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COVID-19 induced lockdown effect on wheat supply chain and prices in India – Insights from state interventions led resilience

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A R T I C L E   I N F O

JEL classification:
D12
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A B S T R A C T

COVID-19 incidence in India, impacted the food market, wheat in particular, as the crop harvest coincided with the lockdown disrupting the supply chain and prices posing a few researchable issues - the lockdown effect on wheat supply chain; how the state intervention bolstered the sector to restore; the insights the government interventions offer, etc. The study, using the interrupted time series analysis, investigated the disruption in wheat supply chain, and captured the impact of lockdown on wheat prices. Despite relaxation allowed to agricultural-related activities, lack of transport and labour shortage were reported. Nevertheless, the country registered a record wheat procurement of 38.99 million tonnes. Though the prices spiked post-lockdown, there was no evidence of structural-break and persisting volatility. The findings affirm that supply chain disruption is the main driver for the observed price changes and government interventions like staggered procurement and logistics support resulted in restoration of the wheat economy. The relief measures, infrastructure and its efficient usage, and easing restrictions rendered resilience to wheat supply chain against the COVID-19 shocks. The experience of coordinated efforts of the state machinery and the cooperative farm communities offers confidence about the national capacities to manage disasters of even greater scale in agriculture.

1. Introduction

COVID-19, caused by a novel coronavirus (SARS-Cov-2), has unsettled all the sectors of Indian economy including agriculture. People were exhorted upon to observe a voluntary lockdown (Janata Curfew) on March 22 to contain the spread of the virus, and subsequently, a nationwide lockdown was imposed beginning from March 25, 2020. The lockdown was sudden and there was no time for people to prepare or respond to the crisis in time. The agriculture sector was under essential production to consumption [1]. On production front, failure in or immediate effects on supply chain of food commodities right from given relaxation from the lockdown. However, the lockdown had its services and eventually the harvest and marketing of lockdown was sudden and there was no time for people to prepare or prepared the sector to restore; the insights the government interventions offer, etc. The study, using the interrupted time series analysis, investigated the disruption in wheat supply chain, and captured the impact of lockdown on wheat prices. Despite relaxation allowed to agricultural-related activities, lack of transport and labour shortage were reported. Nevertheless, the country registered a record wheat procurement of 38.99 million tonnes. Though the prices spiked post-lockdown, there was no evidence of structural-break and persisting volatility. The findings affirm that supply chain disruption is the main driver for the observed price changes and government interventions like staggered procurement and logistics support resulted in restoration of the wheat economy. The relief measures, infrastructure and its efficient usage, and easing restrictions rendered resilience to wheat supply chain against the COVID-19 shocks. The experience of coordinated efforts of the state machinery and the cooperative farm communities offers confidence about the national capacities to manage disasters of even greater scale in agriculture.

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1. Introduction

COVID-19, caused by a novel coronavirus (SARS-Cov-2), has unsettled all the sectors of Indian economy including agriculture. People were exhorted upon to observe a voluntary lockdown (Janata Curfew) on March 22 to contain the spread of the virus, and subsequently, a nationwide lockdown was imposed beginning from March 25, 2020. The lockdown was sudden and there was no time for people to prepare or respond to the crisis in time. The agriculture sector was under essential services and eventually the harvest and marketing of Rabi produce were given relaxation from the lockdown. However, the lockdown had its immediate effects on supply chain of food commodities right from production to consumption [1]. On production front, failure in or limited access to critical inputs causes production disruption [2]. Reduction in work hours and or workforce due to pandemic, alternative days of work were the causes of labour shortage limiting operations in production [3]. Restriction in vehicle movement causes transportation disruption resulting in a negative impact on smooth flow of products [4,5]. Moreover, limited interaction among various supply chain partners caused ambiguity in information and muted response affecting the supply chain management [6,7]. From a consumer’s point there was a sharp increase in demand for essential products causing a temporary shortage in the market [8,9] and notable behavioural changes in food waste management [1,10,11]. Sudden increase in demand and restrictive movement lead to delay in delivery causing loss of produce especially perishables like food items [12]. Socio-psychological factors,
perceived threats and uncertainty about future were the reasons for sudden increase in demand leading to supply chain disruption [13]. In the aforementioned ways COVID-19 induced disruption in supply chain by affecting the demand and supply of both producers and consumers. The ultimate impact of these disruptions is on agriculture prices which is susceptible to respective demand and supply based on their price elasticities [14].

