Online Appendix

For

Food Prices and Inflation

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Appendix A: Data

Table A1 lists the variables and data sources. Table A2 provides the details on testing whether the time series data is stationary.

Table A1: Data Description

Variables	Source	Description
CPI	HSIE	Consumer price index for Industrial workers. The base is 2001.
dfp	HSIE	Domestic food price index. It is measured by food CPI
dnfp	HSIE	Domestic non-food price index. It is measured by non-food CPI
wfp	WBDBG	World food price index.
er	HSIE	The rupee-US dollar exchange rate.
wnfp	OECD	World non-food price index. It is measured by the producer price index in the US
m-p	HSIE	Real broad money supply, M3. It is the sum of currency, demand deposits and fixed deposits with commercial banks.
y	HSIE	Real GDP. The base is 2004-05
i	HSIE	Average interest rate on deposits of maturity 1 to 3 years
infn	HSIE	Annual percentage change in consumer price index
Δ_{12}er	HSIE	Annual percentage change in rupee-US dollar exchange rate
goldp	FRED	Annual percentage change in gold fixing price in London Bullion market per troy ounce in rupees.
ag	HSIE	Agricultural output gap
non-ag	HSIE	Non-agricultural output gap
wenergy	WBDBG	World energy price index. It is weighted average of coal (4.7%), crude oil (84.6%), and natural gas (10.8%).
wferti	WBDBG	World fertilizer price index. It is weighted average of natural phosphate rock (16.9%), phosphate (21.7%), potassium (20.1%), nitrogen (41.3%).
msp	HSIE	Minimum support price. It is measured as the percentage change in average MSP of both paddy common and wheat
fd	HSIE	Centre's fiscal deficit.

Notes: HSIE: Handbook of Statistics on Indian Economy, 2015-16, Reserve Bank of India. WBDPG: World Bank's Development Prospects Group. OECD: Organisation for Economic Cooperation and Development. FRED: Federal Reserve Bank of St. Louis database.

Table A2: ADF Tests for Unit Roots, 1996 to 2015

Variables	*t*-statistics for level without time trend [a]	*t*-statistics for level with time trend [b]	*t*-statistics for first differences without time trend [a]	Decision
CPI	0.74 (4)	-1.18 (4)	-2.83* (3)	I(1)
dfp	0.83 (4)	-1.25 (4)	-2.90** (3)	I(1)
dnfp	0.31 (2)	-1.86 (4)	-3.90*** (1)	I(1)
wfp	-0.79 (2)	-2.72 (1)	-6.42*** (1)	I(1)
er	-1.10 (1)	-1.89 (1)	-6.48*** (0)	I(1)
wnfp	-0.43 (2)	-2.29 (2)	-6.70*** (1)	I(1)
m-p	-1.84 (4)	-0.18 (4)	-2.64* (3)	I(1)
y	0.56 (0)	-2.60 (0)	-9.03*** (0)	I(1)
i	-2.01 (0)	-1.77 (0)	-8.52*** (0)	I(1)
infn	-1.63 (4)	-1.87 (4)	7.46*** (3)	I(1)
Δ_{12}er	-1.65 (8)	-0.97 (10)	-6.91*** (7)	I(1)
goldp	-1.77 (4)	-1.37 (4)	-7.25*** (3)	I(1)
ag	-4.35***(0)			I(0)
non-ag	-4.56***(1)			I(0)
wenergy	-1.18 (2)	-3.06 (1)	-6.13*** (0)	I(1)
wferti	-1.46 (1)	-3.13 (1)	-4.87*** (0)	I(1)
msp	-3.11**(0)	---	---	I(0)
fd	-6.05***(0)	---	---	I(0)

Notes:
[a] The critical values are -3.53, -2.90, and -2.59 at 1%, 5%, and 10% level of significance, respectively.
[b] The critical values are -4.08, -3.47, and -3.16 at 1%, 5%, and 10% level of significance, respectively.
***, **, and * denote rejection of null hypothesis at 1%, 5%, and 10% level of significance, respectively.
Figures in brackets indicate the lag length of the lagged dependent variable selected on the basis of Schwarz Information Criterion (SIC).

Appendix B: Details on General to Specific Modeling

We built the 3 models of inflation by first estimating a separate general model for each measure, based on Equation 6. We checked whether the general model satisfied the assumptions of a classical linear regression model (no serial correlation, no heteroscedasticity, non-linearity, normality). If these conditions were not met (for example, due to the extreme values evident in Figure 1 and discussed in the main paper), then we included an impulse dummy variable to address this problem. Once the conditions were met, we next reparametrized the model by dropping insignificant regressors (while retaining the key variables of interest). We have also estimated the models without the impulse dummy variables, and we have also employed heteroscedastic and autocorrelation consistent (HAC) standard errors, as robustness checks. The qualitative results were unchanged.

