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# The impact of macroeconomic factors on food price inflation: an evidence from India

Asharani Samal<sup>1\*</sup> , Mallesh Ummalla<sup>2</sup> and Phanindra Goyari<sup>1</sup>

## Abstract

The present study investigates the impact of macroeconomic factors on food price inflation in India utilizing the monthly time series during January 2006–March 2019. The long-run relationship is confirmed among the variables using the ARDL bounds testing approach to cointegration. The coefficients of long-run estimates show that per capita income, money supply, global food prices, and agricultural wages are positively and significantly impacted food price inflation in both the short and long-run. While food grain availability has a negative and significant impact on food price inflation in both the short-run and long run. Further, the short-run estimates revealed that real exchange rate positively impacts food price inflation. However, the coefficient is insignificant in the short-run. The Granger causality estimates show that a short-run bidirectional causality is confirmed among per capita income, the exchange rate, per capita net availability of food grain and food price inflation. Further, there is evidence of unidirectional causality running from global food prices to food price inflation. However, there is no causal relationship running from money supply and agricultural wages to food price inflation in the short-run.

**Keywords:** Food price inflation, Macroeconomic factors, ARDL bounds testing approach, Causality test

**JEL Classification:** E31, E03, C40

## Introduction

The main objective of monetary policy in any economy is to maintain price stability. However, high food price inflation affects not only macroeconomic stability but also small farmers and poor consumers of the developing country where poor people spend their massive portion of income on food consumption. Agricultural commodity price volatility negatively impacts all societies by causing macroeconomic instability; specifically, it affects the impoverished that spend a large portion of their resources on food and fuel [47]. Therefore, high food price inflation has become a significant concern among the researchers and policymakers in determining responsible factors to surge in food price inflation. The high food price inflation has been experienced in the recent period due to increasing demand for biofuels in many

developed countries, increasing demand for various diets among newly prosperous populations as compared to the production of such foodstuff, rise in minimum support prices, rapid regional economic growth, increasing the cost of fertilizers and other inputs, rising oil prices, etc.

Agriculture is very competitive in producing homogeneous goods, given its vulnerability and high dependence on monsoon. It also contributes 17% of gross domestic product and employs more than 50% of the population. However, the contribution of the agricultural sector to GDP has been declining substantially since 2014, and the growth of agriculture is likely to increase by 2.1% in 2018–19 [23]. Further, price of agricultural products is more volatile than the non-agricultural sector due to high dependence on climate change. Therefore, attention should be given to the agricultural sector and the behavior of agriculture prices, especially for developing countries like India, where the majority of the population depends on agriculture. The persistent and high food price inflation over the period has gained more extensive

\*Correspondence: [asamal@uohyd.ac.in](mailto:asamal@uohyd.ac.in); [ashasamal01@gmail.com](mailto:ashasamal01@gmail.com)

<sup>1</sup> School of Economics, University of Hyderabad, Hyderabad 500046, India  
Full list of author information is available at the end of the article

attention in India by the researchers and policymakers as food price inflation has been the major contributor behind the increase in overall Wholesale Price Index (WPI) inflation in India [2]. Further, agricultural price is susceptible to relative changes in input prices, supply factors, etc.

Theoretically, rising food prices are basically due to two factors in the literature, i.e., real and monetary shocks. These are explained by structuralist and monetarist approaches, respectively. According to structuralists, the money supply is passive, and the real shocks in a particular sector tend to upsurge in food price inflation. Hence, inflation occurs in the prices of other goods. However, monetarists argued that inflation could arise through an autonomous increase in money supply via generating aggregate demand, which increases the relative price of commodities. Therefore, an increase in money supply is a cause for inflation, not necessarily by real shocks.

However, the developing countries like India are not exceptional from higher food prices and macro-economic instability. Since the 1991 economic reforms, the Indian economy has maintained a single-digit economic growth rate and moderate inflation. However, in recent years, one of the major problems that the Indian economy is facing is higher food price inflation. The WPI food price inflation was documented 10.20% during January 2008–July 2010 [33]. Further, CPI-IW for food was experienced at 8.05% during 2006–2019 while it was recorded at 13%, especially in 2013. However, the growth rate of gross food grain production was 2.66% during this period. The demand for food commodities increases at a higher rate due to the high economic growth rate (7–9%) per annum. In contrast, the annual growth of agriculture is relatively low (1.5%) compared to the service sector and GDP growth [40]. The total investment in agriculture has been reduced from 2.43 to 1.28% during 1979–80 to 2007–08 period [28]. The expenditure on subsidies, maintenance of existing projects, the relatively lower allocation for irrigation, rural infrastructure and research, lack of adequate credit support, and credit infrastructure in rural areas are the drivers of slow growth in public investment in agriculture [43]. Given this high food price inflation, researchers and policymakers have raised severe concern about reducing the food price inflation because most of the population spend half of the income on food expenditure, and food containing a larger share in the CPI basket. Therefore, it is necessary to find the causes and suitable majors to reduce food price inflation.

The present study contributes to food price inflation literature in several ways. First, a wide range of studies has investigated the drivers of food price inflation in India. The various demand and supply-side factors, namely, per capita income, growth of money supply,

changing patterns of the consumer's dietary habits, high agricultural wages, speculations, and low growth of agricultural productions, are accountable for high food inflation. However, the results are ambiguous and vary considerably across countries due to different data periods and econometric methodologies applied in their studies. Second, the change in macroeconomic factors may have a substantial effect on food price inflation. For instance, if the food prices positively impact money supply, the consumer suffers from welfare loss. If it negatively effects on food prices, the producer suffers from welfare loss. However, this relationship of macroeconomic factors has not empirically analyzed significantly with respect to food price inflation in India. Third, various studies have explored the impact of macroeconomic factors on food price inflation across the world. For example, Kargbo [24] for Eastern and Southern Africa, Kargbo [25] for West Africa, Reziti [38] for Greek, Kargbo [26] for South Africa, Yu [46] for China and Sasmal [40]. Nevertheless, few studies have empirically examined the impact of selected macroeconomic factors on food price inflation by incorporating a control variable like per capita net availability of food grain into account. To the best of my knowledge, there is no study existing in the context of India. Fourth, most of the studies have taken WPI food indices, food items from only primary food articles or some of the index of selected food items, such as cereals and pulses, fruits and vegetables, milk and milk products, egg, meat, and fish as a measure of food price inflation. However, the present study has used the combined price index for industrial worker food (CPI-IW-F). Fifth, numerous studies have concluded that food price inflation is triggered by supply-side factors (see, [11, 17, 33]). However, to examine the rise in food price inflation, we have included both demand and supply-side factors in our study. Six, the present study also considered that food price inflation is not only influenced by domestic factors but also by global factors. More specifically, changes in global food prices and the exchange rate might positively and significantly impact food price inflation. However, the effect of these external factors on food price inflation does not explain the extent of food price inflation driven by domestic supply-side factors. For this purpose, we have included the per capita net availability of food grain as a control variable in the model. Suppose the demand for agricultural food items rises remarkably owing to a surge in macroeconomic factors. However, the supply of food items failed to meet the demand proportionately, then food items prices will go up. Therefore, the goal of the present study is to analyze the long-run and short-run impact of macroeconomic factors on food price inflation and

verify the causal relationship aspect of these variables in the case of India over the period January 2006–March 2019.