Wheat is a major staple crop and plays a pivotal role in supplementing the food security needs of India [15]. The lockdown coincided with the harvest of wheat (a major Rabi crop: October to March) and therefore it is pertinent to know the impact of lockdown on supply chain and its consequence on prices. Previous literature on COVID-19 pointed at several immediate effects on agricultural prices. Prices in Canada’s fruit and vegetable market affected significantly due to the closure of restaurants [2]. A 15% increase in agricultural prices in India and Africa from pre COVID-19 levels has been reported [16]. At global level there was a decrease in demand for meat by 7–18% and dairy products by 4–7% during the first wave of COVID-19 [17]. Ezeaku et al. [18] found that international grain and cereals prices are more resilient to COVID-19 pandemic than other. A recent study [19] concluded that although decline in local production had a little effect on global prices of grains, trade restriction had a serious influence. Indian agriculture also affected by the pandemic in various forms. First, the reverse migration resulted in scarcity of labour that adversely affected the harvest of Rabi crops particularly wheat in the north-western parts of India [20]. Second, the restrictions on movement of goods and services disrupted the commodity supply chain hampering the uninterrupted flow of inputs and outputs within the agricultural system [21,22]. Large buffer stocks of rice and wheat supplemented by a record harvest in 2019-20 Rabi season and timely adoption of fiscal measures by the union government strengthened the Indian food system in tackling the pandemic [23,24]. Some instance of selling wheat below the support price was reported too indicating the prevalence of distress sale among farmers. On a quick response, a few studies analyzed the changes and impact of COVID-19 on agricultural markets using publicly available time series data [25,26], but the time span used in those studies were very short to capture the actual impact especially when the lockdown has continued in multiple phases. To our knowledge, no research evidence documented hitherto on wheat supply chain disruption amidst COVID-19. Therefore, our work is an attempt to fill this research gap and provide insights and quantitative evidence of the lockdown impact on wheat supply chain and markets. The main purpose of the study was to document the supply chain disruption and analyze the impact of lockdown (induced by COVID-19) on wheat prices in spatially separated zones of India. Further, we also aimed to assess the policy interventions proposed by the government during lockdown aiming for restoration.

2. Conceptual design

COVID-19 induced lockdown disrupted agricultural systems worldwide. Wheat markets in India are no exception with the lockdown effect witnessed all along the supply chain as well as on commodity prices. The government have initiated a few policy reforms and immediate relief packages to neutralize the adverse effects of COVID-19 on the supply chain stakeholders. Nevertheless, the effect was felt on harvesting, marketing and consumption of wheat. Thus, this study evaluates the responsiveness of wheat markets for the effect of COVID-19 on wheat supply and prices, homogeneity, volatility and structural break in the wheat price series. The spatio-temporal effect was captured across different zones of the country (North, West, East, North East (NE) and South). Further, we aimed to review the policy responses of the government during the lockdown and document its impact on producers and consumers. In addition, the study provides, after synthesizing literature evidence and based on the results, on different ways of restoring the wheat supply chains from this exogenous shock. Thus, the present study evaluates the responsiveness of wheat market stakeholders to COVID-19, resilience and restoration of the sector as a result of government support and policy responses under the following conceptual research framework (Fig. 1).

3. Data and methodology

3.1. Data

Information on supply chain disruption has been captured through literature and government reports. Secondary data for a period of 305 days spanning from November 01, 2019 to August 31, 2020 on retail and wholesale prices (modal prices) of wheat in five zones of India were compiled from the official source1 to capture the lockdown impact on wheat prices. The prices, generally of the ‘Fair Average Quality’, were collected from 167 market centers (either online or through email or fax) and compiled by the respective State Civil Supplies Departments for the Department of Consumer Affairs (Price Monitoring Cell), Ministry of Consumer Affairs, Food and Public Distribution, Government of India. These prices are representative of the prices prevailing in North, West, East, South and North-easter zones of the country. The same dataset is used by the Price Monitoring Division (PMD), Department of Consumer Affairs to analyze the daily price situation in the country and give early feedback to policymakers for implementing commodity-specific market interventions.2

