Ind. Jn. of Agri. Econ.
Vol.74, No.2, April-June 2019

Determinants of Food Inflation in India

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ABSTRACT

This paper aims to elucidate the different determinants of food inflation in India over 1997 to 2017. The paper uses a Vector Error Correction Model (VECM), and a Vector Auto Regression Model (VAR).The paper considers both supply and demand-side determinants on an annualised scale. The VECM model finds a long-run relationship between Food Inflation in India, Area under Acreage, Minimum Support Prices (MSP), and the trend in Urban Population. The VAR model finds a relationship between Food Inflation, and the FAO's Food Price Index; Food Inflation, and Total Cost of Cultivation; and Food Inflation and the Long Period Average at I (1).

Keywords: VECM, VAR, Zivot-Andrews test, Philips-Perron unit root test, Johansen's test for Cointegration, Food inflation.

JEL: E31, P44, Q11, Q18.

I

INTRODUCTION

With a population of 1.32 billion (2016 estimate) as per a World Bank Report and the Census of India (2011), and with more than half the population spending more than 50 per cent of their income on food, food inflation becomes an important topic to study. This paper aims to elucidate the different determinants of food inflation in India over 1997 to 2017. The paper uses a Vector Error Correction Model (VECM), and a Vector Auto Regression Model (VAR). The paper considers both supply and demand-side determinants on an annualised scale.

Inflation in India (as per the RBI database on Indian economy) is measured using the Consumer Price Index (CPI), however, until 2014 the Wholesale Price Index (WPI) was used. The switch was to adopt a more representative basket of what an average Indian consumes. The WPI gave more weightage to manufactured goods; while the CPI gave a higher weightage to food articles.[1] Food inflation (here) is the change in the prices of food commodities from YoY. The data finds that over the time period of 1997 to 2017, general inflation has averaged 5.81 per cent, while food inflation has averaged 6.65 per cent, as can be seen in Graph 1.

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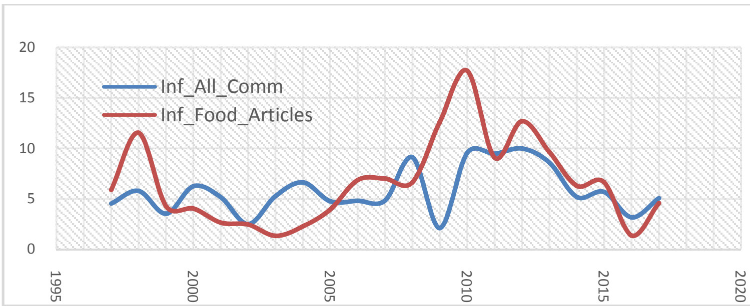
The author would like to thank Mr. Kunal Rahar (Researcher, RBI) for mentoring him and guiding him through the process of writing this paper; Mr. Kamal Gupta (Assistant General Manager, Monitoring & Research Unit, RBI) for also guiding and mentoring the author; and Mr. Shashidharan Sharma for his help with the VAR & VECM frameworks.



Graph 1. General and Food Inflation.

We find that food inflation has generally remained higher than generalised inflation for the past twenty years. There has been more of a convergence of general and food inflation starting around 2012 (when CPI estimates started to be available).[2]

This paper is organised as follows: Section 1 discusses the overall trend in food inflation in India. Section II elucidates literature on food inflation and its determinants in India. Section III – Data: discusses the trends in commodity-specific inflation; and reasons for the price hikes and dips in commodities. Section IV of the paper discusses the methodology. Section V elucidates the models, and the empirical results, and Section VI presents the concluding remarks.

II

LITERATURE REVIEW

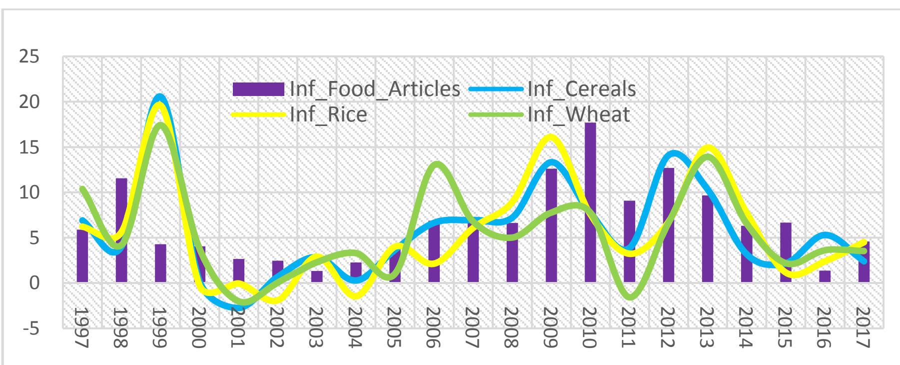
Mishra (2016) argue that while studying the overall effects of food inflation on the Indian economy is important, it is also important to understand the reasons for the variability in food inflation. They found food inflation to be consistently higher than non-food inflation. Furthermore, animal source foods (milk, eggs, meat etc.), processed food (sugar, edible oils), fruits and vegetables (onions, tomatoes, potatoes), and cereals (rice, wheat) were found, by them, to be the primary drivers of food inflation in India. Anand, Kumar and Tulin (2016) suggest that the demand side factors are key determinants of food inflation – they estimate that if private consumption growth picks up to 7 per cent and supply growth remains at its historical level, Indian food inflation is likely to exceed non-food inflation by 2.5 to 3 percentage points per year. Gopakumar and Pandit (2017) state that demand side factors, have been deterministic in the trends in food inflation, especially those of proteins. A paper (Sekhar *et al.*, 2017) by the International Food Policy Research Institute suggests that cereals and edible oils mainly depend on supply-side factors such as production, wage rates, and minimum support prices (MSP); for pulses, the effects of both demand and supply-side factors appears to be equal; while prices of products such as milk, vegetables, fruits, and eggs are driven more by demand side factors. Malhotra and Maloo (2018) find that hikes in MSP, combined with other government interventions in food caused increases in central and state government deficits – these led to inflation in the immediate following years, caused prolonged inflationary pressures, and a rise in inflationary expectations. Malhotra and Maloo (2018) assert that since India is a net exporter of food commodities, there is a mild effect of international food prices on domestic food prices (and food inflation). Gopakumar and Pandit (2017) find a significant relationship between international and domestic food prices. Gulati and Saini (2015) showed that three factors – fiscal deficit, rising farm wages and transmission of the global food inflation together accounted for 98 per cent of the food inflation in India during 1995-96 to December, 2012. This paper considers both demand and supply side factors.