The remaining of the paper is structured as follows. “[Literature review](#)” section follows the review of the literature on the relationship between macroeconomic factors and food price inflation. “[Methods](#)” section represents data and methodology. “[Results and discussion](#)” section discusses the results of the study. “[Conclusions](#)” section provides conclusive remarks and policy implications.

### Literature review

This paper aims to examine the impact of macroeconomic factors on food price inflation. This section provides a review of the literature to establish the empirical basis of the link between macroeconomic factors and food price inflation.

#### Per capita income and food price inflation

Per capita income has a positive impact on food price inflation via increasing purchasing power of the money in the hands of the people, which leads to a surge in demand for food items resulting in a rise in food prices. Carrasco and Mukhopadhyay [10] argued that per capita income is positively affected food prices in three South Asian economies. However, the decline in agricultural production increases food prices up, and magnitudes are varying across countries. Agrawal and Kumarasamy [1] documented that food price inflation rose with the response to increases in India’s per capita income. They also suggested a 1% surge in per capita income upsurges the demand for fruits, vegetables, milk, and edible oil by 0.55–0.65%, and animal products by 0.38%. However, it reduces the demand for cereals and pulses by 0.05% and 0.20%, respectively. Joiya and Shahzad [22] and Sasmal [40] reported the same findings in Pakistan and India, respectively. In contrast, the study also found a negative association between food price inflation and per capita income. Kargbo [24] in Ethiopia and Malawi among Eastern and Southern African countries, Kargbo [25] for Cote d’Ivoire of West African countries.

#### Money supply and food price inflation

An increase in the money supply positively affects food price inflation through market credit facility by generating aggregate demand. However, it reduces food prices by creating investment via availing credit to the producer. Numerous studies have investigated the impact of money supply on food price inflation across the world. For example, Mellor and Dar [29] found that the expansion of money supply largely determines upward pressure on food grains prices. Barnett et al. [5] found that money supply positively affects food inflation and agricultural

commodity prices in the U.S. Similar results were found by Kargbo [26] and Asfaha and Jooste [3] for South Africa. Further, Bhattacharya and Jain [8] concluded that an unexpected monetary tightening induces food price inflation in emerging and developed countries. However, a negative relationship is established between money supply and food prices for Kargbo [24], Kargbo [25], and Yu [46] for Eastern and Southern African countries and West African countries and China.

#### Exchange rate and food price inflation

The depreciation of the real exchange rate increases food price inflation by expanding the cost of importing petroleum products, fertilizer, and other finished products relating to agricultural commodities, leading to rising domestic market prices. In other words, depreciation of the exchange rate directly affects the agricultural sectors by changing the prices of tradable and non-tradable goods resulting in a change in the prices of agricultural products in favor of the farmer. Taylor and Spriggs [45] showed that the exchange rate has a greater influence on volatility of agricultural prices in Canada. Similarly, Mitchell [30] and Mushtaq et al. [32] and Iddrisua and Alagidede [19] also concluded that the depreciation of the exchange rate is positively affected food prices in the U.S., Pakistan and South Africa, respectively. In contrast to this, Cho et al. [12] confirmed that change in the exchange rate has a negative impact on relative agricultural prices. However, Sasmal [40] found no significant relationship between the exchange rate and food price inflation in India during 1971–2012.

#### Global food price and food price inflation

The increase in the global food price of the commodity can influence the domestic price via international trade mechanism. The export increases as the global food price increases resulting in a decrease in domestic market supply followed by a hike in prices. On the contrary, the rise in import raises the domestic substitute food item’s price followed by a surge in domestic market price. Robles [39] indicated that the international prices transmission has a positive impact on the domestic agricultural market in Asian and Latin American countries. Gulati and Saini [16] revealed that the global food price index is positively impacted food price inflation in India. Similarly, Baltzer [4] states that an increase in international prices promotes domestic prices in the case of Brazil and South Africa. However, the price.

transmission is very limited in China and India. Lee and Park [27] confirmed that the lagged values of global food price inflation are positively impacted food price inflation in 72 countries. Selliah et al. [41] revealed that an increase in global food price increases domestic food

prices in both the short and long run in Sri Lanka. Similarly, Holtemöller and Mallick [17], Bhattacharya and Sen Gupta [6], and Huria and Pathania [18] also documented that global food price shocks have a significant and positive inflationary trend on food inflation in India. However, Rajmal and Mishra [37] pointed out a limited transmission of prices from international food prices to domestic prices in India.

### Agricultural wage and food price inflation

One of the significant public work programs is the National Rural Employment Guarantee (NREG), which promotes the real daily agricultural wage rates. On the one hand, an increase in rural wages can induce food prices by increasing production costs. On the other hand, it raises food prices via higher purchasing power, resulting in higher wages, which boosts the demand for food items. Gulati and Saini [16] revealed that domestic farm wages are positively associated with food price inflation in India. Goyal and Baikar [15] showed that the rapid increase in MGNREGA wages when it merged with inflation boosts agricultural wages rather than the implementation of MGNREGA across India. Bhattacharya and Sen Gupta [6, 7] examined the drivers of food price inflation in India over the period 2006–2013. The structural vector error correction model (SVECM) showed that agricultural wage inflation promotes food price inflation after the implementation of MNGREGS.

The above literature review shows that both demand and supply-side factors have contributed to food price inflation. Many studies have investigated the impact of macroeconomic factors on food price inflation across the globe. However, only a few studies have been directed, which empirically examined the effect of macroeconomic factors on food price inflation by incorporating per capita net availability of food grain and agricultural wages in a multivariate framework. So far as we know, there is no study available in the case of India in this regard employing monthly data over the period January 2006–March 2019. Hence, our study attempts to fill this gap.

