforcing the nexus between prices and wages. Furthermore, wage increases buttressing demand further reinforced India's food inflation, underpinned by wage and input cost inflation. As econometric analysis in Mohanty (2014) suggests, both the costs of material inputs and wages have sharp positive impact on food inflation in India. However, wage growth affects food inflation gradually, and is more persistent than the impact of the increase in the costs of material inputs.

FACED WITH FOOD INFLATION, WHAT CAN MONETARY POLICY DO?

The established conventional wisdom for monetary policy is to look through transitory supply shocks, to food and fuel prices in particular. Persistent supply shocks, however, require monetary policy action to mitigate their second-round effects on generalized inflation, and to keep the inflation process in check by anchoring inflation expectations. It is therefore important to ascertain whether second-round effects are important in India, and, if they are, to estimate their size.

Are Second-Round Effects Important in India?

To formalize the relationship between food inflation and its pass-through to core inflation, it is worth assessing the dynamics of headline inflation with respect to core inflation. To do so, we ask the following questions:

- *Does headline inflation revert to core inflation*?—If headline inflation reverts quickly to core inflation, then the impact of food and fuel price shocks is temporary, and second-round effects are probably limited. But if headline inflation does not revert to core, either the shocks are persistent or the second-round effects are large because of higher inflation expectations and accelerating wages.
- *Does core inflation revert to headline inflation?*—If core inflation reverts to headline inflation, it would indicate that shocks to headline inflation, such as those caused by commodity price spikes, feed into inflation expectations and price setting, driving core inflation to catch up with headline inflation.

The empirical results suggest that second-round effects are indeed significant (Box 9.1). It can therefore be concluded that headline does not revert to core, suggesting that either food shocks are persistent or second-round effects are large. This suggests that core inflation catches up with headline inflation and reverts to headline quickly. Thus, large second-round effects are present.[3]

[3]The estimates reported correspond to consumer price index for industrial workers (CPI-IW) inflation. Conclusions remain the same if wholesale price index inflation is used instead.

BOX 9.1 How Important Are Second-Round Effects in India?

We follow Cecchetti and Moessner (2008) and Clark (2001) to estimate the following equations, using monthly inflation data for 1996–2013, to answer these two questions:

Does headline inflation revert to core inflation?

$$\pi_t^{headline} - \pi_{t-12}^{headline} = \alpha + \beta\left(\pi_{t-12}^{headline} - \pi_{t-12}^{core}\right) + \varepsilon_t$$

Does core inflation revert to headline inflation?

$$\pi_t^{core} - \pi_{t-12}^{core} = \delta + \gamma\left(\pi_{t-12}^{core} - \pi_{t-12}^{headline}\right) + \varepsilon_t$$

where $\pi_t^{headline}$ and π_t^{core} denote headline and core year-over-year CPI inflation, respectively.

The empirical results suggest that second-round effects are indeed significant (Table 9.1.1). Specifically, if headline reverts to core, the coefficient β is expected to be negative. The results, however, suggest that the null of $\beta = 0$ cannot be rejected, which implies that headline inflation does not revert to core inflation. At the same time, individually both the hypothesis that $\beta = -1$ and that $\beta = -1$ and $\alpha = 0$, (that is, that headline fully reverts to core within a year) are rejected. Therefore, it can be concluded that headline does not revert to core, suggesting that either food shocks are persistent or second-round effects are large. On the other hand, the estimate of γ is –0.68, which is highly statistically significant, suggests that core inflation reverts to headline inflation. At the same time, the null hypothesis of $\gamma = 0$, which corresponds to a situation where core does not revert to headline, is rejected. Moreover, both the hypothesis that $\gamma = -1$ and that $\gamma = -1$ and $\delta = 0$ cannot be rejected. This suggests that core inflation catches up with headline inflation and reverts to headline quickly. Therefore, large second-round effects are present.

TABLE 9.1.1

Regression Analysis of Noncore Inflation Pass-Through

Dependent Variable	$\pi_t^{headline} - \pi_{t-12}^{headline}$	$\pi_t^{core} - \pi_{t-12}^{core}$
$\pi_{t-12}^{headline} - \pi_{t-12}^{core}$	–0.31	
	(0.27)	
$\pi_{t-12}^{core} - \pi_{t-12}^{headline}$		–0.68***
		(0.21)
Constant	0.136	–0.11
	(0.59)	(0.49)
Sample: 1997–2013		

Source: IMF staff estimates.
Note: Robust standard errors in parenthesis.
*** $p < .001$.