Appendix C: Further Model Details

This section provides additional details for estimating the error correction terms in the five sectors considered in the main text (the deviations based on Equations 1-5).

C.1 The External Food Sector

The components of the world food price index are cereals, vegetable oils and meals, and other food. The weights for cereals, vegetables oils and meals, and other foods are 28.2%, 40.8%, and 31% percent respectively. Cereal consists of rice (8.5%), wheat (7.1%), maize (11.5%), and barley (1.2%). Vegetables oils and meals consists of soybeans (10.1%), soybean oil (5.3%), soybean meal (10.7%), palm oil (12.3%), coconut oil (1.3%), and groundnut oil (1.1%). Other food consists of sugar (9.8%), banana (4.9%), meat, beef (6.8%), meat, chicken (6%), and oranges (3.6%). Figure C1 depicts the relative world price to the domestic food price.

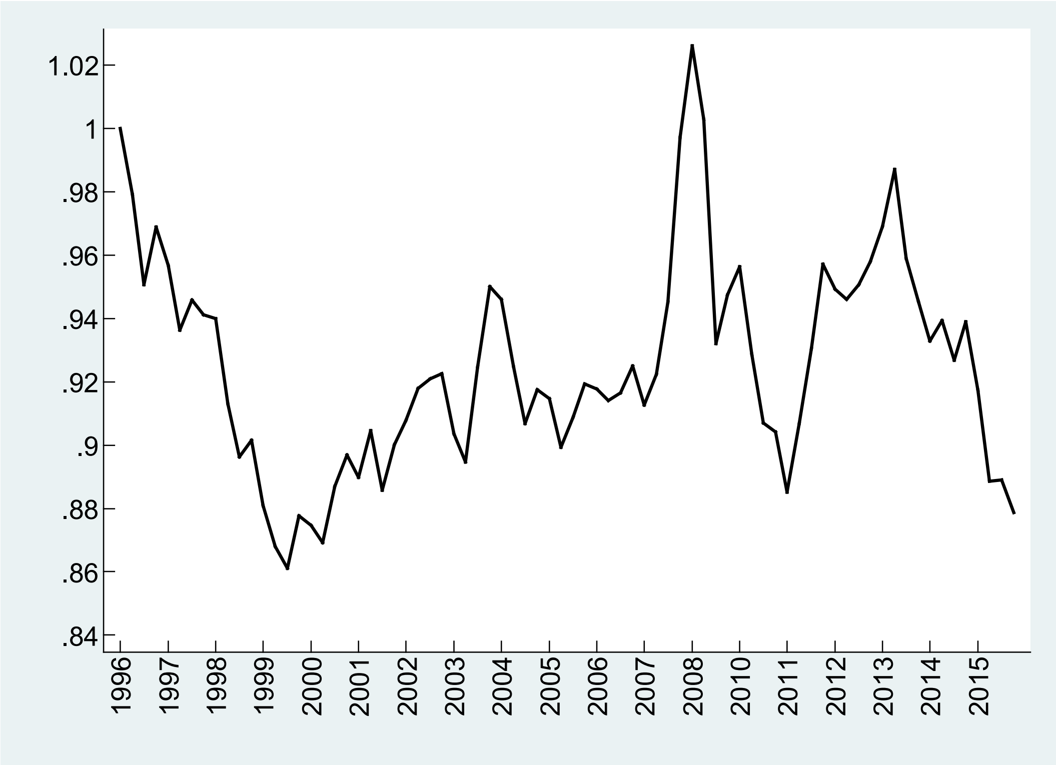

Figure C1. Relative Price of Food, 1996-2015

Note: The relative price of food is calculated as the ratio of the world food price measured in rupees (the product of wfp and er) to the domestic food price (dfp). World food is measured by the world food price index. Domestic food price is measured by the domestic food consumer price index for industrial workers. Exchange rate is measured by the rupee-US dollar exchange rate. Domestic food consumer price index for industrial workers and exchange rate come from the Handbook of Statistics on Indian Economy, 2015-16, Reserve Bank of India. World food price index comes from the World Bank's Development Prospects Group (WBDPG).

The key variables (e.g. the domestic food price (dfp), rupee-US dollar exchange rate (er), and world food price (wfp)) considered for analysing the external food sector are found to be nonstationary, but they are stationary in their first difference (see Table A2). Therefore, these variables are I(1) in levels and there might be a cointegrating relationship between them.