## Methods

### Data

The present study makes use of monthly time series data on per capita GDP (Y), real exchange rate (EX), money supply (M3), global food price index (GF), per capita net availability of food grain (NFG), agricultural wages (AW) and combined price index-industrial workers for food (CPI-IW-F) indices as a proxy for food price index (FP) during January 2006–March 2019. The data on per capita GDP, real exchange rate, money supply is collected from the Reserve Bank of India (RBI), whereas combined price index-industrial workers for food and agricultural wages

are retrieved from the Ministry of Labor Bureau, Government of India. The data on per capita net availability of food grain and real global food price index are obtained from the Directorate of Economics and Statistics, Department of Agriculture & Farmers Welfare, Government of India, and the Food and Agriculture Organization of the United Nations, respectively. Monthly data on per capita net availability of food grain and per capita GDP is not available in the case of India. Therefore, we have used the linear interpolation method to get the monthly data for this variable.<sup>1</sup> The selection of the data period has been considered based on the availability of uniform and consistent monthly data over a period of time. We use high-frequency data while working on macroeconomic variables to capture the true impact of it [31]. Further, data on food price inflation is volatile, measuring the impact of macroeconomic factors on food inflation using high-frequency data, namely, weekly and monthly, provides accurate estimates rather than annual series. Since, data on a targeted variable i.e., food inflation is not available on a weekly basis for a longer period in the case of India. Therefore, we have used monthly data for this purpose.

The real exchange rate (EX) is measured as the real effective exchange rate which is trade based weighted average value of Indian currency against 36-currency bilateral weights, per capita income (Y) is measured as the percentage change in per capita gross domestic product, money supply (MS) is measured as broad money (M3), global food prices (GF) are measured as a real global food price index, and agricultural wages (AW) is measured as average daily wage rates from agricultural occupations; per capita net availability of food grain (NFG) is measured as gross production plus net imports plus stocks. Finally, food price inflation (FP) is measured as combined price index-industrial workers for food index (CPI-IW-F). The food inflation was experienced in India from 2006 onwards. However, the CPI-combined series is used and available from 2014 onwards to measure the official inflation rate. To get a more extended frequency of data on food inflation series, we have used consumer price index-industrial workers for food (CPI-IW-F) as a proxy for food inflation measures. We select to use CPI-IW-F because Bicchil and Durai [9] and Goyal [14] established that CPI-IW and CPI-combined have similar properties with CPI-IW is available for a more extended period. All the variables are seasonally adjusted

<sup>1</sup> By using the linear interpolation method, we have converted the annual data into the monthly time series data. Because the high-frequency data increases the power of a statistical test and provide robust results [48]. The interpolation method has been widely used in the empirical analysis [34, 42, 44].

using CENSUS X13 and converted into the natural logarithm form except per capita GDP.

#### Unit root tests

One should necessarily check the properties of all the variables before commencing any econometric techniques as it gives spurious and invalid results. The ARDL technique requires to check the integration properties of the selected variables to confirm that none of the variables should follow I (2) process, which seems to be invalid and unsuitable for applying the ARDL approach. Therefore, we use the ADF and PP tests to check the order of integration of the variables.

#### ARDL bounds testing approach to cointegration

We employ the ARDL bounds testing approach to cointegration propounded by Pesaran and Shin [35] and

Pesaran et al. [36] in order to examine the long-run and short-run association between macroeconomic factors and food price inflation in India. This method is superior over other traditional approaches of Johansen and Juselius [21] and Johansen [20] cointegration on the following grounds. First, it is one of the most popular and flexible methods. It does not impose any restriction on any nature of data and can be applied irrespective of all the order of integration I (1) or I (0) or both mix. Second, as noted by Pesaran and Shin [35] that ARDL estimators give the true parameters, and coefficients are super consistent as compared to other long-run estimates, especially when the sample size is small. Third, it also helps to eradicate the problem of the endogeneity that appears in the model. Fourth, it is even able to capture both short-run and long-run estimates simultaneously. The unrestricted error correction models (UECM) of the ARDL model can be represented as follows:

$$\begin{aligned} \Delta \ln FP_t = & \alpha_1 + \alpha_F \ln FP_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_M \ln MS_{t-1} + \alpha_E \ln EX_{t-1} + \alpha_G \ln GF_{t-1} \\ & + \alpha_{NF} \ln NFG_{t-1} + \alpha_A \ln AW_{t-1} + \sum_{h=1}^{m_1} \beta_h \Delta \ln FP_{t-h} + \sum_{i=0}^{n_1} \beta_i \Delta \ln Y_{t-i} \\ & + \sum_{j=0}^{o_1} \beta_j \Delta \ln MS_{t-j} + \sum_{k=0}^{p_1} \beta_k \Delta \ln EX_{t-k} + \sum_{l=0}^{q_1} \beta_l \Delta \ln GF_{t-l} \\ & + \sum_{m=0}^{r_1} \beta_m \Delta \ln NFG_{t-m} + \sum_{n=0}^{s_1} \beta_n \Delta \ln AW_{t-n} + \varepsilon_{1t} \end{aligned} \quad (1)$$

$$\begin{aligned} \Delta \ln Y_t = & \alpha_2 + \alpha_Y \ln Y_{t-1} + \alpha_F \ln FP_{t-1} + \alpha_M \ln MS_{t-1} + \alpha_E \ln EX_{t-1} + \alpha_G \ln GF_{t-1} \\ & + \alpha_{NF} \ln NFG_{t-1} + \alpha_A \ln AW_{t-1} + \sum_{h=1}^{m_2} \beta_h \Delta \ln Y_{t-h} + \sum_{i=0}^{n_2} \beta_i \Delta \ln FP_{t-i} \\ & + \sum_{j=0}^{o_2} \beta_j \Delta \ln MS_{t-j} + \sum_{k=0}^{p_2} \beta_k \Delta \ln EX_{t-k} + \sum_{l=0}^{q_2} \beta_l \Delta \ln GF_{t-l} \\ & + \sum_{m=0}^{r_2} \beta_m \Delta \ln NFG_{t-m} + \sum_{n=0}^{s_2} \beta_n \Delta \ln WA_{t-n} + \varepsilon_{2t} \end{aligned} \quad (2)$$

$$\begin{aligned} \Delta \ln MS_t = & \alpha_3 + \alpha_M \ln MS_{t-1} + \alpha_F \ln FP_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_E \ln EX_{t-1} + \alpha_G \ln GF_{t-1} \\ & + \alpha_{NF} \ln NFG_{t-1} + \alpha_A \ln AW_{t-1} + \sum_{h=1}^{m_3} \beta_h \Delta \ln MS_{t-h} + \sum_{i=0}^{n_3} \beta_i \Delta \ln FP_{t-i} \\ & + \sum_{j=0}^{o_3} \beta_j \Delta \ln Y_{t-j} + \sum_{k=0}^{p_3} \beta_k \Delta \ln EX_{t-k} + \sum_{l=0}^{q_3} \beta_l \Delta \ln GF_{t-l} \\ & + \sum_{m=0}^{r_3} \beta_m \Delta \ln NFG_{t-m} + \sum_{n=0}^{s_3} \beta_n \Delta \ln AW_{t-n} + \varepsilon_{3t} \end{aligned} \quad (3)$$