Quantifying the Size of Second-Round Effects

Analysis of inflation dynamics suggest that second-round effects are big, and policymakers need to pay close attention to food price shocks.[4] Incorporating the second-round effects of food price inflation is essential for monetary policy formulation in India, and estimating their size is important for understanding the

[4] We also estimated using 12-month monthly CPI-IW headline and core inflation. The results are similar.

country's inflation dynamics and monetary transmission. We estimate these effects using a variant of the small New Keynesian macroeconomic model with rational expectations developed by Berg, Karam, and Laxton (2006a, 2006b).

We then estimate a New Keynesian Phillips curve in a dynamic small open economy model, and analyze the effect of the output gap, lagged inflation, exchange rate, and inflation expectations on current inflation. To estimate the second-round effects, we modify the model to capture the pass-through from headline to core inflation. Although this model is simple and abstracts from many important features of the economy, such specifications have long been the workhorse of monetary policy analysis at the IMF. In addition to effectively capturing the key channels of monetary policy transmission, this framework has the virtues of clarity and tractability.

The Model

The model features a small open economy, including forward-looking aggregate supply and demand with micro foundations, and with stylized (realistic) lags in the different monetary transmission channels. Output developments in the rest of the world feed directly into the small economy because they characterize foreign demand for Indian products. Changes in foreign inflation or interest rates affect the exchange rate, and, subsequently, demand and inflation in the Indian economy. The model is set up in gap terms (that is, deviation of variables from their respective steady-state value). To estimate the second-round effects, we add an equation to capture the pass-through from headline to core inflation.

The baseline model has five behavioral equations: (1) an aggregate demand curve that relates the level of real activity to expected and past real activity, the real interest rate, the real exchange rate, and the foreign output gap; (2) a price-setting or Phillips curve equation that relates core CPI inflation to past and expected inflation, the output gap, and the exchange rate, as well as the pass-through from the headline to core inflation; (3) a food inflation equation that relates food inflation to past and expected inflation, the output gap, and the exchange rate; (4) an uncovered interest parity condition for the exchange rate, with some allowance for backward-looking expectations; and (5) a rule for setting the policy interest rate as a function of the output gap and expected inflation.

The output gap equation is given by:

$$ygap_t = \beta_{ld}\, ygap_{t+1} + \beta_{lag}\, ygap_{t-1} - \beta_{RRgap} RRgap_{t-1} + \beta_{Zgap} zgap_{t-1} + \beta_{RWygap}\, ygap_t^{RW} + \varepsilon_t^{ygap}$$

in which $ygap$ is the output gap, $RRgap$ the real interest rate gap, $zgap$ the gap of real exchange rate, $ygap^{RW}$ the output gap in the rest of the world, β a series of parameters attached to those variables, and ε^{ygap} an error term, which captures other temporary exogenous effects.[5]

[5] We use the U.S. output gap as the proxy for the output gap of the rest of the world.

The headline inflation equation is given as the aggregation of the core and food and fuel inflation:

$$\pi_t = (1-\vartheta)\pi_t^c + \vartheta\pi_t^{ff} + \varepsilon_t^{\pi}$$

in which π_t^c is core inflation rate, $\pi_{c,t}^{ff}$ is noncore (food and fuel), ϑ is the weight on noncore inflation, and ε_t^{π} an error term. A residual captures other temporary exogenous effects that are not explicitly modeled.

We then have two pricing equations for core inflation and food and fuel inflation, which have a very similar structure except for an additional term in the former to capture the pass-through from headline to core inflation, or the second-round effects.

$$\pi_t^c = \alpha_{c,\pi ld}\pi 4_{t+4}^c + (1-\alpha_{c,\pi ld})\pi 4_{t-1}^c + \alpha_{c,ygap}\,ygap_{t-1} + \alpha_{c,z}(z_t - z_{t-1}) + \alpha_{c,\pi}(\pi 4_{t-1} - \pi 4_{c,t-1}) + \varepsilon_t^{\pi,c}$$

$$\pi_t^{ff} = \alpha_{ff,\pi ld}\pi 4_{t+4}^{ff} + (1-\alpha_{ff,\pi ld})\pi 4_{t-1}^c + \alpha_{ff,ygap}\,ygap_{t-1} + \alpha_{ff,z}(z_t - z_{t-1}) + \varepsilon_t^{\pi,ff}$$