III

DATA

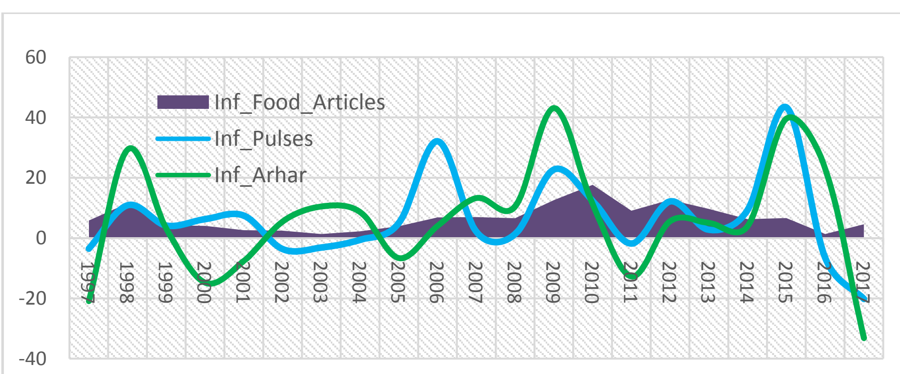
Information about some food commodities[3] have been provided below[4]:

I. *Generalised Cereals and Wheat and Rice (Graph 2)*



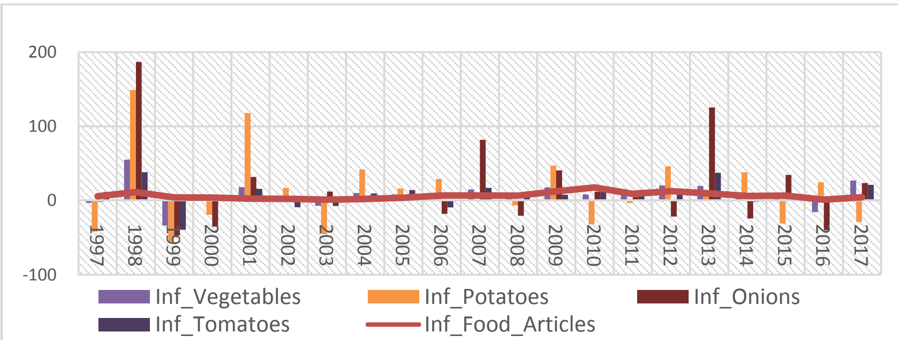
Graph 2. Food, Cereals, Rice and Wheat Inflation.[5]

II. *Generalised Pulses, and Arhar (Graph 3)*



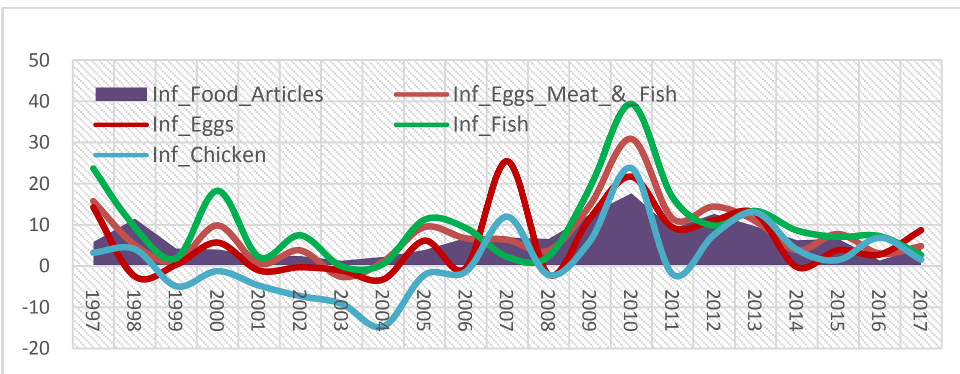
Graph 3. Food, Pulses and Arhar Inflation.[6]

III. *Generalised Vegetables, and Onions, Tomatoes and Potatoes (Graph 4)*



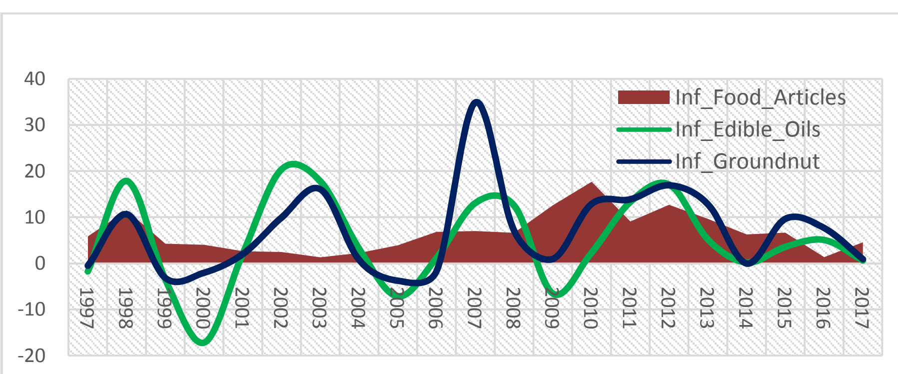
Graph 4. Food, Vegetables, Potatoes, Onions and Tomatoes Inflation.[7]

IV. *Eggs, Fish and Chicken Inflation (Graph 5)*



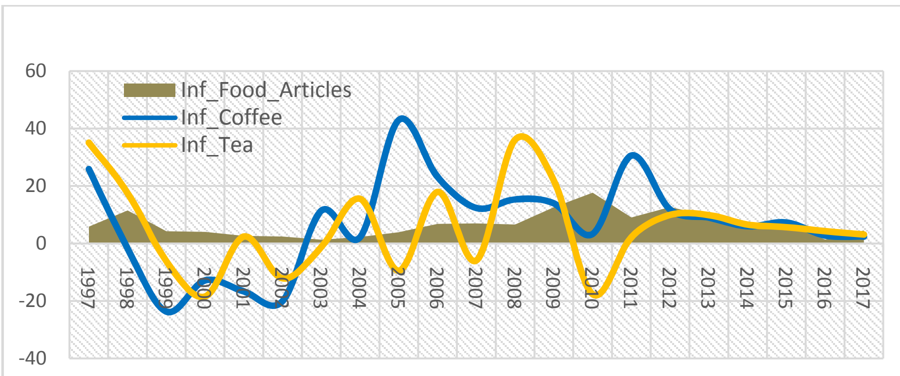
Graph 5. Food, Eggs Meat and Fish, Eggs, Chicken, and Fish[8]

V. *Edible Oils, and Groundnut (Graph 6)*



Graph 6. Food, Edible Oils and Groundnut Inflation.[9]

VI. *Tea and Coffee Inflation (Graph 7)*



Graph 7. Food, Coffee and Tea Inflation.[10]

IV

METHODOLOGY

The variables whose data was collected are: (i) World Prices;[11] (ii) Long Period Average;[12] (iii) Percentage of Urban Population;[13] (iii) Minimum Support Price (MSP);[14] (iv) Cost of Cultivation;[15] (v) Acreage, Yield and Production;[16] (vi) Food Inflation (and commodities);[17] (vii) Other Variables.[18]