$$\begin{aligned}
\Delta \ln EX_t = & \alpha_4 + \alpha_E \ln EX_{t-1} + \alpha_F \ln FP_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_M \ln MS_{t-1} + \alpha_G \ln GF_{t-1} \\
& + \alpha_{NF} \ln NFG_{t-1} + \alpha_A \ln AW_{t-1} + \sum_{h=1}^{m_4} \beta_h \Delta \ln EX_{t-h} + \sum_{i=0}^{n_4} \beta_i \Delta \ln FP_{t-i} \\
& + \sum_{j=0}^{o_4} \beta_j \Delta \ln Y_{t-j} + \sum_{k=0}^{p_4} \beta_k \Delta \ln MS_{t-k} + \sum_{l=0}^{q_4} \beta_l \Delta \ln GF_{t-l} \\
& + \sum_{m=0}^{r_4} \beta_m \Delta \ln NFG_{t-m} + \sum_{n=0}^{s_4} \beta_n \Delta \ln AW_{t-n} + \varepsilon_{4t}
\end{aligned} \tag{4}$$

$$\begin{aligned}
\Delta \ln GF_t = & \alpha_5 + \alpha_G \ln GF_{t-1} + \alpha_F \ln FP_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_M \ln MS_{t-1} + \alpha_E \ln EX_{t-1} \\
& + \alpha_{NF} \ln NFG_{t-1} + \alpha_A \ln AW_{t-1} + \sum_{h=1}^{m_5} \beta_h \Delta \ln GF_{t-h} + \sum_{i=0}^{n_5} \beta_i \Delta \ln FP_{t-i} \\
& + \sum_{j=0}^{o_5} \beta_j \Delta \ln Y_{t-j} + \sum_{k=0}^{p_5} \beta_k \Delta \ln MS_{t-k} + \sum_{l=0}^{q_5} \beta_l \Delta \ln EX_{t-l} \\
& + \sum_{m=0}^{r_5} \beta_m \Delta \ln NFG_{t-m} + \sum_{n=0}^{s_5} \beta_n \Delta \ln AW_{t-n} + \varepsilon_{5t}
\end{aligned} \tag{5}$$

$$\begin{aligned}
\Delta \ln NFG_t = & \alpha_6 + \alpha_{NF} \ln NFG_{t-1} + \alpha_F \ln FP_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_M \ln MS_{t-1} + \alpha_E \ln EX_{t-1} \\
& + \alpha_G \ln GF_{t-1} + \alpha_A \ln AW_{t-1} + \sum_{h=1}^{m_6} \beta_h \Delta \ln NFG_{t-h} + \sum_{i=0}^{n_6} \beta_i \Delta \ln FP_{t-i} \\
& + \sum_{j=0}^{o_6} \beta_j \Delta \ln Y_{t-j} + \sum_{k=0}^{p_6} \beta_k \Delta \ln MS_{t-k} + \sum_{l=0}^{q_6} \beta_l \Delta \ln EX_{t-l} \\
& + \sum_{m=0}^{r_6} \beta_m \Delta \ln GF_{t-m} + \sum_{n=0}^{s_6} \beta_n \Delta \ln AW_{t-n} + \varepsilon_{6t}
\end{aligned} \tag{6}$$

$$\begin{aligned}
\Delta \ln AW_t = & \alpha_7 + \alpha_A \ln AW_{t-1} + \alpha_F \ln FP_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_M \ln MS_{t-1} + \alpha_E \ln EX_{t-1} \\
& + \alpha_G \ln GF_{t-1} + \alpha_{NF} \ln NFG_{t-1} + \sum_{h=1}^{m_7} \beta_h \Delta \ln AW_{t-h} + \sum_{i=0}^{n_7} \beta_i \Delta \ln FP_{t-i} \\
& + \sum_{j=0}^{o_7} \beta_j \Delta \ln Y_{t-j} + \sum_{k=0}^{p_7} \beta_k \Delta \ln MS_{t-k} + \sum_{l=0}^{q_7} \beta_l \Delta \ln EX_{t-l} \\
& + \sum_{m=0}^{r_7} \beta_m \Delta \ln GF_{t-m} + \sum_{n=0}^{s_7} \beta_n \Delta \ln NFG_{t-n} + \varepsilon_{7t}
\end{aligned} \tag{7}$$


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**Table 1** Descriptive statistics

	FP	Y	MS	EX	GF	NFG	AW
Empirical results							
Mean	5.375	0.445	11.185	4.687	4.619	5.130	6.931
Median	5.424	0.489	11.266	4.698	4.614	5.137	7.055
Maximum	5.770	0.590	11.927	4.804	4.862	5.194	7.615
Minimum	4.771	0.130	10.149	4.571	4.346	5.043	6.043
Std. Dev	0.321	0.120	0.511	0.057	0.121	0.047	0.535
Skewness	−0.420	−1.232	−0.389	−0.149	−0.128	−0.061	−0.321
Kurtosis	1.789	3.953	1.962	2.116	2.558	1.430	1.567

Source: Authors' estimations

**Table 2** Results of correlation matrix

	FP	Y	MS	EX	GF	NFG	AW
FP	1						
Y	0.183	1					
MS	0.994	0.135	1				
EX	0.639	0.228	0.656	1			
GF	0.129	−0.470	0.140	0.170	1		
NFG	0.909	0.119	0.907	0.515	0.080	1	
AW	0.993	0.178	0.989	0.625	0.107	0.936	1

Results are calculated using natural logarithms data. Source: Authors' estimations

where  $\Delta$  denotes first difference operator;  $\varepsilon_t$  is the error term;  $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6$ , and  $\alpha_7$  are the constant;  $\alpha_F, \alpha_Y, \alpha_M, \alpha_E, \alpha_G, \alpha_{NF}$ , and  $\alpha_A$  are the long-run coefficients;  $\beta_h, \beta_b, \beta_j, \beta_k, \beta_l, \beta_m$  and  $\beta_n$  are the short-run coefficients.

The optimal lag selection has been made based on the Akaike Information Criteria (AIC). The primary step in the ARDL model is to estimate the Eqs. (1–7) by ordinary least squares (OLS). The long-run relationship is determined based on the  $F$  test or Wald test for the coefficient of the lagged levels of the variables. The null hypothesis of no long-run relationship is  $H_0: \alpha_F = \alpha_Y = \alpha_M = \alpha_E = \alpha_G = \alpha_{NF} = \alpha_A = 0$  against the alternative hypothesis of the long-run,  $H_1: \alpha_F \neq \alpha_Y \neq \alpha_M \neq \alpha_E \neq \alpha_G \neq \alpha_{NF} \neq \alpha_A = 0$  referred to the equation follows as (FP/Y, MS, EX, GF, NFG, AW). According to Pesaran et al. [37], the null

hypothesis of no long-run association can be rejected if  $F$ -statistics is greater than the upper critical bound (UCB). It suggests that there is a long-run association among the variables. While, test statistics falls below the lower critical bound (LCB), null hypothesis cannot be rejected. It suggests that there is no long-run association among the variables. If the calculated value falls between the lower and upper critical points, the result is inconclusive. Because the two asymptotic critical values bound lower value (assuming the regressors are I (0)) and upper (assuming purely I (1) regressors) provide a test for cointegration.