in which $\pi_t^c 4_{t+4}$ and $\pi_t^{ff} 4_{t+4}$ are the four-quarter-ahead year-over-year core and food and fuel inflation rates, respectively,[6] $\pi_t^c 4_{t-1}$ and $\pi_t^{ff} 4_{t-1}$ are their one-quarter lagged year-over-year inflation rates, *ygap* the output gap, $z_t - z_{t-1}$ the real depreciation, α_c a series of parameters, and $\varepsilon_t^{\pi,c}$ and $\varepsilon_t^{\pi,ff}$ are error terms. The additional term $(\pi 4_{t-1} - \pi 4_{c,t-1})$ is added to the core inflation equation to allow for the possibility of relative price and real wage resistance; or more precisely that workers and other price setters may try to partially keep their prices rising in pace with past movements in headline CPI (Berg, Karam, and Laxton 2006b). Expected inflation enters the equation due to the assumption of staggered price-setting (Calvo 1983), while indexation schemes can rationalize the backward-looking inflation component. The real exchange rate *z* reflects the effect of the prices of imported goods on inflation in an open economy.[7]

The real exchange rate equation is given by:

$$z_t = \delta_z z_{t+1} + (1-\delta_z)z_{t-1} - (RR_t - RR_t^{RW} - \rho^*)/4 + \varepsilon_t^z$$

in which z_t is the real exchange rate (an increase represents a depreciation), RR_t the real interest rate, RR_t^{RW} the real interest rate in the United States, ρ^* the equilibrium risk premium on the domestic currency, δ_z parameters, and ε_t^z an error term. A residual captures other temporary exogenous effects.

Finally, the monetary policy rule is given by:

$$RS_t = \gamma_{RSlag}RS_{t-1} + (1-\gamma_{RSlag}) * [RR_t^* + \pi 4_t + \gamma_{\pi}(\pi 4_{t+4} - \pi_{t+4}^*) + \gamma_{ygap}\,ygap_t] + \varepsilon_t^{RS}$$

in which RS_t is the nominal interest rate, RR^* the equilibrium real interest rate, π^* the inflation objective, γ parameters, and ε_t^{RS} an error term.

[6] Core CPI is compiled by stripping out food and energy items from the CPI basket.

[7] An increase in the real exchange rate (*z*) corresponds here to a real depreciation.

The model is a two-country model where the home country is small and open, whereas the foreign country—the home country's main trading partner—is relatively large and closed; in effect, exogenous to the home country. Thus, the foreign country enters the home country equations through the impact of its activity on the home country demand, and the impact of its real interest rate on the bilateral exchange rate. Conversely, the home country does not affect the foreign country, which implies that the output gap of the foreign country does not depend on the bilateral exchange rate or the home country activity; and foreign country inflation does not depend on the bilateral exchange rate. Hence, the uncovered interest rate parity condition is irrelevant for the foreign country model. So there are three additional behavioral equations that describe the foreign sector: an output-gap equation, an inflation equation, and a policy reaction function, except that no rest-of-the-world (*RW*) variables appear.

Estimation

The parameter values are chosen based on the modeling experience of other country models, but adapted to our knowledge about the characteristics of the Indian economy and policy making. The model is estimated as an open economy, where the United States is treated as the relevant foreign sector for India. For the United States, we use the prior distributions used in Berg, Karam, and Laxton (2006b).

The long-term steady-state values for key parameters—the inflation objective, real exchange rate, and real interest rate—are chosen to match the historical average of these variables. The equilibrium real interest rate for the rest of the world is set at 1.5 percent and the inflation rate at 2.4 percent. We set India's long-term headline CPI inflation rate at 6.5 percent and the equilibrium real interest rate at 1.5 percent. This implies an equilibrium nominal short-term interest rate of about 8 percent. Because we use a detrended real exchange rate series, which removes average real appreciation of about 1 percent a year, we make a technical assumption of zero equilibrium risk premium. All gaps that measure deviations of actual variables from their long-run equilibrium are, by definition, zero.

To estimate the model, we use key macroeconomic variables for India from the first quarter of 1996 to the fourth quarter of 2013. The three-month Treasury bill rate is used as a proxy for nominal interest rate, and real exchange rate (CPI-based) is used as a proxy for real exchange rate. For India's inflation, we use a backcasted CPI-Combined based on the CPI-IW. We use U.S. GDP, inflation, and interest rate data for the rest of the world in the model. Variables are seasonally adjusted using an X12 filter.