We use the Johansen method (1991) to test for a long-run equilibrium relationship between variables and find strong evidence of one cointegrating vector, as we cannot reject the null hypothesis of one cointegrating relationship (i.e. r=1). The long run estimates for dfp are reported in Table C1. Note that the AIC, Likelihood Ratio (LR) Test, and Adjusted LR test simultaneously suggest the optimum lag length to be 2 after including a dummy variable which takes the value of 1 for 2008q2 and 0 otherwise.

Table C1: Cointegration Analysis of the External Food Sector, 1996-2015

Null Hypothesis	r=1	r ≤ 1	r ≤ 2	
Eigen Value	0.32	0.18	0.04	
Trace:	47.69** [34.87]	18.37 [20.18]	3.20 [9.16]	
λ-max:	29.31** [22.04]	15.16 [15.87]	3.20 [9.16]	
Cointegrating vector				
	dfp	wfp	er	constant
β_i	1.00 -1.00	-0.99 (-7.01)	-1.16 (-4.73)	3.65 (5.39)
Adjustment coefficients				
a_i	-0.082*** (-4.75)	-0.044 (-1.65)	0.087 (1.46)	
		Weakly exogenous	Weakly exogenous	

Notes: The numbers in square brackets are 95% critical values. The figures in parentheses are t-ratios. ***, **, and * indicate significance at 1%, 5% and 10% level. The VAR includes 2 lags on each variable, three centered seasonal dummy variables, and one impulse dummy for 2008q2.

The adjustment parameter in the dfp equation equals -0.08 and is statistically significant at the 1% level (see table C2). This suggests that the dfp is endogenously determined, and the long-run food PPP function is represented by the cointegrating vector. The adjustment coefficients in the er, and wfp equations are not significant. Hence, they are weakly exogenous. India, being a developing economy, is unlikely to impact global food prices. Similarly, the supply and demand for currency due to food trade, respectively, is unlikely to impact the dollar rupee exchange rate, which is largely determined by capital inflows.

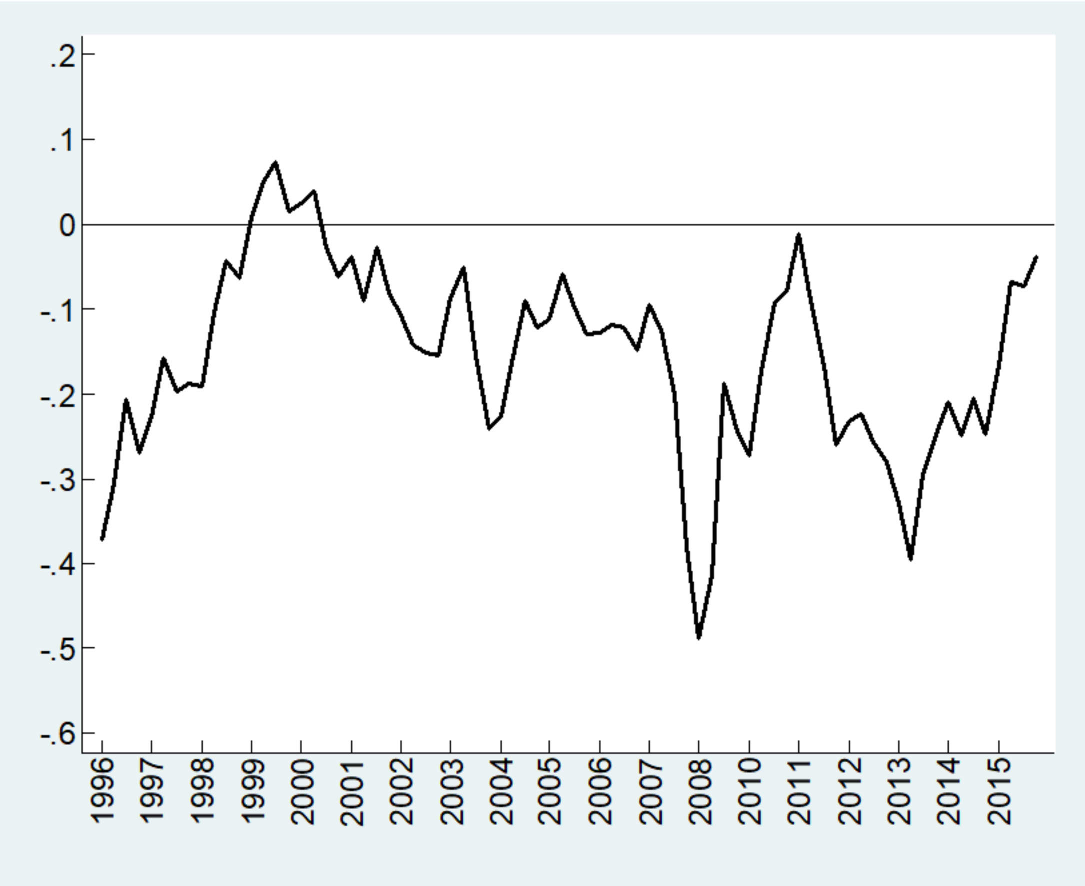

Figure. C2. External Food Sector Cointegrating Vector, fp-1.16er-0.99wfp+3.64, 1996-2015