To determine the effects of different variables on food inflation a Vector Error Correction Model (VECM),[19] and a Vector Auto-Regression (VAR) model[20] were used. The first step in the modelling process was selecting an optimal lag where there is no, to very little autocorrelation in the data (within a 95 per cent confidence band). This was achieved using several different lag selection criteria – Akaike Information Criterion (AIC), Final Prediction Error (FPE), Hannan-Quinn Information Criterion (HQIC), and Schwarz's Bayesian Information Criterion (SBIC). To check whether the variables under consideration can be used in a VECM and VAR framework, we had to check whether there was a structural break in the data – this was achieved through the Zivot-Andrews Unit Root Test, which checks for breaks in trend, intercept, and both. After determining the existence of a structural break, those variables with a break in the data were dropped/not considered in the model. The next condition to check was whether an individual variable was stationary or not, for this condition, the Philips Perron Test for Unit Root was used – trend stationary and non-trend stationary conditions were both checked. Those variables that were stationary were dropped/not considered in the VECM model, however, for the VAR model, stationary conditions were checked at I (1), if they were found to be stationary, then they were included in the model, or else they were dropped. The optimal lag is again determined, but this time with the set of all variables – that are to be included in the model. When using a VECM, after determining the optimal lag, the Johansen Test for

Cointegration is used to determine the number of cointegrating equations. A VECM model is then applied. A VAR model can be applied after choosing variables that are stationary at I(0) or I (1). To check for robustness after, the LM test for serial auto-correlation, and the Jarque-Bera test for normally distributed errors were performed. The Wald Test was used to check for short-run causality in the VECM model, and the Granger-Causality test was applied to the VAR framework. The 1 per cent significance level was considered for all the tests to ensure reliability and robustness of the data.

V

EMPIRICAL RESULTS

The first model (VECM specification) considers the effect of average acreage, average MSP, and percentage of urban population on food Inflation – these results can be seen in Tables 1 and 2.

TABLE 1. SHORT TERM RELATIONSHIP BETWEEN FOOD INFLATION AND THE EXPLANATORY VARIABLES

Vector error-correction model

Sample:	1999 - 2017	Number of obs =	19
		AIC =	16.08536
Log likelihood =	-125.8109	HQIC =	16.31249
Det(Sigma_ml) =	6.630924	SBIC =	17.42746

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_Inf_Food_Art~s	6	2.64309	0.6712	26.53821	0.0002
D_Average_Acre~e	6	.50665	0.2668	4.730947	0.5788
D_Average_MSP	6	81.7671	0.6123	20.53534	0.0022
D__UrbanPop	6	.063334	0.9739	484.1324	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_Inf_Food_Articles						
_ce1 L1.	-.6610903	.1637095	-4.04	0.000	-.981955	-.3402257
Inf_Food_Articles LD.	-.1249882	.1613136	-0.77	0.438	-.4411569	.1911806
Average_Acreage LD.	2.603255	1.26028	2.07	0.039	.1331527	5.073358
Average_MSP LD.	.0199438	.0099908	2.00	0.046	.0003622	.0395253
_UrbanPop LD.	-73.44466	24.94773	-2.94	0.003	-122.3413	-24.54802
_cons	-1.349957	3.793144	-0.36	0.722	-8.784383	6.084469

TABLE 2. LONG TERM RELATIONSHIP BETWEEN FOOD INFLATION AND THE EXPLANATORY VARIABLES

Identification: beta is exactly identified

Johansen normalization restriction imposed

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
_ce1						
Inf_Food_Articles	1	.	.	.	.	.
Average_Acreage	4.799235	2.349927	2.04	0.041	.1934636	9.405007
Average_MSP	.0383908	.0052298	7.34	0.000	.0281407	.048641
UrbanPop	-12.89081	1.778812	-7.25	0.000	-16.37721	-9.404399

Table 1 shows us the short-term relationship between food inflation and the explanatory variables – average acreage, average MSP, and percentage of urban population. The coefficient of interest in Table 1 is the coefficient of _ce1, which is -0.66 (significant at 1 per cent since p=0.000). This -0.66 implies that (i) there is long-run causality that flows from average acreage, average MSP, and percentage of urban population to inflation in food articles, and (ii) 66 per cent of the error in food inflation is corrected by the combined effect of average acreage, average MSP, and percentage of urban population in 1 lag. The adj-R^2 of this short-run relationship and short-run model is 67 per cent.

Table 2 shows the long run relationship between food inflation and the explanatory variables. The long run relationship equation that we get from the same is:

$$Inf\_Food\_Articles = \underset{(-7.25)}{12.89\,UrbanPop} - \underset{(2.04)}{4.79\,Average\_Acreage} - \underset{(7.34)}{0.038\,Average\_MSP} + \_ce1$$

Therefore we see that there appears to be a significant effect on food inflation due to the changes in urban population in the long run, average acreage also has a significant negative relationship, while MSP has a mild negative effect. The Wald Test was used to check the short run causality, and it was found that short-run causality flows from all the variables – percentage of urban population, average acreage, average MSP – individually, and also as a combined effect. No autocorrelation was found and the errors were found to be normally distributed.

The second model (VAR specification) looks at the relationship between food Inflation, and the FAO's Food Price Index (International World Food Price Proxy) – the result can be seen in Table 3.

Table 3 finds that there is a significant relationship between food inflation, and the FAO's Food Price Index (International Food Price Proxy) (R^2 is 61.38 per cent). We find that individually, only the second lag for the FAO Food Price Index has a significant effect on Food Inflation, however, we the Granger Causality test finds that there is an individual causal effect flowing from this Food Price Index to Food Inflation. We further compute the Forecast-Error Variance Decomposition (FEVD), and Impulse Response Functions (IRFs) of these variables, which can be seen in Figure 1.

TABLE 3. RELATIONSHIP BETWEEN FOOD INFLATION AND FAO'S FOOD PRICE INDEX

Vector autoregression

Sample:	2001 - 2016	Number of obs	=	16
Log likelihood =	-98.60648	AIC	=	14.57581
FPE =	9857.491	HQIC	=	14.62032
Det(Sigma_ml) =	772.8273	SBIC	=	15.44497

Equation	Parms	RMSE	R-sq	chi2	P>chi2
FAO_Food_Price~x	9	18.2054	0.7413	45.84985	0.0000
Inf_Food_Artic~s	9	3.49326	0.6138	25.43086	0.0013

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Inf_Food_Articles						
FAO_Food_Price_Index						
L1.	.0065204	.0412226	0.16	0.874	-.0742745	.0873153
L2.	.1621703	.0388445	4.17	0.000	.0860366	.2383041
L3.	-.0074071	.0476014	-0.16	0.876	-.1007041	.0858898
L4.	-.0218022	.0492938	-0.44	0.658	-.1184164	.0748119
Inf_Food_Articles						
L1.	-.2668401	.2827494	-0.94	0.345	-.8210186	.2873385
L2.	.3128513	.3735224	0.84	0.402	-.4192392	1.044942
L3.	-.4169645	.2837578	-1.47	0.142	-.9731196	.1391906
L4.	-.4658454	.2080994	-2.24	0.025	-.8737126	-.0579781
_cons	-.5784535	.7671786	-0.75	0.451	-2.082096	.9251889