Estimated Aggregate Demand Equation

Coefficient estimates for the output gap equation are reported in Table 9.2:

$$ygap_t = \beta_{ld}\, ygap_{t+1} + \beta_{lag}\, ygap_{t-1} - \beta_{RRgap}\, RRgap_{t-1} + \beta_{Zgap}\, zgap_{t-1} + \beta_{RWygap}\, ygap_t^{RW} + \varepsilon_t^{ygap}$$

TABLE 9.2

Aggregate Demand Equation		
Parameter	**Prior Mean**	**Posterior Mean**
β_{ld}	0.40	0.19
β_{lag}	0.60	0.59
β_{RRgap}	0.05	0.04
β_{Zgap}	0.05	0.04
β_{RWygap}	0.15	0.10

The β parameters in the output gap equation depend to a large extent on the degree of inertia in the economy, the effectiveness of monetary policy transmission, and the openness of the economy. Drawing on the experience of several applied country modeling efforts, Berg, Karam, and Laxton (2006b) suggest that the value of β_{lag} should lie between 0.5 and 0.9, with a lower value for countries more susceptible to volatility.

The estimated coefficient of 0.6 for β_{lag} is comparable to other emerging markets. The lead of the output gap β_{ld} is typically small, and the estimated value for India is 0.2. The coefficient estimate on the lead of the output gap indicates that expectations on the future level of the output gap are important. This corroborates the importance of confidence effects in promoting economic activity in India (Anand and Tulin 2014). The parameter β_{RRgap} depends on the effectiveness of monetary transmission mechanism, while β_{zgap} and β_{RWygap} depend on the importance of the exchange rate channel and the degree of openness. Significant lags in the transmission of monetary policy imply that the sum of β_{RRgap} and β_{zgap} should be small relative to the parameter on the lagged gap in the equation. A β_{RRgap} coefficient of 0.04 implies that a one percentage point increase in real interest rates would lead a 0.04 percent fall in the output gap the following period. The value for β_{RWygap} of 0.1 implies that a 1 percentage point increase in the foreign output gap leads to a contemporaneous 0.1 percentage point increase in the Indian output gap.

Estimated Philips Curve Equations

Coefficient estimates for the core and headline CPI inflation equations are reported in Tables 9.3 and 9.4:

$$\pi_t^c = \alpha_{c,\pi ld}\pi 4_{t+4}^c + (1-\alpha_{c,\pi ld})\pi 4_{t-1}^c + \alpha_{c,ygap}ygap_{t-1} + \alpha_{c,z}(z_t - z_{t-1}) + \alpha_{c,\pi}(\pi 4_{t-1} - \pi 4_{c,t-1}) + \varepsilon_t^{\pi,c}$$

$$\pi_t^{ff} = \alpha_{ff,\pi ld}\pi 4_{t+4}^{ff} + (1-\alpha_{ff,\pi ld})\pi 4_{t-1}^c + \alpha_{ff,ygap}ygap_{t-1} + \alpha_{ff,z}(z_t - z_{t-1}) + \varepsilon_t^{\pi,ff}$$

The α parameters in the core inflation equations depend on the role of expectations and aggregate demand on inflation, and the degree of pass-through from the exchange rate to prices. The $\alpha_{c,\pi ld}$ parameter in the core inflation equation determines the forward component of inflation (while its inverse, $1 - \alpha_{c,\pi ld}$,

TABLE 9.3

Phillips Curve Equation for Core Inflation

Parameter	Prior Mean	Posterior Mean
$\alpha_{c,\pi ld}$	0.20	0.26
$\alpha_{c,ygap}$	0.25	0.25
$\alpha_{c,z}$	0.30	0.15
$\alpha_{c,\pi}$	0.30	0.32

TABLE 9.4

Phillips Curve Equation for Food Inflation

Parameter	Prior Mean	Posterior Mean
$\alpha_{ff,\pi ld}$	0.20	0.22
$\alpha_{ff,ygap}$	0.25	0.28
$\alpha_{ff,z}$	0.30	0.33

determines the backward component). This can be interpreted as depending in part on the credibility of the central bank, and in part on institutional arrangements regarding wage indexation and other price-setting mechanisms. A higher value of $\alpha_{c,\pi ld}$ close to 1 would suggest that small changes in monetary policy cause large changes in price expectations; a low value would suggest that inertia and backward-looking expectations cause prices to respond with greater delays to changes in monetary policy. The estimated Philips curve for India is backward looking (the backward-looking component in the core inflation is 0.8), suggesting that inflation is highly inertial and that shocks to inflation are persistent. Patra and Kapur (2010) have found similar estimates for the forward- and backward-looking components.[8]