C.2 The External Non-food Sector

The variables that are considered to analyse the external non-food sector include domestic non-food prices (dnfp), the rupee-US dollar exchange rate (er), and world non-food prices (wnfp). They are found to be nonstationary, but they are stationary in their first difference (see Table A2). Therefore, these variables are I(1) in levels.

Figure C3 plots the log of relative non-food price index from 1996q2 to 2015q1. It is measured as the ratio of the log of world non-food price in terms of local currency (i.e. the product of wnfp and er) to the domestic non-food price (dnfp). It appears that the ration of non-food prices is not stationary. Further, the Johansen method suggests that there is no co-integrating relationship. Thus, we use the Hodrick-Prescott filter to find the trend in non-food relative prices. The deviations of actual non-food relative price from the trend relative price is shown in Figure C4.

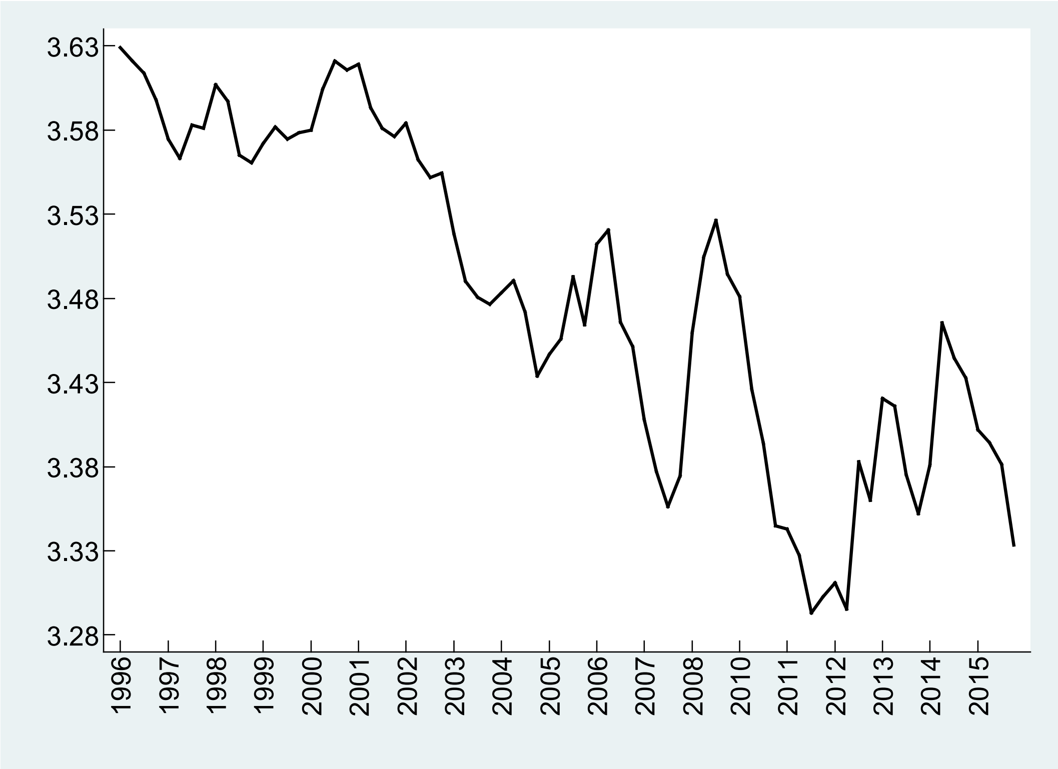

Figure C3. Relative Non-Food Prices 1996-2015

Notes: The relative price of non-food items is calculated as the ratio of the world non-food price (the product of wnfp and er) to the domestic non-food price (dnfp). World non-food price is measured by the producer price index in the US. Domestic non-food price is measured by domestic non-food consumer price index for industrial workers. Exchange rate is measured by the rupee-US dollar exchange rate. Domestic non-food consumer price index for industrial workers and exchange rate come from the Handbook of Statistics on Indian Economy, 2015-16, Reserve Bank of India and producer price index in the US come from Federal Reserve Bank of St. Louis database