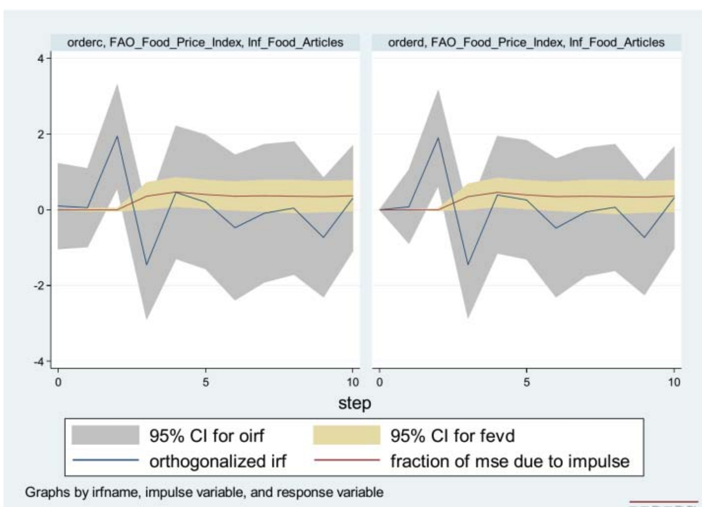


Figure. 1.

Figure 1 shows that an increase in the index causes an increase in food inflation after the first lag (Indian food prices should mirror the international[21] market to a large extent since India is a large trader in various food commodities), fall in food inflation until about three lags (as the local Indian government intervenes to arrest the rising prices), and almost stabilisation of prices close after five lags. The fraction of MSE (Mean Standard Error) of the response (Food Inflation) due to impulse (FAO

Food Price Index) shows the amount of MSE that is caused by the impulse (Food Price Index) – hence, in this case, at around 3 lags, about 0.3 (or 30 per cent) of the MSE in Food Inflation is explained by the international food price index. There was found to be no autocorrelation in the post-estimation, and the errors were normally distributed.

The third model (VAR specification) looks at the relationship between Food Inflation, and the Total Cost of Cultivation for selected food commodities in India – the results are shown in Table 4.

TABLE 4. RELATIONSHIP BETWEEN FOOD INFLATION AND TOTAL COST OF CULTIVATION

Vector autoregression

Sample:	1999 - 2016	Number of obs =	18
Log likelihood =	-255.4257	AIC =	29.49175
FPE =	2.27e+10	HQIC =	29.55996
Det(Sigma_ml) =	7.25e+09	SBIC =	29.9864

Equation	Parms	RMSE	R-sq	chi2	P>chi2
Total_CC	5	35163.4	0.0641	1.233042	0.8726
Inf_Food_Artic~s	5	3.53482	0.2730	6.757663	0.1493

	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
Inf_Food_Articles						
Total_CC						
L1.	-.0000475	.0000239	-1.99	0.047	-.0000943	-6.68e-07
L2.	-.000031	.0000394	-0.79	0.432	-.0001082	.0000462
Inf_Food_Articles						
L1.	-.2134926	.2208197	-0.97	0.334	-.6462913	.219306
L2.	-.0417866	.2028563	-0.21	0.837	-.4393777	.3558044
_cons	1.62552	1.218706	1.33	0.182	-.7631002	4.014139

We find that there is somewhat of a significant relationship between food Inflation, and the total cost of cultivation (R^2 is 27.3 per cent). We find that individually, only the first lag for the total cost of cultivation has a significant effect on Food Inflation, however, the Granger Causality test finds that there is an individual causal effect flowing from the total cost of cultivation to food Inflation. We further compute the Forecast-Error Variance Decomposition (FEVD), and Impulse Response Functions (IRFs) of these variables, which can be seen in Figure 2.

This result in Figure 2 shows that an increase in Total Cost of Cultivation causes a dip in food inflation until the second lag (this happens because of supply chain inefficiencies, and farmers, though they face higher costs, are not able to pass on the prices to the consumers), and then the inflation rises as the truer costs of production start to reflect in consumer prices for food commodities. After the third/fourth lag, the impulse ceases to have an effect on the response. The fraction of MSE (Mean

Standard Error) of the response (Food Inflation) due to impulse (Total Cost of Cultivation) shows the amount of mse that is caused by the impulse (Total Cost of Cultivation) – hence, in this case, starting at around 2 lags, about 0.1 (or 10 per cent) of the MSE in food inflation is explained by total cost of cultivation. Mild autocorrelation was found in post-estimation, and errors were not found to be normally distributed.

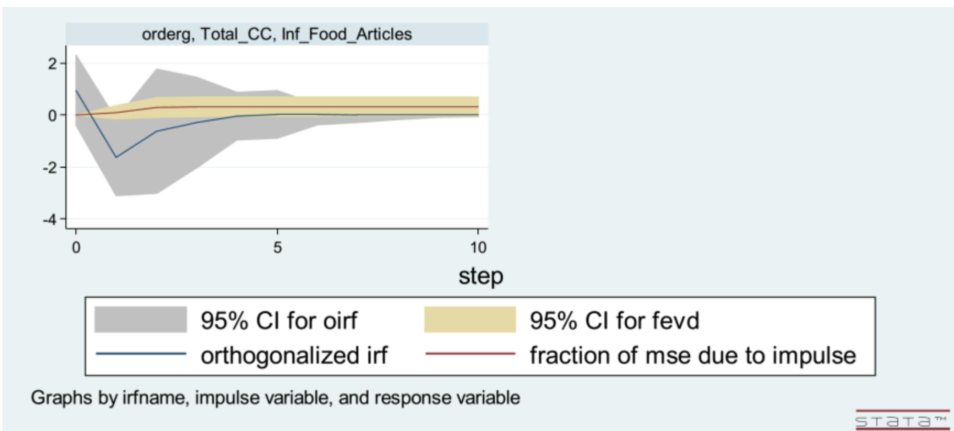


Figure 2.

The fourth model (VAR specification) looks at the relationship between Food Inflation, and the Long Period Average (Rainfall).[22] This can be seen in Table 5.

TABLE 5. RELATIONSHIP BETWEEN FOOD INFLATION AND LONG PERIOD AERAGE (RAINFALL)

Vector autoregression

Sample:	1998 - 2016	Number of obs =	19
Log likelihood =	-121.5494	AIC =	13.42626
FPE =	2335.148	HQIC =	13.47673
Det(Sigma_ml) =	1235.12	SBIC =	13.7245

Equation	Parms	RMSE	R-sq	chi2	P>chi2
Inf_Food_Artic~s	3	3.51558	0.2774	7.293485	0.0261
LPA_Damp	3	11.9456	0.3993	12.63202	0.0018

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Inf_Food_Articles						
Inf_Food_Articles L1.	-.3505522	.187275	-1.87	0.061	-.7176044	.0165
LPA_Damp L1.	-.1047005	.0528735	-1.98	0.048	-.2083307	-.0010702
_cons	-.4653706	.7415088	-0.63	0.530	-1.918701	.98796

We can see from Table 5 that there is somewhat of a significant relationship between Food Inflation, and the Long Period Average (LPA) (R^2 is 27.74 per cent). We find that individually, the LPA affects the first lag of Food Inflation. The Granger Causality test finds that there is an individual causal effect flowing from the LPA to Food Inflation. We further compute the Forecast-Error Variance Decomposition (FEVD), and Impulse Response Functions (IRFs) of these variables, which can be seen through Figure 3.