After identifying the long-run relationship among the variables, our next step is to apply the vector error correction model to examine the directions of causality among the variables in both the short-run and long-run. The model of VECM can be written as follows.

**Table 3** Unit root test results

Variables	ADF		PP	
	At Level	First difference	At Level	First difference
FP	−0.163 (0.993)	−9.152*** (0.000)	−0.010 (0.995)	−8.907*** (0.000)
Y	−2.579 (0.290)	−12.422*** (0.000)	−2.715 (0.232)	−12.422*** (0.000)
MS	−2.097 (0.543)	−15.691*** (0.000)	−2.236 (0.465)	−15.996*** (0.000)
EX	−2.528 (0.314)	−10.756*** (0.000)	−2.528 (0.314)	−10.643*** (0.000)
GF	−3.271 (0.075)	−8.476*** (0.000)	−2.738 (0.222)	−8.648*** (0.000)
NFG	−2.704 (0.236)	−2.223*** (0.025)	−2.268 (0.448)	−3.303*** (0.001)
AW	−0.516 (0.981)	−17.154*** (0.000)	−0.789 (0.963)	−17.781*** (0.000)

\*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels, respectively.  
Source: Authors' estimations

**Table 4** ARDL bounds testing approach

Bound testing approach to cointegration		
Estimated model	Optimal lag length	F statistics
$FP = f(Y, MS, EX, GF, NFG, AW)$	(2, 0, 0, 1, 0, 0, 0)	4.155**
$Y = f(FP, MS, EX, GF, NFG, AW)$	(2, 2, 0, 1, 1, 0, 0)	11.043***
$MS = f(FP, Y, EX, GF, NFG, AW)$	(2, 0, 0, 1, 0, 0, 0)	10.239**
$EX = f(FP, Y, MS, GF, NFG, AW)$	(2, 0, 0, 1, 0, 0, 1)	3.015
$GF = f(FP, Y, MS, EX, NFG, AW)$	(2, 0, 2, 0, 0, 0, 0)	3.335
$NFG = f(FP, Y, MS, EX, GF, AW)$	(2, 2, 0, 0, 0, 0, 0)	2.611
$AW = f(FP, Y, MS, EX, GF, NFG)$	(2, 0, 0, 0, 0, 0, 0)	2.418
<i>Critical values</i>		
Significance level	Lower bound I (0)	Upper bound I (1)
10%	2.12	3.23
5%	2.45	3.61
1%	3.15	4.43

\*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels, respectively.  
Source: Authors' estimations

$$\begin{bmatrix} \Delta \ln FP_t \\ \Delta \ln Y_t \\ \Delta \ln MS_t \\ \Delta \ln EX_t \\ \Delta \ln GF_t \\ \Delta \ln NFG_t \\ \Delta \ln AW_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \\ \alpha_6 \\ \alpha_7 \end{bmatrix} + \begin{bmatrix} \beta_{11,1} & \beta_{12,1} & \beta_{13,1} & \beta_{14,1} & \beta_{15,1} & \beta_{16,1} & \beta_{17,1} \\ \beta_{21,1} & \beta_{22,1} & \beta_{23,1} & \beta_{24,1} & \beta_{25,1} & \beta_{26,1} & \beta_{27,1} \\ \beta_{31,1} & \beta_{32,1} & \beta_{33,1} & \beta_{34,1} & \beta_{35,1} & \beta_{36,1} & \beta_{37,1} \\ \beta_{41,1} & \beta_{42,1} & \beta_{43,1} & \beta_{44,1} & \beta_{45,1} & \beta_{46,1} & \beta_{47,1} \\ \beta_{51,1} & \beta_{52,1} & \beta_{53,1} & \beta_{54,1} & \beta_{55,1} & \beta_{56,1} & \beta_{57,1} \\ \beta_{61,1} & \beta_{62,1} & \beta_{63,1} & \beta_{64,1} & \beta_{65,1} & \beta_{66,1} & \beta_{67,1} \\ \beta_{71,1} & \beta_{72,1} & \beta_{73,1} & \beta_{74,1} & \beta_{75,1} & \beta_{76,1} & \beta_{77,1} \end{bmatrix} \times \begin{bmatrix} \Delta \ln FP_{t-1} \\ \Delta \ln Y_{t-1} \\ \Delta \ln MS_{t-1} \\ \Delta \ln EX_{t-1} \\ \Delta \ln GF_{t-1} \\ \Delta \ln NFG_{t-1} \\ \Delta \ln AW_{t-1} \end{bmatrix} + \dots + \begin{bmatrix} \beta_{11,m} & \beta_{12,m} & \beta_{13,m} & \beta_{14,m} & \beta_{15,m} & \beta_{16,m} & \beta_{17,m} \\ \beta_{21,m} & \beta_{22,m} & \beta_{23,m} & \beta_{24,m} & \beta_{25,m} & \beta_{26,m} & \beta_{27,m} \\ \beta_{31,m} & \beta_{32,m} & \beta_{33,m} & \beta_{34,m} & \beta_{35,m} & \beta_{36,m} & \beta_{37,m} \\ \beta_{41,m} & \beta_{42,m} & \beta_{43,m} & \beta_{44,m} & \beta_{45,m} & \beta_{46,m} & \beta_{47,m} \\ \beta_{51,m} & \beta_{52,m} & \beta_{53,m} & \beta_{54,m} & \beta_{55,m} & \beta_{56,m} & \beta_{57,m} \\ \beta_{61,m} & \beta_{62,m} & \beta_{63,m} & \beta_{64,m} & \beta_{65,m} & \beta_{66,m} & \beta_{67,m} \\ \beta_{71,m} & \beta_{72,m} & \beta_{73,m} & \beta_{74,m} & \beta_{75,m} & \beta_{76,m} & \beta_{77,m} \end{bmatrix} \times \begin{bmatrix} \Delta \ln FP_{t-1} \\ \Delta \ln Y_{t-1} \\ \Delta \ln MS_{t-1} \\ \Delta \ln EX_{t-1} \\ \Delta \ln GF_{t-1} \\ \Delta \ln NFG_{t-1} \\ \Delta \ln AW_{t-1} \end{bmatrix} + \begin{bmatrix} \gamma_1 \\ \gamma_2 \\ \gamma_3 \\ \gamma_4 \\ \gamma_5 \\ \gamma_6 \\ \gamma_7 \end{bmatrix} \times (ECM_{t-1}) + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \\ \varepsilon_7 \end{bmatrix} \quad (8)$$

where  $\Delta$  is the difference operator;  $ECM_{t-1}$  is the lagged error correction term, which is derived from the long-run cointegration relationship;  $\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}, \varepsilon_{4t}, \varepsilon_{5t}, \varepsilon_{6t}$  and  $\varepsilon_{7t}$  are the random errors;  $\gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5, \gamma_6$  and  $\gamma_7$  are the speed of adjustments. The long-run relationship among the variables indicates that there is a presence of Granger-causality at least one direction, which is determined by  $F$ -statistics and lagged error correction term. The short-run causal relationship is represented by  $F$ -statistics on the explanatory variables while long-run causal relationship is represented by  $t$ -statistics on the coefficient of the

lagged error correction term. The error correction term ( $ECT_{t-1}$ ) is negative and statistically significant ( $t$ -statistic) at the 1% significance level.