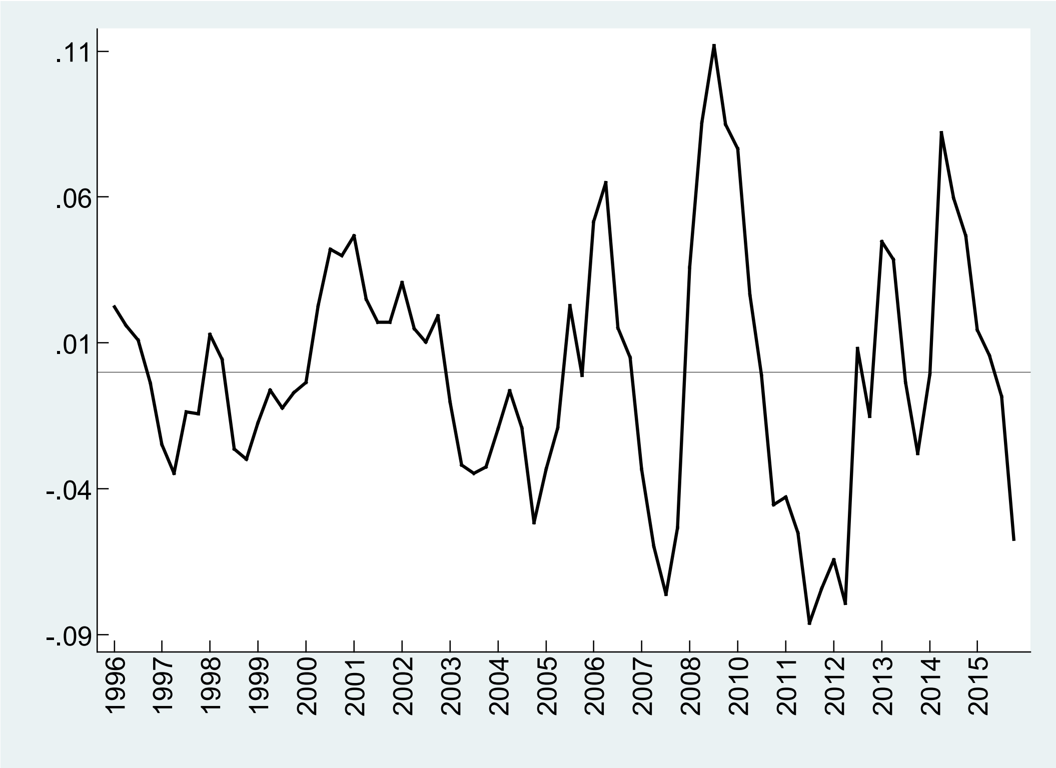

Figure C4. Deviations in the Equilibrium Non-Food Relative Price, 1996-2015

Note: The deviations in the external non-food sector are calculated as the difference between the actual non-food relative price and the equilibrium/trend relative non-food price. The equilibrium non-food relative price is calculated using Hodrick-Prescott filter method. Also see Notes to Fig C3.

C.3 The Domestic Monetary Sector

Modeling the money demand function for India has received attention in the recent past because of financial sector reforms. Several measures were taken to improve the efficiency of financial markets during 1990s. These include the deregulation of interest rates, the removal of restrictions on the inter-bank market, the liquidity adjustment facility, a gradual reduction of the cash reserve ratio, and the introduction of short-term money market instruments such as commercial paper, treasury bills, and certificates of deposit. Now commercial banks are free to set their deposit and lending rates. The bank deposit rate varied between 4.6% and 11.5% during the study period. Therefore, the interest rate may be a good measure of the opportunity cost of holding money.

The variables that we consider likely to affect money demand in India include real GDP (y), the interest rate (i), inflation (infn), the percentage change in the exchange rate (Δ_{12}er), and the percentage change in gold prices (goldp). Table A1 further defines the variables and lists the data sources. All the variables are found to be nonstationary in levels and stationary in their first difference (see Table A2).

We again use the Johansen method (1991) to test for a long-run equilibrium (co-integrating) relationship among these variables. The Akaike Information Criterion and Adjusted Likelihood Ratio test suggest that the optimum lag length is 2. To confirm the optimum lag length, serial correlation tests were also carried out and found that all equations are free from significant serial correlation problems (results available upon request).