The $\alpha_{c,ygap}$ parameter depends on the extent to which output responds to price changes and, conversely, how much core inflation is influenced by real demand pressures, and is typically between 0.25 and 0.50. This parameter is estimated to be 0.25 for India. This is in line with the literature estimates of 0.20–0.30 (Patra and Kapur 2010). The $\alpha_{c,zgap}$ parameter represents the short-term pass-through of (real) exchange rate movements into prices, and depends on trade openness, price competition, and monetary policy credibility. The exchange rate pass-through coefficient is estimated to be 0.15 in India. This is in line with the findings of Patra and Kapur (2010) and other cross-country findings that estimate exchange rate pass-through to be about 0.16 for countries with low (less than 10 percent) inflation (Choudhuri and Hakura 2001).

Finally, the parameter $\alpha_{c,\pi}$ represents the pass-through coefficient from headline to core inflation; that is, the extent to which price setters keep their prices rising in step with past movements in headline CPI. If $\alpha_{c,\pi}$ is zero, the gap between past headline and core inflation (namely, inflation of food and energy

[8] This is also consistent with the cross-country evidence that finds the coefficient on expected inflation to be below 0.5 (Berg, Karam, and Laxton 2006a).

prices) will have no effect on core inflation. In other words, there will be no second-round effects in the economy. Our estimation of the second-round effect coefficient indicates that if headline inflation exceeds core inflation by 1 percentage point, it will lead to a 0.3 percentage point increase in core inflation in the next quarter. As expected, the pass-through from headline to core inflation is relatively large. This estimate is consistent with our analysis of year-over-year inflation dynamics in India, as discussed in an earlier section. However, some caution is warranted in interpreting a rather large pass-through coefficient. An alternative interpretation of a strong pass-through coefficient estimate may reflect a faster response of food inflation to aggregate demand, because commodity prices, including food items, tend to be more flexible than nonfood prices. Another reason could be that food inflation may also react faster than nonfood inflation when inflation expectations are not firmly anchored.

Estimated Uncovered Interest Parity Equation

$$z_t = \delta_z z_{t+1} + (1-\delta_z) z_{t-1} - (RR_t - RR_t^{RW} - \rho^*)/4 + \varepsilon_t^z$$

The δ_z parameter in the real exchange rate equation determines the relative importance of forward- and backward-looking real exchange rate expectations. If δ is equal to 1, the equation behaves as in the Dornbusch overshooting model; that is, the real exchange rate is a function of the future sum of all real interest rate differentials. The estimated coefficient of 0.5 makes monetary policy potentially a more effective tool, though the incomplete exchange rate pass-through in India somewhat reduces its efficacy (Table 9.5).

Estimated Open-Economy Taylor-Rule Equation

$$RS_t = \gamma_{RSlag} RS_{t-1} + (1-\gamma_{RSlag}) * [RR_t^* + \pi 4_t + \gamma_\pi (\pi 4_{t+4} - \pi_{t+4}^*) + \gamma_{ygap}\, ygap_t] + \varepsilon_t^{RS}$$

The γ parameters in the monetary policy rule equation depend on the speed and aggressiveness with which the monetary authorities adjust the nominal interest rate, and the relative importance of the inflation target versus the real activity target (Table 9.6). There is a high degree of interest rate smoothing in India

TABLE 9.5

Uncovered Interest Parity Equation

Parameter	Prior Mean	Estimate (Posterior Mean)
δ_z	0.60	0.40

TABLE 9.6

Taylor-Rule Equation

Parameter	Prior Mean	Estimate (Posterior Mean)
γ_{RSlag}	0.80	0.82
γ_π	1.90	1.88
γ_{ygap}	0.60	0.64

(the coefficient is 0.8), which is in line with the estimates of this parameter by Mohanty and Klau (2004) and Anand, Saxegaard, and Peiris (2010). The value of γ_π is 1.9. The estimate of γ_{ygap} is 0.6, suggesting that the RBI puts weight on stabilizing real activity, which is expected, considering that the central bank followed an approach of multiple objectives during most of the analysis period.