## Results and discussion

### Preliminary analysis

A preliminary analysis is conducted using commonly used descriptive statistics. We also reported the summary of descriptive statistics of all the considered variables during the study period in Table 1. The results revealed that the average food price index and the real



**Table 5** Results of the long-run and short-run analysis

Variables	Coefficient	t-statistics	p-value
<i>Panel-I: Long-run results</i>			
Constant	3.527	2.012	0.046
Y	0.143***	2.835	0.005
MS	0.363***	4.853	0.000
EX	−0.309***	−2.501	0.013
GF	0.131***	2.686	0.008
NFG	−0.694***	−2.179	0.030
AW	0.310***	3.744	0.000
R squared	0.998		
<i>Panel-II: short-run results</i>			
CPI(−1)	0.361***	4.723	0.000
Y	0.023***	2.546	0.011
MS	0.059***	3.392	0.000
EX	0.026	0.550	0.582
GF	0.021***	2.788	0.006
NFG	−0.113**	−2.164	0.032
AW	0.051***	3.088	0.002
ECT(−1)	−0.168***	−4.886	0.000
<i>Diagnostic tests</i>			
Breusch-Godfrey test	1.313 (0.272)		
ARCH LM test	0.053 (0.818)		
Durbin-Watson	1.94		
Ramsey RESET	0.111 (0.911)		
CUSUM	Stable		
CUSUMSQ	Stable		

\*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels, respectively.  
Source: Authors' estimations

exchange rate is 5.375% and 4.687% during the study period. However, the average money supply and real global food price index is 11.185% and 4.619%. The per capita net availability of food grain and agricultural wages is 5.130% and 6.931% whereas, per capita income is 0.445%, which is lower than other variables across the sample period. The results of the correlation matrix are represented in Table 2. The correlation analysis results revealed that per capita income, money supply, real exchange rate, real global food price index, per capita net availability of food grain and agricultural wages are positively associated with food price inflation. For instance, food price inflation is highly correlated with per capita income, money supply, real exchange rate, per capita net availability of food grain, and agricultural wages. It suggests that macroeconomic factors might be promoting food price inflation in India. Similarly, per capita income is positively correlated with money supply, exchange rate, and per capita net availability of food grain, and agricultural wages. Further, there is a high positive correlation between agricultural wages and per capita net availability of food grain.

### Results of unit root tests

To avoid spurious and invalid results of all the non-stationary data, we have checked the integration properties of all the variables and confirm that none of the variables follows the I (2) process. Therefore, the ADF and PP unit root tests are used to check the order of integrations of the variables. The results of unit root tests are reported in Table 3. It indicates that food price inflation (FP), per capita income (Y), money supply (MS), real exchange rate (EX), real global food price index (GF), per capita net availability of food grain (FG) and agricultural wages (AW) are integrated of order I (1).

### Results of ARDL cointegration tests

The above unit root test results show that all variables follow a same order of integration, i.e., I (1). Therefore, we apply the ARDL technique to check the long-run relationship among the variables using Eqs. (1)–(7) during January 2006–March 2019. Here, the optimal lag length is 2, according to VAR lag order selection criteria. The results of the ARDL model are presented in Table 4. The result shows that calculated *F*-statistics (4.155) is larger than UCB at the 5% level of significance when food price inflation is considered a dependent variable (FP/Y, MS, EX, GF, NFG, WA). It indicates that there is a long-run relationship among food price inflation (FP) and per capita income (Y), money supply (MS), real exchange rate (EX), global food prices (GF), per capita net availability of food grain (NFG), and agricultural wages (WA). Likewise, calculated *F*-statistics (11.043) is also larger than UCB at the 5% level of significance when per capita income is considered a dependent variable and integrated order (1). Therefore, UCB is applied to establish a long-run relationship among the variables. Likewise, calculated *F*-statistics (10.239) is also larger than UCB at the 5% level of significance when money supply (MS) is considered a dependent variable. Similarly, calculated *F*-statistics (3.335) is also larger than UCB at the 10% level of significance when global food price (GF) is considered a dependent variable. However, calculated *F*-statistics is lower than UCB when the exchange rate (EX), per capita net availability of food grain (NFG), and agricultural wages (AW) serve as dependent variables. It suggests a there is no long-run relationship among the variables when the exchange rate, per capita net availability of food grain and agricultural wages are the dependent variables.

### Results of long-run and short-run estimates

The cointegration test results based on the ARDL model revealed the long-run equilibrium relationship among the variables. However, these results do not explain the cause-and-effect association among the food price

**Table 6** Result of VECM Granger causality test based on ARDL

Dependent variable	Direction of causality							Long-run [t-statistics]
	Short-run F-statistics (p-values)							
	$\Delta \ln FP$	$\Delta \ln Y$	$\Delta \ln MS$	$\Delta \ln EX$	$\Delta \ln GF$	$\Delta \ln NFG$	$\Delta \ln AW$	
$\Delta \ln FP$		12.987*** (0.000)	0.337 (0.562)	25.481*** (0.000)	3.583* (0.060)	3.272* (0.070)	1.748 (0.188)	0.124 [0.353]
$\Delta \ln Y$	11.232*** (0.000)		0.902 (0.343)	1.603 (0.204)	2.807* (0.063)	0.438 (0.509)	1.182 (0.278)	2.85E-15 [3.637]
$\Delta \ln MS$	21.511*** (0.000)	0.195 (0.659)		24.566*** (0.000)	14.172*** (0.000)	9.510** (0.002)	2.942* (0.088)	-2.23E-15*** [-3.478]
$\Delta \ln EX$	14.696*** (0.000)	0.292 (0.589)	1.204 (0.302)		0.092 (0.761)	1.670 (0.198)	1.843 (0.162)	3.80E-15 [4.511]
$\Delta \ln GF$	1.926 (0.1673)	28.554*** (0.000)	0.316 (0.574)	4.444** (0.036)		0.545 (0.461)	1.847 (0.176)	-2.52E-15 *** [-2.967]
$\Delta \ln NFG$	17.869*** (0.000)	16.223*** (0.000)	6.564*** (0.011)	9.512*** (0.002)	11.371*** (0.001)		0.073 (0.786)	-7.07E-16*** [-2.467]
$\Delta \ln AW$	16.200*** (0.000)	35.767*** (0.000)	8.100*** (0.005)	5.073** (0.025)	3.852** (0.051)	29.711*** (0.000)		-1.42E-15 [1.135]