We conducted a formal test on whether the intercept is present in the cointegrating vector using the eigen values of restricted and unrestricted models (See Enders, 1995, p.393-394). The calculated value of the corresponding $\chi 2$ statistic is 30.06. With 5 degrees of freedom, the critical value is 11.07, at the 5% level of significance. Therefore, we conclude that the VAR contains no intercept. For this model, we find evidence of two cointegrating vectors using the trace test, but only one cointegrating vector when using the λ-max test. It is argued that "… the results of the trace and λ-max tests can conflict. The λ-max test has the sharper alternative hypothesis. It is usually preferred for trying to pin down the number of cointegrating vectors" (Enders, 1995, p.393). Accordingly, we conclude that there is one cointegrating relationship (i.e. r=1). Table C2 reports the long run estimation results.

The coefficient on the error correction term equals 0.04 and is statistically significant at the 10% level (see Table C2). As the adjustment parameter is significant, the real money stock is likely endogenously determined, and the long-run money demand function is represented by the cointegrating vector. The adjustment coefficients for i, er, and infn are also statistically significant. These findings imply a possible feedback effect. The adjustment parameters for y and goldp are not highly statistically significant (but have reasonable signs and magnitudes). In other words, they might be exogenous. For example, in the long run, actual GDP is primarily determined by potential GDP and the gold price is determined by global demand and supply factors.

Table C2: Cointegration Analysis for the Monetary Sector, 1996-2015

Rank Test						
Null Hypothesis	r=1	$r \leq 1$	$r \leq 2$	$r \leq 3$	$r \leq 4$	$r \leq 5$
Eigen Value	0.45	0.33	0.28	0.12	0.08	0.06
Trace:	121.07** [95.87]	76.41** [70.49]	46.42 [48.88]	21.11 [31.54]	11.06 [17.86]	4.63 [8.07]
λ-max:	44.65** [39.83]	29.98 [33.64]	25.31 [27.42]	10.04 [21.12]	6.42 [14.88]	4.63 [8.07]
Cointegrating vector						
	m-p	y	i	Goldp	er	infn
β_i	1.00 -1.00	-1.312 (-38.25)	0.026 (2.92)	-0.003 (-2.4)	0.007 (2.13)	-0.013 (-1.88)
Adjustment coefficients						
a_i	-0.04* (-1.73)	0.04 (1.63)	-3.77*** (-4.28)	10.37 (0.67)	-19.97** (-2.21)	9.40*** (2.92)
		Weakly exogenous		Weakly exogenous		

Note: The numbers in square brackets are 95% critical values. The figures in parentheses are t-ratios. ***, **, and * indicate significance at 1%, 5% and 10% level, respectively. The VAR includes 2 lags on each variable and three centered seasonal dummy variables.