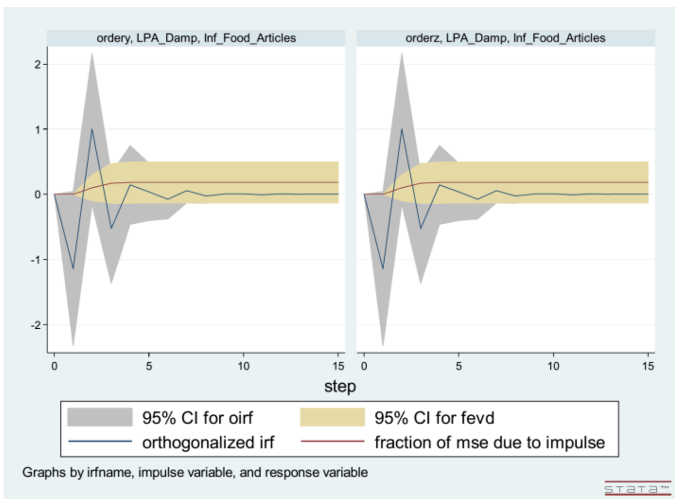


Figure 3.

Figure 3 shows that an increase in the Long Period causes a dip in food inflation for one lag (a good rainfall implies a good harvest, which leads to higher supply, which subsequently lowers prices), and then the inflation rises until about two and a half lags (potential cobwebb phenomenon at play). After the fifth lag, the impulse ceases to have an effect on the response. The fraction of MSE (Mean Standard Error) of the response (Food Inflation) due to impulse (Long Period Average) shows the amount of MSE that is caused by the impulse (Long Period Average) – hence, in this case, starting at around 2 lags, about 0.1 (or 10 per cent) of the MSE in Food Inflation is explained by the Long Period Average. No autocorrelation was found, and errors were normally distributed.

VI

CONCLUDING REMARKS

We can see from the preceding models that there are various determinants of food inflation in India – total cost of cultivation, percentage of urban population, average minimum support price, average acreage, the FAO's food price index, and long period average. It may be important for the government to take note of these variables when looking to mitigate or decelerate food inflation in India.[23]

With a large population in India spending more than 50 per cent of their income on food; and with about 300,000 farmers having committed suicides between the years of 1998-2018 due to the absence of fair prices – mainly due to the existence of middlemen – there is utmost need to focus on food inflation, and to look past just the MSP, PDS, and other existing government programmes.

Received August 2018. *Revision accepted June 2019.*

NOTES

1) A caveat to note here is that the use of both the WPI and CPI can cause discrepancies in the analysis of the data – the divergence (and therefore a limitation) rests largely on the weightage differences of different items in both the CPI and WPI, this in turn can lead to either under or over evaluation of actual inflation (and food inflation) numbers which can skew the analysis one way or the other. The other limitation with the splicing of these indices arises due to the fact that number of items included (for calculation) in WPI are much higher than the CPI, furthermore, the number of price quotations are also vastly different between the WPI and CPI, which further makes a convergence tough. The third and final limitation is the use of the geometric mean for the calculation of the CPI, and the use of the weighted mean for the WPI, which furthers the divergence. This paper tries to reconcile point 1 (weightage of different items), and point 3 (use of the geometric mean v/s weighted mean), but lacks reconciliation of point 2 (differences in the amount of data collected) – this is an important point to note for all readers. Though the hope was to use CPI estimates for all twenty years to get the best representative analysis, lack of availability of CPI estimates guided the use of both – however, this was hoped to be corrected in some part by 2 actions: (i) looking at the analysis (though not included here) in the period when the WPI was used, and then in the period that the CPI was used, then comparing the data to look at trends, and subsequently looking at an overall analysis and contrasting it with these two distinct time periods (when the two different metrics were used); (ii) using minimal smoothening techniques to perpetuate some level of equivalence between these two metrics to get to a more thorough and unbiased analysis.

2) For the purpose of this paper, WPI estimates have been taken until 2012, and CPI estimates have been used after that.

3) That have a significant weight in both CPI and WPI estimates

4) The reasons for some of the volatility in the prices of these goods is provided in the footnotes.

5) A report by the Planning Commission mentions how one of the reasons of the price rise in 1998-1999 was the increase in procurement prices. The other reason is the fall in the availability of cereals during 1997-98 and 1998-99. The prices of wheat increased sharply during the year 1998-99 because of the poor wheat output during the preceding year. The output of wheat fell by 7.62 per cent from 69.35 million tonnes during 1996-97 to 66.35 million tonnes during 1997-98. Similarly, the output of coarse cereals fell by 10.85 per cent during 1997-98, from 34.1 million tonnes to 30.4 million tonnes.

6) We find that prices of pulses (and Arhar) are highly erratic. A study by CRISIL has observed that inflation in pulses follows a cyclical pattern, with prices shooting up every 2-3 years – between 2006-2017 there have been as many as four such cycles. Furthermore, upon decomposing the data for the past 12 years, we observe that gram and tur/arhar have experienced high price volatility and dominated the cyclical price movements in pulses in the past 6 years. Second, there is a cobweb phenomenon (Joshi *et al*., 2017 discusses this in their paper) at play, wherein production responds to prices with a lag, causing a recurring cycle of rise and fall in output and prices. This has to do with the fact that farmers base their sowing decisions on the prices observed in the previous period, and accordingly over- or under-produce the crops, triggering a price cyclicality. Restrictions on export and private stockholding have been another supply side factor in this phenomenon.

7) The prices of vegetables in India show extremely high levels of volatility. A report by the Competition Commission of India found that the onion market is plagued by large numbers of traders, the practice of cartelisation, and also hoarding. "Collusion" was also identified as a major hurdle in fair trade (Chengappa *et al*., 2012). Furthermore, market structure of onion is unilaterally dictated by the traders, not farmers. Minimal role of farmers in price discovery due to low size of average farm holdings—1.15 to 1.3 acre, unfavourable weather conditions and price

risk are the reasons for the situation. Furthermore, approximately 18 per cent of the country's fruits and vegetables' production goes to waste every year because there aren't enough cold storage facilities as per the Central Institute of Post-Harvest Engineering and Technology.