3.2. Analytical methods

Test for homogeneity in variance: Initially the price series were examined for quality testing using time plot to check for any outliers followed by testing (F statistic) for homogeneity in variance ($\sigma^2$) using

1 https://fcainfoweb.nic.in/Reports/Report_Menu_Web.aspx
2 https://consumeraffairs.nic.in/price-monitoring-cell/price-monitoring-cell.
the Levene’s [27] approach. The test has been widely used since it is less sensitive to the departure of time series from the normal distribution and is performed with the following assumption:

**Null Hypothesis (H₀):**

\[ \sigma_1^2 = \sigma_2^2 = \ldots = \sigma_k^2 \]

**Alternate Hypothesis (Hₐ):**

\[ \sigma_1^2 \neq \sigma_2^2 \neq \ldots \neq \sigma_k^2 \]

For a time series having a sample size of \( N \) comprising \( k \) sub-groups, where \( N_i \) is the sample size of the \( i \)th sub-group, the Levene’s test statistic \( W \) is defined as:

\[
W = \frac{(N-k)}{(k-1)} \sum_{i=1}^{k} \sum_{j=1}^{N_i} (Z_{ij} - \bar{Z}_i)^2
\]

where, \( Z_{ij} \) can have one of the following three definitions viz., difference between actual minus mean or median or 10% of the trimmed mean of the \( i \)th sub-group. \( \bar{Z}_i \) are the group means of the \( Z_{ij} \) and \( \bar{Z} \) is the overall mean of the \( Z_{ij} \). After Levene’s test, the following analytical methods were employed to address the set objectives.

**Price risk:** Cuddy Della Valle instability index (CDVI) [28], a refinement of the coefficient of variation has been used to capture the risk in daily wholesale and retail prices for pre- and post-lockdown periods. It is estimated as follows:

\[ CDVI = CV \times \sqrt{(1 - R^2)} \]

where, \( CV \) is the coefficient of variation, and \( R^2 \) is the coefficient of determination.

**Price volatility:** Generalised autoregressive conditional heteroscedasticity (GARCH) model was used to track the extent of volatility in daily wholesale and retail prices for pre- and post-lockdown periods following Bollerslev’s [29] approach. First, we carried out the autoregressive integrated moving average (ARIMA) filtration analysis to determine the best fit ARCH term followed by fitting a suitable GARCH model [30] represented by GARCH \((p, q)\) for each price series. GARCH models of order \( p \) (order of GARCH effect) and/or \( q \) (order of ARCH effect) were estimated and selected as given by Jordaan et al. [31]. The model constructed is represented as:

\[
Y_t = \alpha_0 + b_1 Y_{t-1} + b_2 Y_{t-2} + \epsilon_t
\]

\[
\sigma_{t+1}^2 = \omega + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 + \sum_{i=1}^{q} \alpha_i \epsilon_{t-i}^2
\]

where; \( Y_t \) is the price series in \( t \)th period of \( i \)th commodity, \( p \) is the order of the GARCH and \( q \) is the order of the ARCH. The summation of \( \alpha_i \) and \( \beta_i \) indicates the degree of volatility persistence in commodity prices. The
value ($\alpha_0 + \beta_1$) closer to ‘one’ indicates the persistence of volatility for a longer time and more than ‘one’ alarm that the price series is explosive and observations meander away from mean. Further, ARCH-LM test has been carried out to identify serial correlation, if any in residuals.

**Structural break in price series:** A modified additive outlier (AO) model was used to demonstrate the structural break in price series. In the present study, Baum’s [32] modified version of single structural break (AO1) model was employed against the conventional Clemente et al. (1998) version. ‘clemao1’ Stata routine was used to test the AO1 model following the critical values given in Ref. [33]. A two-step procedure captured the structural break in prices.