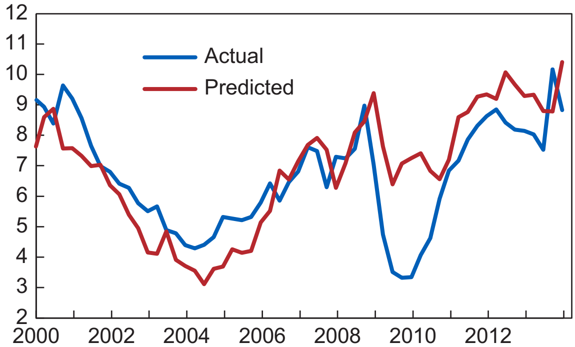
Key Results of the Model

Estimated results of the model suggest the following:

- A temporary increase of 100 basis points in the interest rate leads to a peak widening of the output gap by almost 1 percent in about four quarters, slowing in the core CPI inflation by about ¾ of a percentage point, an almost 1 percentage point decline in headline CPI inflation, and a nearly 2 percent peak real appreciation.
- With a 1.5 percentage point jump in food and fuel price inflation, the output gap widens at peak by about 0.5 percentage point, and headline and core inflation rise by about 0.5 percent. The interest rate increases by about 80 basis points, while the exchange rate appreciates by about 2.5 percent. Inflation shocks lead to widening of the output gap, a rise in inflation and the interest rate, and real appreciation. Furthermore, the headline inflation shock passes through to core inflation, which rises by about 0.2 percentage point.

We can use the estimated model to study the behavior of interest rates in India to examine its monetary policy stance since 2000. Figure 9.3 presents actual and model-predicted nominal interest rates. As is evident, since mid-2008 actual interest rates are consistently below those predicted by the model, suggesting that monetary policy shocks have been negative. The gap between the two rates (actual and predicted) was large during 2008–09. The gap again opened in late 2010 and averaged about 100 basis points during 2011–12. This was highlighted by

Figure 9.3. Interest Rates in India: Predicted versus Actual
(Percent)



Sources: Anand and Tulin (2014); Haver Analytics; and IMF staff estimates.
Note: Interest rates correspond to three-month Treasury bill yield.

successive IMF India Article IV Staff Reports, which argued for a tighter monetary stance to counter inflation and inflationary pressures (IMF 2011b, 2012, 2013, 2014a, 2014b).

CONCLUSION

India has seen a prolonged period of high inflation, to a large extent driven by persistently high food inflation. This has made the RBI's task more challenging, with many arguing that the central bank has a very limited role in combating food inflation, particularly when growth has slowed considerably and external demand remains subdued. While economists agree that a central bank should look through transitory supply shocks, they also agree that monetary policy should react to second-round effects.

There is growing evidence that second-round effects could be large in emerging market economies for several reasons: the high share of food in households' expenditure, less firmly anchored expectations, and highly persistent supply shocks. India has these characteristics, suggesting that second-round effects are important and play a role in inflation dynamics.

Indeed, recognizing the seminal nature of food inflation and its second-round effects for inflation dynamics in India, the Patel Committee Report (RBI 2014, 20) recommends: "Since food and fuel account for more than 57 percent of the CPI on which the direct influence of monetary policy is limited, the commitment to the nominal anchor would need to be demonstrated by timely monetary policy response to risks from second round effects and inflation expectations in response to shocks to food and fuel."

Our results suggest that monetary policy needs to respond decisively to tackle India's high and persistent inflation. Furthermore, as emphasized in the Patel Committee Report, headline CPI inflation should be the nominal anchor for monetary policy—and because of the persistent and entrenched nature of CPI inflation, it should be the guiding factor for the monetary policy stance.[9] At the current juncture, with food inflation remaining persistently high during 2009–14, monetary policy needs to remain tight to control generalized inflation. This analysis suggests that the RBI may also need to raise rates to tackle inflation durably, particularly if faced with a persistent and sizable supply-side food price shock putting pressure on broad-based inflation. Because inflation is mostly backward looking, monetary policy has to remain tight for a prolonged period. Nevertheless, recent revisions to the RBI's liquidity management framework should improve monetary transmission, thereby requiring lower policy interest rate adjustments to contain inflation and inflationary pressures. Finally, given that India's Phillips curve is relatively flat, progress on structural reforms to raise potential growth is critical to reduce the burden of adjustment on monetary policy.

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[9] Says the Patel Committee Report: "The CPI-Combined based headline inflation measure appears to be the most feasible and appropriate measure of inflation—as the closest proxy of a true cost of living index—for the conduct of monetary policy" (RBI 2014, 15).

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