8) The prices of these products fell from 1997 until about 1999 because of an increase in production. A paper by the International Food and Agribusiness Management Review found that India's poultry industry had been growing exponentially, with (i) genetic progress in poultry strains for meat and egg production; (ii) better understanding of nutrition fundamentals; and (iii) disease control (Hellin *et al*., 2015). This is one of the primary reasons why there was found to be deflation in prices of chicken until about 2004. With the price boom in fish prices in 2009-2010, an article by The Hindu finds that it was due to a moratorium on fishing with the help of mechanized boats that was imposed that year. Though it was only imposed for a 45 day period, prices took some time to adjust and get back to levels closer to those of general food inflation.

9) The price spike in edible oils during 1998-99 was due to the fact that the business was severely hit by the deaths that occurred from dropsy that broke out as a result of the consumption of adulterated mustard oil. The majority of state governments banned the sale of loose mustard oil which severely shook the edible oil market (Sharma and Kumar, Planning Commission, 2001). The subsequent dip in prices was attributed to the fact a decrease came about in world prices of edible oils (specifically palm oil) and the Indian edible oil market mimicked this movement (as suggested by Briggs *et al*. (2011) and Anderson (2000) in their respective papers).

10) The price dip of tea starting in 1997 can be attributed to the fact that many US firms started to sell tea at below the cost price, this, in turn hurt Indian exports and there was a subsequent over-supply which led to a drop in prices. In 2000, India, along with six other European nations filed a complaint against the U.S. – an act called the Continued Dumping and Subsidy Offset Act (U.S.) was declared illegal by the WTO and this in turn helped Indian exports of tea and prices got some relief. Papers by the Integrated Coffee Association and the Articles in The Guardian suggests these reasons (Kollewe, 2011; Osorio, 2002).

11) The world prices for different commodities were taken from the World Bank's Pink Sheet. The data was provided in USD, to convert the data into Rupees, the average exchange rate was taken (Bank of England, 2018; Exchange Rate, RBI, 2018). The raw data was converted into "kilograms". The commodities whose world prices were taken are – Rice, Wheat, Chicken, Fish, Prawn, Coconut Oil, Palm Oil, Soyabean Oil, Groundnut Oil, Sugar, Coffee, Tea, Banana, and Milk (Reed and Royales, 2014; Aicha Couibaly, 2013). The average world food price inflation was also taken (Wiggins, 2010). This data was gathered from the FAO's Food Price Index and also the US Department of Agriculture.

12) The Long Period Average is the average of rainfall received in India between 1951 to 2001 (50 years). Here, for the purpose of the study, the percent deviation from the Long Period Average is taken from various reports of the Indian Meteorological Department.

13) This was taken as a factor to discuss changing dietary patterns with a move to urban areas, and how they subsequently affect food inflation. The data was gathered from the CEIC website.

14) The minimum support price data was taken from various reports from the Commission for Agricultural Costs and Prices (CACP). Minimum support prices were taken for Sugarcane, Paddy, Tur (Arhar), Safflower, Groundnut, Sunflower, Soyabean, Seasum, Wheat, and Mustard.

15) Cost of cultivation estimates were taken from the Directorate of Economics and Statistics, Ministry of Agriculture, and through its various "Agricultural Statistics at a Glance" reports. Since the data provided cost of cultivation estimates of each commodity for different states, a weighted average was taken to estimate the cost of cultivation for each commodity. The weights were the production of that specific commodity relative to the total production across all of India of that specific commodity in a given year. Cost of cultivation estimates were taken for Tur (Arhar), Groundnut, Soyabean, Wheat, Onion, Potato, and Sugarcane

16) The data was gathered from the National Horticulture Research and Development Foundation; Ministry of Agriculture and Farmers Welfare, Department of Agriculture, Cooperation and Farmers Welfare, Directorate of Economics and Statistics; and monthly reports for commodities such as onions, and potatoes. The data was gathered for Sugarcane, Paddy, Tur (Arhar), Potato, Groundnut, Sunflower, Soyabean, Onion, Wheat, Mustard, and Banana.

17) Food inflation was evaluated using WPI data from 1997-2012, and then CPI data was used from 2012-2017. The data was taken from DBIE and the website of the Office of the Economic Advisor. Commodity specific inflation was also considered. The commodities whose inflation was covered were – Cereals (General), Rice, Wheat, Pulses (General), Tur/Arhar, Vegetables (General), Potatoes, Onions, Tomatoes, Fruits (General), Banana, Apple, Milk, Eggs Meat and Fish (General), Eggs, Fish, Chicken, Edible Oils (General), Groundnut, Tea, Coffee, Sugar and Products (General), and Sugarcane.

18) Diesel Prices (The prices of diesel were taken as a proxy for transportation costs. The prices were taken from a Reuters report discussing fuel prices in India, and also from an Indian Oil Corporation website report); Population (Population growth was taken as a demand side factor. With the census being conducted every 10 years, the data of each year was estimated using the average population growth rate in each year – estimated by the World

Bank); Per Capita Income (This was also taken as a demand side factor. Again, data from the World Bank was used. This data is in PPP Dollars – the standard (adjusted for prices) for per capita income globally; Money Supply (Currency in Circulation) (This data was gathered from the Database for the Indian Economy website that is under the Reserve Bank of India. This too was a demand side factor to discuss availability of hard cash and its effect on food inflation); Core Inflation (Inflation Excluding Food and Fuel) Data was taken from the website of the Office of the Economic Advisor – which comes under the Department of Industrial Policy and Promotion (DIPP), Ministry of Commerce and Industry – for WPI data (until 2012), and the CPI data was taken from the DBIE website (2012-2017). The weights of individual commodities was also taken from these websites. The weighted core inflation (excluding food and fuel) was then calculated).

19) A standard VAR for M endogenous variables can be transformed into a VECM that can be represented as follows

$$\nabla \mathbf{y}(t) = \Gamma \mathbf{y}(t-\rho) + \sum_{j=1}^{\rho-1} \Pi_j \nabla \mathbf{y}(t-j) + \varepsilon(t)$$

Assuming that there is a set of observations Trunning from $t = 0$ to $t = T-1$. Let the observations on $\nabla y(t)$for t = 0, 1…T-1 be collected in a successive row vectors which together make a matrix Y of order TxM. Similarly, the observations on $\nabla y(t-1), \ldots, \nabla y(t-\rho+1)$are collected in a matrix X_2 of order TxM$(\rho-1)$ and let X_1 is the matrix of successive observations on $y(t-\rho)$. Then the system of equations is

$$Y = X_1B_1 + X_2B_2 + \varepsilon = XB + \varepsilon$$

Where $B_1 = \Gamma'$ and $B_2 = [\Pi'_1, \ldots, \Pi'_{\rho-1}]$The hypothesis of cointegration is that the MxM matrix $B_1 = \Gamma'$ is of rank S<M. This is equivalent to the proposition that $B_1 = A\Delta'$ where A has order MxS and Δ' has order SxM and both matrices are of rank S. The log-likelihood function of the model that needs to be optimized to obtain parameter estimates has the following form

$$L^*(B, \epsilon) = -\frac{MT}{2}\log(2\pi) - \frac{T}{2}\log|\epsilon| - \frac{1}{2}Trace\{\varepsilon'\varepsilon\,\epsilon^{-1}\},$$

wherε is the variance covariance matrix of the VECM.