The functional form is given as,

$$y_i = \mu + \beta_1 t + \gamma DT_{i} + \tilde{y}_i$$

where, $t = 1, 2, \ldots, T$, $DT_{i}$ is a dummy variable which takes the value 1 if $t > T_{b}$, the first structural break; and $\tilde{y}_i$ is the de-trended price series. In this case, $\tilde{y}_i$ is regressed against control dummies and lagged differences to make the test statistic distribution tractable [32,33]. The test equation is given as follows:

$$\tilde{y}_i = \sum_{i=0}^{k} \delta_i DT_{i} + \alpha_0 + \alpha_1 DT_{i-1} + \sum_{i=1}^{k} \alpha_2 \Delta y_{i-1} + \epsilon_i$$

where, $D(TB)_{i}$ is a dummy variable taking value 1 if $t = T_{b} + 1$ and 0 otherwise; $\epsilon_i$ is the iid error-term with zero mean, constant variance and a finite fourth moment. The null hypothesis of unit root is rejected if the $t$ statistic for $\alpha_1$ is more than the critical value [33]. A characteristic feature of the AO1 model is that the time of structural break as well as the lag specification ($k$) is unknown. These are arrived after a grid search for the least $t$-statistic of unit root hypothesis ($\alpha_1 = 1$) and sequential $F$ tests, respectively [34,35].

**Impact of lockdown on wheat prices:** Interrupted time series analysis (ITSA) was used to capture the impact of COVID-19 induced lockdown on wheat wholesale and retail prices. In the present study, the approach of Bernal et al. [36–38] was used and the functional form is given as follows:

$$Y_{t} = \beta_0 + \beta_1 t_{1}, + \beta_2 \text{level} + \beta_3 \text{trend}_t + \epsilon_t$$

where, $Y$ represents the wholesale or retail prices, the outcome variable; $\beta_0$ is the level at $t = 0$, $\beta_1$ is the pre-intervention trend (i.e. before lockdown), $\beta_2$ is the level change post-intervention and $\beta_3$ is the change in slope post-intervention. The assumption is that COVID-19 induced intervention (i.e. lockdown) is completely exogenous and the coefficient of ‘level’ variable in Eq. (3) captures its impact. In Eq. (3), $\beta_2$ and $\beta_3$ are the parameters of our interest which indicate the treatment effects immediately after intervention and over time, respectively. The STATA package ‘itsa’ has been used to estimate the coefficients of Eq. (3) [39]. It uses OLS regression approach but produces Newey-West standard errors to account for autocorrelation and possible heteroskedasticity. To test for autocorrelation as well as to decide on the number of lags to be included in the regression-based time series model, we used another STATA package ‘actest’ [40]. The ‘actest’ uses Cumby and Huizinga [41] general test for autocorrelation.

### 4. Results and discussion

**Supply chain disruption:** Supply chain disruption is an unanticipated trigger which jeopardize, significantly, the smooth flow of goods and services [42]. It is an event-oriented concept relating to potential occurrence and its adverse consequences [43,44]. COVID-19 pandemic had disrupted the supply chain at all levels. Wheat being a major Rabi (winter) crop, its harvest and post-harvest operations coincided with the lockdown. Conventionally, the nutri-rich cereal known for its prominent role in ensuring food security reaches the end-user via multiple marketing channels (Fig. 2) which have been entirely disrupted despite relaxation given for agricultural related activities. Fig. 3 shows the supply and demand factors in wheat. Trade is determined by the extent of demand and supply which in turn is determined by several socio-economic factors. For instance, wheat demand is influenced by the socio-economic factors. For instance, wheat demand is influenced by the

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3 The ARCH test carried out in residuals is a Lagrange multiplier (LM) test [25] and it is estimated from an auxiliary regression. GARCH models with disregarded ARCH effects may result in asymptotic efficiency problems and end up in rejecting the test for standard autocorrelation [28]. Therefore, the following regression was attempted in the squared-residuals ($\hat{e}_t^2$) to test the null hypothesis that there is no ARCH effect till its designated order $q$. The test equation is:

$$\hat{e}_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \hat{e}_{t-i}^2 + \nu_t$$

4 Model derivation and in-depth discussion is given in Baum [33,34].
extent of food expenditure and the income elasticity, whereas, supply is determined by the intensity of capital and labour used in production. The demand-supply framework is supported by external factors like credit, energy and exchange rates. The concern here is that both supply and demand baffled owing to the incidence of COVID-19. On the supply side, reverse migration of agricultural laborers limited the activities of harvesting and post harvest in wheat; and on the demand side, negative income shock, closure of restaurants, schools, malls, restricted movement and inter-region trade suppressed the demand for food commodities [1,45,46]. As far as post-harvest operations are concerned, almost 40% of the total wheat produced is backed by the public procurement, which is usually routed through commission agent at the local markets. Closure of wholesale markets during the initial days of lockdown owing to the panic of COVID-19 put the farmers and traders on a perplexing situation. Additionally, closed external markets restricted wheat trade all around the world. The effect of these disruptions on retail and wholesale prices coupled with negative income shock has implications on consumption expenditure of food commodities and food waste [37].