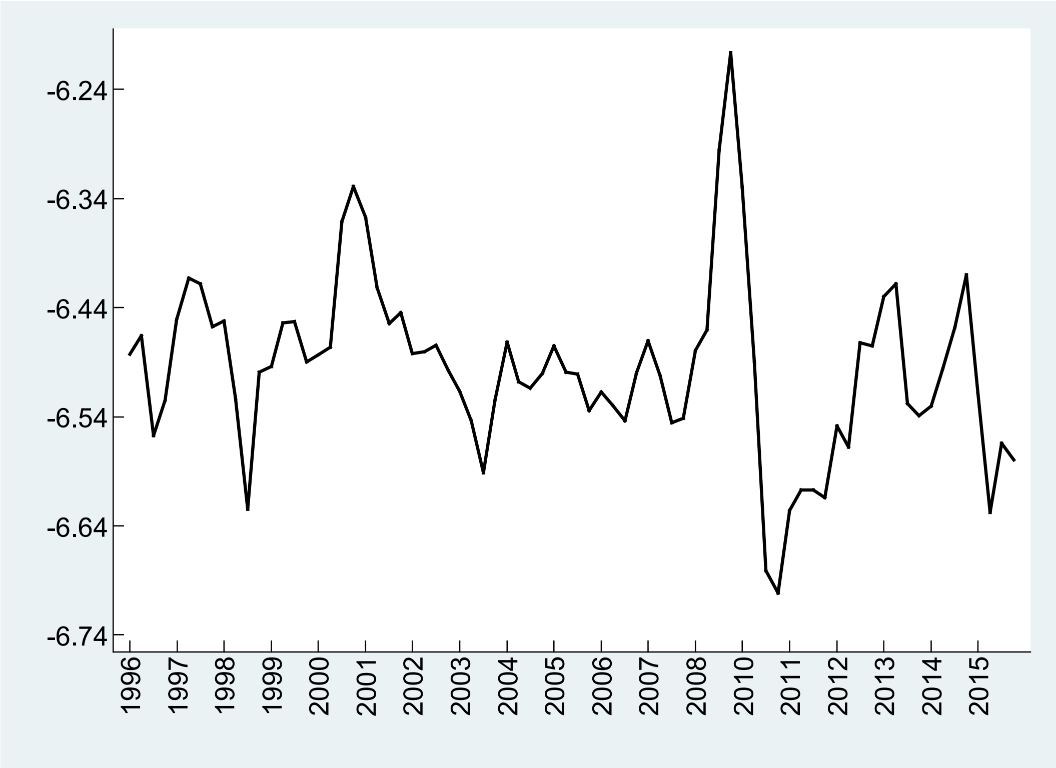

Figure C5. Money Demand Cointegrating Vector, (m-p)-1.31y+0.03i-0.002gold+0.007er-0.012infn, 1996-2015

C.4 The Domestic Non-Agricultural and Agricultural Sectors

The non-agricultural output gap is the deviation of actual non-agricultural output from its potential level and the agricultural output gap is the difference between actual and potential agricultural output. We use data on production of non-agricultural and agricultural output to analyse these sectors. We assume that the demand for goods and services increase along with any increase in potential agricultural and non-agricultural output. Hence, an increase in demand for goods and services does not affect inflation. It is only the deviation from their potential level due to demand or supply shocks that results in changes in the price level.

We have followed three steps to estimate these output gaps. We first estimate seasonally adjusted agricultural and non-agricultural output using US Census Bureau's X-13-ARIMA method. After obtaining their seasonally adjusted levels, we apply the Hodrick-Prescott filter to calculate their trend levels. Finally, the estimated trend output is subtracted from their respective seasonally adjusted output to obtain the respective output gaps. Figure C6 shows the domestic non-agricultural output gap and inflation in India. Figure C7 plots the agricultural output gap and inflation.