20) A VAR model describes the evolution of a set of k variables over the same sample period (t = 1, ..., T) as a linear function of only their past values. The variables are collected in a k × 1 vector y_t, which has as the i[th] element, $y_{i,t}$, the observation at time "t" of the i[th] variable.

A p-th order VAR, denoted VAR(p), is

$y_t = c + A_1y_{t-1} + A_2y_{t-2} + \ldots + A_py_{t-p} + e_t$

where the l-periods back observation y_{t-l} is called the l-th lag of y, c is a k × 1 vector of constants (intercepts), A_i is a time-invariant k × k matrix and e_t is a k × 1 vector of error terms, satisfying

1) $E(e_t) = 0$ – every error term has mean as 0;
2) $E(e_te'_t) = \Omega$ – the contemporaneous covariance matrix of error terms is Ω (a k × k positive-semidefinite matrix);
   $E(e_te'_{t-k}) = 0$ for any non-zero k — there is no correlation across time; in particular, no serial correlation in individual error term.

21) These prices and estimates are gathered from various sources such as the world bank, international estimates on commodity markets, international sources on prices of fish, milk & dairy, shrimp, and estimates by the United Nations on what happened to the world food prices and why. Reports by the USDA also help in providing supporting data

22) The Long Period Average here has been dampened by 0.01 to eliminate the existence of structural breaks in the data.

23) A caveat here to consider is that there are different definitions for Rural and Urban as defined by the Census, and those that are defined by state governments, for example, census towns are defined as "rural" when it comes to state government definitions. The implication here is that when looking at the rural-urban migration, much of it may be to "census towns" which have a large presence of agricultural markets – this has effects on food prices and food inflation, and also on the numbers that are reported for the same (though this analysis is beyond the scope of this paper for now.

REFERENCES

Anand, Rahul *et al*. (2016), *Understanding India's Food Inflation: The Role of Demand and Supply Factors*, International Monetary Fund. www.imf.org/external/pubs/ft/wp/2016/wp1602.pdf.

Anderson, J.W. (2000), "The Surge in Oil Prices: Anatomy of a Non-Crisis" AGECONSEARCH, Resources for the Future, April. ageconsearch.umn.edu/bitstream/10463/1/dp000017.pdf.

Bandara, Jayatilleke S. (2013), "What is Driving India's Food Inflation? A Survey of Recent Evidence", *South Asia Economic Journal*, Vol.14, No.1, 9 May, pp.127–156, doi:10.1177/ 1391561413477944.

Bank of England (2018), "U.S. Dollar to Indian Rupee Spot Exchange Rates for 2018 from the Bank of England" *The Pound Sterling Live - Today's Rolling Coverage of the British Pound Sterling*, www.poundsterlinglive.com/bank-of-england-spot/historical-spot-exchange-rates/usd/USD-to-INR.

Briggs, Phil, *et al*. (2011), "Fluctuations in the International Prices of Oil, Dairy Products, Beef and Lamb between 2000 and 2008: A Review of Market Specific Demand and Supply Factors" *RBNZ*, Reserve Bank of New Zealand, May. www.rbnz.govt.nz/-/media/ReserveBank/Files/Publications/ Discussion%20papers/2011/dp11-02.pdf.

Burnham, Kenneth P. and David R. Anderson (2002), *Model Selection and Multimodel Inference*, Springer.

CEIC, "India Labour Force Participation Rate", www.ceicdata.com/en/indicator/india/labour-force-participation-rate.

Chand, Ramesh (2010), "Understanding the Nature and Causes of Food Inflation", *Economic and Political Weekly*, Vol.45, No. 9, 27 February.

Chengappa, P.G., *et al*. (2012), "Competitive Assessment of Onion Markets in India", Competition Commission of India. www.cci.gov.in/sites/default/files/AO.pdf.

Coulibaly, Aicha (2013), *The Food Price Increase of 2010-2011: Causes & Impacts*. Library of Parliament, *The Food Price Increase of 2010-2011: Causes & Impacts*.

Directorate of Economics & Statistics, *Cost of Cultivation*, Department of Agriculture, eands.dacnet.nic.in/Cost_of_Cultivation.htm.

Energy Information Administration - (EIA) – Independent Statistics and Analysis, "Annual Average Crude Oil Spot Price, 2000-2011" *EIA*, U.S. www.eia.gov/todayinenergy/detail.php?id=4550.

Food and Agriculture Organization of the United Nations (2009), *What Happened to World Food Prices and Why?Rome.*

Food and Agriculture Organization of the United Nations (2011), *Food Outlook: Global Market Analysis*.

Food and Agriculture Organization of the United Nations "International Fish Prices", www.fao.org/in-action/globefish/fishery-information/resource-detail/en/c/338601/.

Food and Agriculture Organization of the United Nations, "Milk and Dairy", www.fao.org/economic/est/est-commodities/dairy/en/.

Gopakumar, K.U. and Vishwanath Pandit (2017), "Food Inflation in India: Protein Products", *Indian Economic Review*, Vol. 52, No. 1-2, 2 December, pp.157–179, doi:10.1007/s41775-017-0006-7.

Government of India (2012), *Agricultural Statistics at A Glance 2012-2016*, Department of Agriculture, Directorate of Economics & Statistics, New Delhi, pp. 85–136.

Government of India (2017), "Monthly Report Potato", *Agricoop*, Horticulture Statistics Division, Ministry of Agriculture, Cooperation & Farmer's Welfare, Ministry of Agriculture & Farmer's Welfare, September, agricoop.gov.in/sites/default/files/Monthly%20Report%20on%20Potato%20 for%20September%202017.pdf.

Government of India (2017), Cooperation and Farmer's Welfare, Ministry of Agriculture & Farmer's Welfare, September, agricoop.gov.in/sites/default/files/Monthly%20Report%20on%20Onion%20 for%20September%202017.pdf.

Government of India, "Analysis of Trends in Prices and Determination of Price Spectrum Band", *Commerce*, http://commerce.gov.in/publications/psf_chapter2.pdf.

Government of India, "Monthly Report Onion" *Agricoop*, Horticulture Statistics Division, Ministry of Agriculture.

Government of India, "Rural Wage Rates" *Labour Bureaunew*, Ministry of Labour & Employment, Chandigarh/Shimla, http://labourbureaunew.gov.in/index.aspx.

Government of India, "State-Wise Analysis of Production, Storage, Market Arrival and Price Trends for Onion and Potato", *Agricoop*, Horticulture Statistics Division, Ministry of Agriculture, Cooperation & Farmer's Welfare, Ministry of Agriculture & Farmer's Welfare, agricoop.nic.in/sites/default/files/ICAR_5.pdf.

Government of India, *Office of the Economic Adviser*, Ministry of Commerce & Industry, www.eaindustry.nic.in/home.asp.