We documented our survey results in Refs. [1,48]. It explains in detail the disruption in the agricultural system in India. Especially, on the production front, labour shortage during peak harvest season in wheat growing areas like Haryana and Punjab, logistics disruption in marketing of wheat and limited access to retail markets, increased consumer prices, negative income shock and change in consumption basket of consumers affecting demand for wheat and wheat flour have been witnessed.

The timely and strategic interventions by the state and central government had reduced the complexity in the commodity harvest and trade. The subsequent section entails the interventions taken by the Government to improve the unexpected agrarian crisis.

Government interventions: Agriculture grew at around 3.4% while India’s GDP growth was plummeting at −23.9% in Q1 FY 2020-21 showcasing the resilience of the sector [48]. Researchers and policy experts attribute the resilience to the immediate policy response of the government, infrastructure-built overtime which helped in cash transfers and food distribution and even the timing of the pandemic [49–51]. COVID-19 social assistance package of US$ 25 billion was announced by the Indian Government under the Pradhan Mantri Garib Kalyan Yojana (PM-GKY) – Prime Minister’s Poor welfare scheme – to provide immediate relief to the poor and vulnerable.5 PM-GKY was targeted to provide 5 kg of cereals and 1 kg of pulses free of cost for 80 crore poor people (under Pradhan Mantri Garib Kalyan Anna Yojana (PMGKAY) – Prime Minister’s Food Security Scheme for the Poor); INR 50 Lakhs (US$ 68,000) health insurance cover per health worker fighting COVID-19; INR 500 (US$ 7) per month to 20 crore women (under Pradhan Mantri Jan Dhan Yojana (PM-JDY) - Prime Minister’s People’s Wealth Scheme - a scheme to increase banking access); increased wages under public work programme – Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA); INR 1000 (US$ 14) to 3 crore poor senior citizen, widows and disabled; pay immediately the next installment (under Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) Prime Minister’s Farmers’ Honour Fund, a cash transfer programme to farmers) of INR 2000 (US$ 27) to benefit 87 million farmers.

A recent study [51] estimated the effect of cash transfers (PM-KISAN) on farmers who received benefits of other components of PM-GKY (like PM-AY and PM-JDY) and farmers who did not receive any kind of benefits using the survey data of 1789 households from 327 villages of India, among which 79% cultivated wheat. PM-KISAN reached 89–94% of farming households and it along with other components of PM-GKY helped farmers buy more seeds, fertilizers and pesticides [51].

Along with the social assistance package, the Government also ramped up the wheat procurement during the Rabi (spanning from October/November to March/April) Marketing Season (RMS) 2020–21.

Table 1

| State       | Procurement (in lakh tonnes) | % change |
|-------------|------------------------------|----------|
|             | RMS 2019–20 (no lockdown)    | RMS 2020–21 (during lockdown) |
| Bihar       | 0.03                         | 0.05     | 67        |
| Gujarat     | 0.05                         | 0.77     | 1440      |
| Haryana     | 93.20                        | 74.00    | −21       |
| Himachal    | 0.01                         | 0.03     | 200       |
| Madhya Pradesh | 67.25               | 129.42   | 92        |
| Punjab      | 129.12                       | 127.14   | −2        |
| Rajasthan   | 14.11                        | 22.25    | 58        |
| Uttar Pradesh | 37.00                       | 35.77    | −3        |
| Uttarakhand | 0.42                         | 0.38     | −10       |
| Chandigarh  | 0.13                         | 0.11     | −15       |
| India       | 341.32                       | 389.92   | 14        |

Source: Food Corporation of India (https://fic.gov.in/procurements.php?view=87).