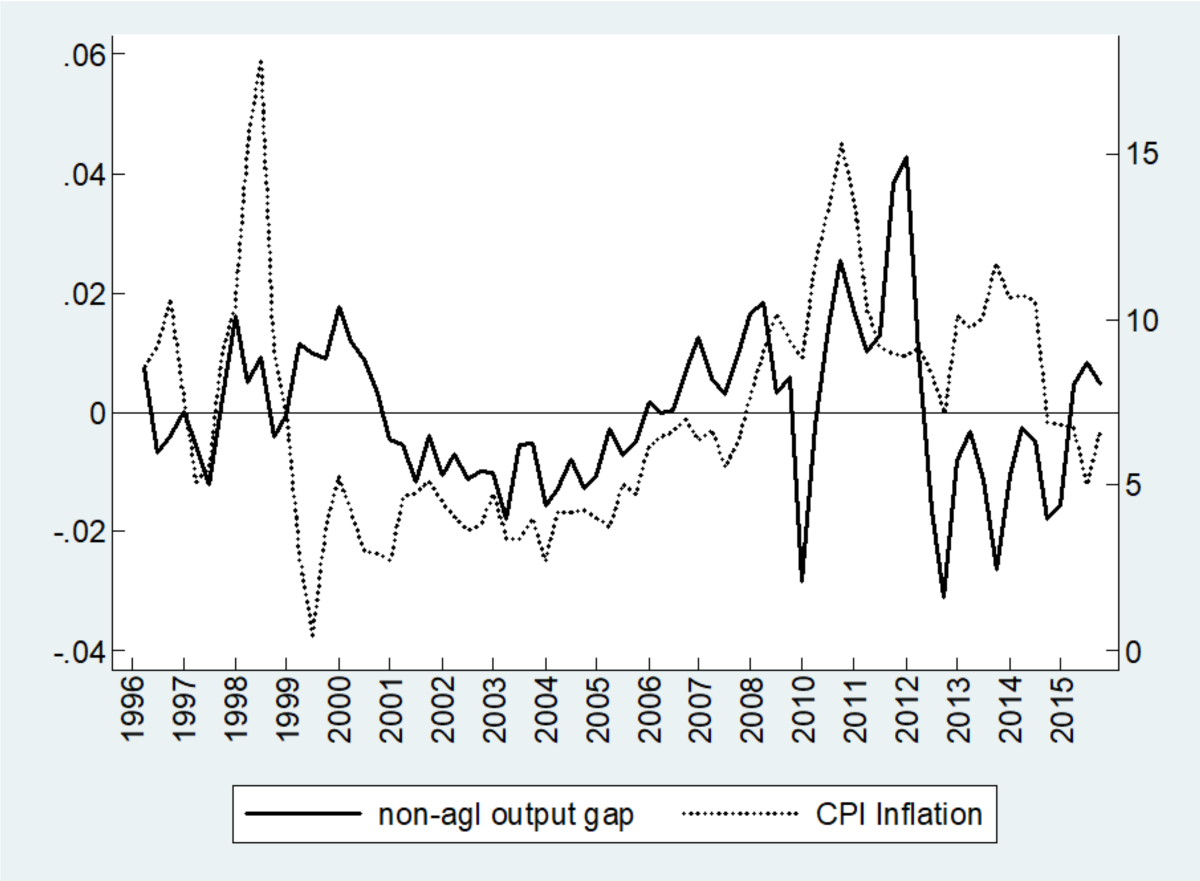

Figure C6. Non-Agricultural Output Gap (left axis) and Annual Inflation, % (right axis) 1996-2015

Notes: Non-agricultural output is the value of real GDP from activities such as mining and quarrying, manufacturing, electricity, gas, water supply and other utilities, construction, trade, hotels, transport, communication, finance, insurance, real estate and business services, and community and social services. Non-agricultural output gap is measured by the deviations of non-agricultural output from its trend value. The trend non-agricultural output is calculated using the Hodrick-Prescott filter. The CPI inflation is measured by the annual percentage change in consumer price index for industrial workers (Base:2001=100). The non-agricultural output and the consumer price index for industrial workers come from the Handbook of Statistics on Indian Economy, 2015-16, Reserve Bank of India..

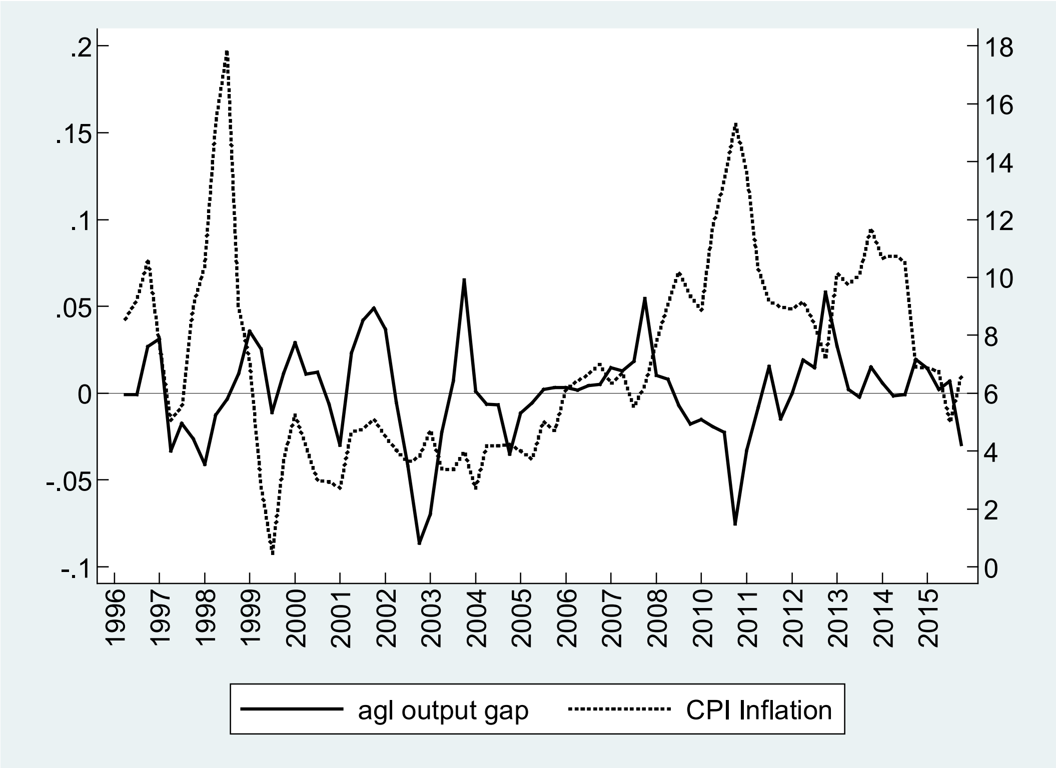

Figure C7. Agricultural Output Gap (left axis) and Annual Inflation, % (right axis) 1996-2015

Notes: Agricultural output is the value of real GDP from agriculture and allied activities. Agricultural output gap is measured by the deviations of agricultural output from its trend value. The trend agricultural output is calculated using the Hodrick-Prescott filter. The CPI inflation is measured by the annual percentage change in consumer price index for industrial workers (Base:2001=100). The agricultural output and the consumer price index for industrial workers come from the Handbook of Statistics on Indian Economy, 2015-16, Reserve Bank of India.