Gulati, Ashok and Shweta Saini (2015), *India's Political Economy Responses to the Global Food Price Shock of 2007-08*, WIDER Working Paper 2015/120, UNU-WIDER, December.

Gupta, Kirti, and Fahad Siddiqui (2014), *Salient Features of Measuring, Interpreting and Addressing Indian Inflation*. Indian Council for Research on International Economic Relations, July. icrier.org/pdf/working_paper_279.pdf.

Hellin, Jon, *et al*. (2015), "India's Poultry Revolution: Implications for Its Sustenance and the Global Poultry Trade", *IFAMA*, International Food and Agribusiness Management Review. www.ifama.org/resources/Documents/v18ia/Hellin-Krishna-Boeber.pdf.

Index Mundi, "Poultry (Chicken) Daily Price", www.indexmundi.com/commodities/?commodity=chicken.

Index Mundi, "Shrimp Daily Price", https://www.indexmundi.com/commodities/?commodity =shrimp &months=300&currency=inr.

Indian Meteorological Department (IMD), "Weather on Web", www.imd.gov.in/pages/main.php.

Indian Oil Corporation, "Previous Price of Diesel", *Indian Oil Corporation | Petrol/Diesel Stations*, www.iocl.com/Product_PreviousPrice/DieselPreviousPrice.aspx.

Joshi, Dharmakirti, *et al*. (2017), "Pulses & Rhythms: Analysing Volatility, Cyclicality and the Cobweb Phenomenon in Prices", *CRISIL*, 11 September, www.crisil.com/content/dam/crisil/our-analysis/reports/Research/CRISIL-Research-Report-Pulses-and-Rhythms-11Sept2017.pdf.

Kollewe, Julia (2011), "Coffee Prices Expected to Rise as a Result of Poor Harvests and Growing Demand", *The Guardian*, Guardian News and Media, 21 April. www.theguardian.com/business/2011/apr/21/commodities-coffee-shortage-price-rise-expected.

Malhotra, Akash and Mayank Maloo, "Understanding Food Inflation in India: A Machine Learning Approach" *ARXIV*, arxiv.org/ftp/arxiv/papers/1701/1701.08789.pdf.

Ministry of Statistics & Program Implementation, "Consumer Price Index (CPI) in India - Weights Table", *NumberBasket.com*, www.numberbasket.com/india/economy/cpi/consumer-price-index-weights-table.

Mishra, Prachi (2016), "Food Inflation in India", in Devesh Roy (Ed.) (2016), *Taming Indian Inflation*, International Monetary Fund, U.S.A..

Nair, Sthanu R. and Leena Mary Eapen (2012), "Food Price Inflation in India (2008 to 2010) A Commodity-Wise Analysis of the Causal Factors", *Democraciaycooperacion.net*, Economic & Political Weekly, Vol.47, No.20, 19 May, pp.46-54. www.democraciaycooperacion.net/IMG/pdf/1_Food_price_Inflation_in_India_2008-2010_.pdf.

National Council for Applied Economic Research (NCAER) (2012), *Annual Report 2011-2012*, August. www.ncaer.org/uploads/annual-report/pdf/annual_report_11_AnnualReport_12.pdf.

National Horticulture Research and Development Foundation (NHRDF), *Area and Production Report*, nhrdf.org/en-us/AreaAndProductionReport.

Office of the Registrar General & Census Commissioner, India, "Census of India" *Census of India Website*, www.censusindia.gov.in/.

Osorio, Néstor (2002), "The Global Coffee Crisis: A Threat to Sustainable Development." International Coffee Organization. www.ico.org/documents/globalcrisise.pdf.

Reed, Kristen and Sharon Royales (2014), "Shrimp Disease in Asia Resulting in High U.S. Import Prices" *BLS*, US Bureau of Labor Statistics, June. www.bls.gov/opub/btn/volume-3/pdf/shrimp-disease-in-asia-resulting-in-high-us-import-prices.pdf.

Reserve Bank of India, “Database on Indian Economy” *DBIE-RBI: Database of Indian Economy*, dbie.rbi.org.in/DBIE/dbie.rbi?site=home.

Reserve Bank of India, “Exchange Rate of the Indian Rupee Vis-a-Vis the SDR, US Dollar, Pound Sterling, D. M./ Euro and Japanese Yen (Financial Year – Annual Average and End-Year Rates)”, www.rbi.org.in/scripts/PublicationsView.aspx?id=15268.

Sainath, P. (2018), "India's Agrarian Crisis has Gone Beyond the Agrarian", *The Wire*, 2 July.

Sekhar, C.S.C.; Devesh Roy and Yogesh Bhatt (2017), *Food Inflation and Food Price Volatility in India: Trends and Determinants*, IFPRI Discussion Paper 1640, International Food Policy Research Institute (IFPRI).

Sharma, Anil, and Parmod Kumar (2001), “An Analysis of the Price Behaviour of Selected Commodities”, *Planning Commission*, Planning Commission, February. planningcommission.nic.in /reports/sereport/ser/stdy_price.pdf.

Sonna, Thangzason, *et al*. (2014), “Analytics of Food Inflation in India” *Reserve Bank of India – Publications*, Reserve Bank of India, 13 October. m.rbi.org.in/Scripts/PublicationsView.aspx? id=16055.

Teather, David (2010), “Coffee Price Rise 20% in a Week”, *The Guardian*, 14 June. www.theguardian.com/business/2010/jun/14/commoditries-coffee-prices-rising-sharply.

Thomson Reuters, (2010), “TABLE-Fuel Prices in India's Capital since 1989”, *Reuters*, 25 June. in.reuters.com/article/india-fuel-reforms/table-fuel-prices-in-indias-capital-since-1989-idINSGE65209520100625.

Trading Economics, “India GDP per Capita PPP | 1990-2018”, tradingeconomics.com/india/gdp-per-capita-ppp.

United States Department of Agriculture (USDA) (2008), “Dairy: World Markets & Trade”, December. usda.mannlib.cornell.edu/usda/fas/dairy-market//2000s/2008/dairy-market-12-11-2008.pdf.

Varma, Subodh (2015). “40% of India Still Banks on Monsoon for Agriculture - Times of India”, *The Times of India*, 30 April, timesofindia.indiatimes.com/india/40-of-India-still-banks-on-monsoon-for-agriculture/articleshow/47115057.cms.

Wiggins, Steve, *et al*., (2010), *What Caused the Food Price Spike of 2007/08? Lessons for World Cereals Markets,* Overseas Development Institute.

World Bank, “Commodity Markets”, www.worldbank.org/en/research/commodity-markets.

World Bank, “Population Growth (Annual %)”, *Data Worldbank*, data.worldbank.org/indicator /SP.POP.GROW?locations=IN.

World Bank, “Rural Population (% of Total Population)”, *Data.worldbank*, data.worldbank.org/indicator/SP.RUR.TOTL.ZS?end=2016.