Table 2

| Date       | Capacity with FCI | Storage capacity (Other Agencies) | Total | % change in stocks |
|------------|-------------------|-----------------------------------|-------|-------------------|
| 01-04-2018 | 362.50            | 480.53                            | 843.03| –                 |
| 01-04-2019 | 388.65            | 467.03                            | 855.68| 1.5               |
| 01-04-2020 | 412.03            | 343.91                            | 755.94| −11.7             |

Wheat procurement by the Government had decreased by 5% in RMS 2019–20 compared to RMS 2018–19; but amidst COVID-19 induced lockdown, government procured a record high of 38.99 million tonnes of wheat in 2020–21 RMS which is a 14% increase compared to previous RMS (Table 1). Tables 1 and 2 shows the state wise procurement of wheat and central pool stocks, respectively during the incidence of COVID-19 and the previous year sans lockdown. From the perusal of the tables, it is explicit that the supply and distribution of wheat were less affected by the lockdown as the Food Corporation of India (FCI) in collaboration with the NGOs, local grocery stores and e-commerce platforms managed to move the government buffer stocks on time [52]. The central pool stocks reduced 11.7% from 85.57 million tonnes in April 2019 to 75.59 million tonnes in April 2020 (Table 2). Therefore, the Union Government put the existing, well established, procurement and distribution infrastructure to full use benefitting both the producers and consumers (especially poor) during the initial stages of lockdown – a lesson to be learnt from the pandemics.

4.1. Disruption in wheat prices

Supply chain disruption distorted the prices (retail and wholesale) affecting the producers as well as consumers at various magnitudes. In the following section, we captured the disruption in wheat prices owing to COVID-19 using various statistical tools and techniques as mentioned earlier in the methods section.

Test for variance homogeneity in retail and wholesale prices: The daily retail and wholesale wheat prices collected from five zones and for all-

5 https://pib.gov.in/PressReleaseframePage.aspx?PRID=1608345.
India were subjected to preliminary analysis of testing for homogeneity in variance. The test assumes equal variance among price series under null hypothesis. The Levene’s test result indicated that all the price series across zones and all-India were significant (Table 3) at one per cent level of probability. The estimated test statistic was almost more than the pre-lockdown. Our analysis rejects the null hypothesis of homogeneity in level of probability. The estimated test statistic was almost more than the pre-lockdown. The regions wherein supply disruption was more owing to the higher incidence of COVID-19. The minimum and maximum price per kg of wheat has not witnessed much change between two periods except north-eastern wheat price (maximum) level, wherein a decrease of ₹8.44 per kg (19.67%) was noticed. It’s noteworthy to observe that the extent of divergence between wholesale and retail prices have declined after the lockdown indicating that the magnitude of increase in retail prices was more than the pre-lockdown wholesale prices. The implication is that the wholesale prices, a proxy for the producer or farm gate prices [54] hasn’t witnessed much change in relative to retail prices. Disruption in retail markets due to COVID-19 has affected the consumers in terms of panic buying and changed shopping behaviour during the lockdown period [1]. The selected price series were positively skewed (Table 4) with the exception of north zone retail price (pre-lockdown), west zone retail price (post-lockdown), west zone wholesale price (pre-lockdown), south zone retail price (pre- and post-lockdown) and south zone wholesale price (post-lockdown). In other words, a majority of the selected price series were clustered around mean (left side), with only a few extreme observations on right side of the tail, a common feature of the high frequency time series data [55].

In general, the agricultural commodity prices exhibit non-stationarity in level along with leptokurtic distribution [53]. Our estimates on kurtosis shows that all the price series turned positive, indicating the leptokurtic (long-tailed) distribution meant the price series contains only a few extreme observations on right side of the tail, a common feature of the high frequency time series data [55].

Table 3
Test for homogeneity in variance.

| Wheat price | Period       | Levene’s test statistic | df₁  | df₂  |
|-------------|--------------|-------------------------|------|------|
| Retail      | Before lockdown | 236.33⁸  | 5   | 864  |
|             | After lockdown | 491.94⁸  | 5   | 954  |
| Wholesale   | Before lockdown | 256.77⁸  | 5   | 864  |
|             | After lockdown | 633.99⁸  | 5   | 954  |

Number of regions are 6 and each region has 145 observations in pre-lockdown and 160 in post-lockdown.

⁸ Denotes the statistical significance at one per cent level of probability.