\*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% significance levels, respectively

inflation and macroeconomic factors, namely, per capita income, money supply, exchange rate, global food prices, per capita net availability of food grains, and agricultural wages. Hence, we have investigated the impact of macroeconomic factors on food price inflation in this part. It is better to check the long-run effect of macroeconomic factors on food price inflation after confirming the cointegration relationship among the variables when food price inflation is considered the dependent variable. The results of the long-run analysis are reported in Table 5 in panel-I. The long-run results illustrate that per capita income is positively and significantly impacted food price inflation. It implies that a one unit increase in per capita income induces food price inflation by 0.14 unit. The rise in per capita income raises the purchasing power of the money, which leads to a surge in demand for food items resulting in a hike in food prices. The results of our study similar to Carrasco and Mukhopadhyay [10] in three South Asian economies, Agrawal and Kumarasamy [1] in India, Joiya and Shahzad [22] in Pakistan and Sasmal [40] in India. However, our result is inconsistent with Kargbo [24] and Kargbo [25], who revealed a negative relation between the variables in Ethiopia and Malawi, and in Cote d'Ivoire, respectively.

Similarly, a 1% increase in money supply increases food price inflation by 0.36%. It implies that the rise in money supply puts upward pressure on food price inflation and is significant at the 1% level of significance. Money supply is positively affecting food price inflation by generating aggregate demand in the market, which pushes the food prices up. This finding is consistent with Kargbo [24] for Kenya, Sudan, and Tanzania

among the Eastern and Southern African countries and contradictory with Sasmal [40] who did not find any long-run relationship between money supply and food price inflation in India and Yu [46] for China who confirmed that monetary policy expansion has a negative impact on prices of seven major food products in the long-run. Similarly, a rise in the real exchange rate has a downward pressure on food price inflation. It indicates that a 1% increase in the real exchange rate will have a negative impact on food price inflation by 0.30%. The increase in the real exchange rate reduces food prices by lowering the import of petroleum products, fertilizer, and other products relating to agricultural commodities in the long run. Hence, organic fertilizers can be used to produce commercial food products to reduce the dependency on fertilizers, which may maintain price stability and reduce the negative welfare impact on food prices. This outcome is consistent with Cho et al. [12] and is inconsistent with Iddrisua and Alagidede [19] in South Africa, Durevall et al. [13] in Ethiopia. Further, per capita net availability of food grain has a negative impact on food price inflation. In other words, there is an inverse relationship between per capita net availability of food grains and food price inflation in India. It suggests that a 1% increase in per capita net availability of food grains reduces food price inflation by 0.69%. The increase in the supply of net food availability in the domestic market by increasing food production can reduce food price inflation. On the other hand, if the supply of food grain availability declines due to crop failure, it increases food price inflation. Therefore, the government should increase domestic

food production and reduce the exports of commodities at the time of food inflation to maintain stability in prices. Further, agricultural production is seasonal, and it is highly correlated to the month of food harvest. The stock of food grain during harvest season can avoid the off seasonal food price inflation. Increasing the stock of food items by establishing a larger cold storage system and strengthen and widening the existing warehouses can also help to control food inflation in India. This result is similar to Kargbo [25] in Cote d'Ivoire and Nigeria and Carrasco and Mukhopadhyay [10] in three South Asian economies and inconsistent with Sasmal [40], who failed to establish a significant relationship between agricultural food production and food price inflation in India in the long-run. Furthermore, our results revealed that food price inflation rose with the response to increases in global food prices. It suggests that a 1% surge in global food price upsurges food price inflation by 0.13%. This result is consistent with Selliah et al. [41] for Sri Lanka, Holtemöller and Mallick [17] for India, and Huria and Pathania [18] for India. However, Rajmal and Mishra [37] and Baltzer [4] pointed out a limited transmission of prices from international food prices to domestic prices in India. The extent of transmission of global food prices on price hike in the domestic market depends on at which magnitudes commodity's international trade takes place. Finally, our study results also found that agricultural wages have a positive and significant impact on food price inflation at the 1% level of significance. It implies that a 1% surge in agricultural wages increases the food price inflation by 0.31% in the long-run. The rise in wage rate via welfare-oriented-schemes like MNGREGS increases the bargaining and purchasing power of money, increasing in demand for food items followed by increased food inflation. The increase in the agricultural wage rate should be substituted with food price inflation by increasing productivity. Hence, the increase in demand for food originated by a hike in the agricultural wage rate can be substituted by raising the productivity of each worker. A similar result is found by Bhattacharya and Sen Gupta [7] for India.

After having discussed long-run results, we shall move in to discuss with reference to the short-run. The results of the short-run analysis are reported in Table 5 in panel-II. The short-run analysis indicates an increase in per capita income and money supply is positively related to food price inflation in the short-run as the coefficients of these variables are statistically significant. Similarly, food price inflation rises with the increase in global food prices. Further, the real exchange rate has a positive impact on food price inflation in the short-run. However, the result is not

significant. Moreover, agricultural wages have a positive impact on food price inflation. It implies that an increase in agricultural wages raises food price inflation in the short run. The outcome is consistent with Huria and Pathania [18] for India. However, per capita net availability of food grain is negatively and significantly impacted food price inflation. It suggests that a 1% increase in food grain availability decreases food price inflation by 0.11% in the short-run. In contrast, a decrease in the growth rate of food grain availability increases food price inflation. This finding is similar to Kargbo [25] in Cote d'Ivoire and Senegal among West African countries. Finally, the results also documented lagged food price inflation positively impacts present food price inflation. It suggests that a 1% increase in lagged food price upsurges food price inflation by 0.36% in the short run.

The sign of lagged ECT is negative and significant at the 1% level, which implies that short-run deviation from food prices can be restored toward the long-run equilibrium with a 16.8% speed. The model has satisfied all the diagnostic tests. This model is free from autoregressive conditional heteroscedasticity; the functional form of the model is well specified, which is represented by the Ramsey RESET coefficient.

#### Results of VECM Granger causality test

After identifying the long-run association between macroeconomic factors and food price inflation, we have employed the VECM Granger causality test to examine the directions of causality among the variables in both the short-run and long-run. The Granger causality results are represented in Table 6. The outcomes of the short-run causality tests are obtained from the *F*-statistics of lagged independent variables, while the results of long-run causality are obtained from the negative and significant coefficients of *t*-statistics of lagged error correction term. The results are reported in Table 6 and show that a short-run bidirectional causality is confirmed between per capita income, exchange rate, and food price inflation at a 1% level. This finding is opposite of Sasmal [40], who reported a unidirectional causality running from per capita income to food price inflation in India. Similarly, a bidirectional causality is existed between per capita net availability of food grain and food price inflation in the short run. It implies that the increase in food grain availability reduces food price inflation by increasing domestic food grain production on the one hand. Whereas on the other hand, an increase in food price inflation also leads to a rise in food grain availability by rising demand for food products. Further, there is a unidirectional causality running from global food prices to food price inflation. It suggests that an increase in global price attracts exporters

to increase their supply of food items to the global market to get high profit, which eventually decreases the domestic market supply, resulting in a price increase. However, there is no causal relationship running from money supply and agricultural wages to food price inflation in the short run.

There is an existence of a bidirectional causal relationship between global food prices and per capita income. However, no causality runs from money supply, exchange rate, per capita net availability of food grain, and agricultural wages to per capita income. A short run unidirectional causality is established from food price inflation, exchange rate, global food prices, and per capita net availability of food grain to money supply. A bidirectional causality has existed between agricultural wages and money supply in the short run. Further, unidirectional causality is running from per capita income, the exchange rate to global food prices. A unidirectional causal relationship is found from per capita income, money supply, the exchange rate, and global food prices to per capita net availability of food grain in the short run. Moreover, short-run unidirectional causality is confirmed from food price inflation, per capita income, the exchange rate and global food prices to agricultural wages.

Moving to the long-run causality, the coefficients of  $ECM_{t-1}$  are negative and statistically significant in Eq. (8), where money supply, global food prices, and per capita net availability of food grain are the dependent variables. Therefore, results revealed a bidirectional causality among the money supply, global food prices, and per capita net availability of food grain production in the long-run.

## Conclusions

This study aimed to examine the impact of macroeconomic factors on food price inflation in India during January 2006–March 2019. To consider the short-run dynamics and the long-run analysis and directions of causality among the variables, we have applied the ARDL model and Granger causality test in our study. The ARDL results have shown evidence of the long-run association among the macroeconomic factors and food price inflation. The long-run result show that per capita income, money supply, global food price, and agricultural wages have a positive and significant impact on food price inflation of India in both the long-run and short run. However, the per capita net availability of food grain negatively impacts food price inflation. It implies that an increase in food grain availability reduces food price inflation in both the short and long run. Further, the real exchange rate is positively affecting food price inflation. However, it is insignificant in the short-run. The Granger causality estimates show that a short-run bidirectional

causality is confirmed among per capita income, the exchange rate, per capita net availability of food grain, and food price inflation. Further, there is evidence of unidirectional causality running from global food prices to food price inflation. However, there is no causal relationship running from money supply and agricultural wages to food price inflation in the short run. The long-run results revealed a bidirectional causality among the money supply, global food prices and per capita net availability of food grain.

Given these results, the paper makes important contribution to the macroeconomic factors and food price inflation in India. The significant policy suggestions are that the growth in money supply promotes food price inflation in the long-run, which affects the welfare of the poor consumer as the majority of the people depend on agriculture. It also positively affects market credit facility by generating aggregate demand followed by changes in relative prices across commodities, which push the food prices up. Therefore, the government should adopt effective policy measures to protect consumers from higher food prices. These are the effectively implementation of public distribution systems, policies for food security, and reducing the money supply via adopting a contractionary monetary policy, which eventually reduces food price inflation by reducing demand for food items. Further, the increase in global food inflation triggers food price inflation by international trade channels. However, the influence of global food inflation on food price inflation can be moderated by introducing a flexible tariff structure. Hence, the government should introduce stable and liberal trade policies that reduce food price inflation without compromising farmers remuneration values.

Moreover, our result also revealed that an increase in the net availability of food grain reduces food price inflation in both the short and long run. Therefore, the government should take necessary steps in favor of an increase in domestic food production. The high yielding variety (HYV) seeds, easily accessible credit facilities should be available to the farmer, increasing the domestic agricultural food production, thereby reducing the import of agricultural goods through the exchange rate and their adverse impact on food inflation. The stock of food grain during harvest season can avoid off seasonal food inflation. The increasing the stock of food items by establishing an extensive cold storage system and strengthening large warehouses can control food inflation in India. Furthermore, the rise in agricultural wages boosts food price inflation. The increase in the agricultural wage rate should be substituted with food price inflation by increasing labor productivity. Hence, the increase in demand originated by a hike in



the agricultural wage rate can be substituted by raising each workers productivity.

Our results also found that per capita income Granger causes food price inflation both in the short-run. In this respect, we can say that there is a huge sectoral imbalance among the sectors. The government should be more focused on the agricultural sector and its growth and productivity by allocating massive funds in the irrigation, agricultural research, and innovation of modern technology and its adaptation in agriculture instead of spending on the name of social security and welfare of the poor. Therefore, balanced and sustainable growth and stability can be achieved for a developing country like India. The real exchange rate and food price inflation Granger causes to each other. The depreciation of the real exchange rate increases the food price inflation via expanding the import of petroleum products, fertilizer, and other finished products relating to agricultural commodities, which are very expensive. The increasing import of these products promotes food price inflation by raising domestic prices. Hence, to reduce the food price inflation, the government should increase the domestic agricultural production to meet our demand for food items rather than importing from other countries.

#### Abbreviations

ARDL: Autoregressive distributed lag; CPI: Combined price index; WPI: Wholesale price index; RBI: Reserve Bank of India.

#### Acknowledgements

Not applicable.

#### Author contributions

AS: Conceptualization, methodology, software, formal analysis, data curation, writing—original draft, reviewing and editing. MU: Resources, data curation, writing—reviewing and editing. PG: Resources, supervision and editing. All authors have read and approved the final manuscript.

#### Funding

The authors declare that no funding from any agencies was received for this study.

#### Availability of data and materials

Data used in the study are available in the Reserve Bank of India, Ministry of Labor Bureau, Directorate of Economics and Statistics, Department of Agriculture & Farmers Welfare, Government of India, and the Food and Agriculture Organization of the United Nations.

#### Declarations

#### Ethics approval and consent to participate

Not applicable.

#### Consent for publication

Not applicable.

#### Competing interests

The authors declare that they have no competing interests.

#### Author details

<sup>1</sup>School of Economics, University of Hyderabad, Hyderabad 500046, India.

<sup>2</sup>School of Business, Woxsen University, Hyderabad 502345, India.

Received: 2 July 2021 Accepted: 15 May 2022

Published: 21 June 2022

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