Table 4
Summary statistics of retail and wholesale wheat prices.

| Descriptive Statistics | Period¹ | North Zone | East Zone | North-Eastern Zone | South Zone | All India |
|------------------------|---------|------------|-----------|-------------------|-----------|----------|
|                        |         | Retail     | Wholesale | Retail            | Wholesale | Retail   | Wholesale |
| Mean (₹/kg)           | Before  | 22.97      | 20.46     | 26.29             | 23.42     | 35.21    | 30.37     |
|                       | After   | 22.38      | 20.24     | 27.21             | 24.26     | 33.54    | 30.29     |
| Minimum (₹/kg)        | Before  | 21.43      | 19.59     | 25.27             | 22.12     | 26.00    | 22.00     |
|                       | After   | 21.00      | 19.01     | 26.30             | 23.32     | 29.00    | 25.93     |
| Maximum (₹/kg)        | Before  | 23.80      | 21.94     | 27.64             | 24.57     | 31.00    | 24.91     |
|                       | After   | 24.31      | 22.12     | 28.33             | 25.11     | 34.80    | 25.44     |
| Skewness              | Before  | –0.48      | 0.55      | –0.15             | 1.37      | 0.57     | 0.22      |
|                       | After   | 0.61       | 1.01      | –0.01             | 0.78      | 0.81     | –0.84      |
| Kurtosis              | Before  | 2.45       | 3.67      | 2.50              | 2.27      | 4.97     | 5.16      |
|                       | After   | 3.10       | 3.31      | 2.06              | 2.04      | 3.70     | 3.78      |
| Standard              | Before  | 0.53       | 0.41      | 0.54              | 0.54      | 1.01     | 0.94      |
|                       | After   | 0.69       | 0.61      | 0.49              | 0.43      | 0.73     | 0.68      |
| Deviation (₹/kg)      | Before  | 0.56       | 0.49      | 0.43              | 0.73      | 0.68     | 0.36      |
|                       | After   | 0.69       | 0.61      | 0.49              | 0.43      | 0.73     | 0.68      |
| Coefficient of Variation (%) | Before  | 3.08       | 3.49      | 1.80              | 1.77      | 2.80     | 2.92      |
|                       | After   | 3.08       | 2.99      | 1.60              | 1.77      | 2.80     | 2.92      |
| Cuddy-Della Valle     | Before  | 2.18       | 1.78      | 1.30              | 1.53      | 3.71     | 3.80      |
|                       | After   | 2.07       | 1.78      | 1.45              | 1.48      | 2.51     | 2.58      |
| Volatility            | Before  | 0.99       | 0.55      | 0.22              | 0.65      | 0.16     | 0.82      |
|                       | After   | 1.00       | 0.99      | 0.53              | 0.09      | 0.26     | 0.13      |
| (GARCH estimates)     | Before  | 0.02       | 0.02      | 0.04              | 0.04      | 0.02     | 0.03      |
|                       | After   | 0.02       | 0.02      | 0.04              | 0.04      | 0.02     | 0.03      |

¹ Before lockdown: 01-11-2019 to 24-03-2020 and after lockdown: 25-03-2020 to 31-08-2020.

After the lockdown, wheat witnessed a 0.11 and 0.28% increase respectively after the lockdown. Across zones, prices increased in west (Retail: 3.50% and Wholesale: 3.59%) and south (Retail: 1.11% and Wholesale: 0.16%), the retail prices witnessed much change in relative to retail prices. Disruption in retail markets due to COVID-19 has affected the consumers in terms of panic buying and changed shopping behaviour during the lockdown period [1]. The selected price series were positively skewed (Table 4) with the exception of north zone retail price (pre-lockdown), west zone retail price (post-lockdown), west zone wholesale price (pre-lockdown), south zone retail price (pre- and post-lockdown) and south zone wholesale price (post-lockdown). In other words, a majority of the selected price series were clustered around mean (left side), with only a few extreme observations on right side of the tail, a common feature of the high frequency time series data [55].

In general, the agricultural commodity prices exhibit non-stationarity in level along with leptokurtic distribution [53]. Our estimates on kurtosis shows that all the price series turned positive, indicating the leptokurtic (long-tailed) distribution meant the price series considered for the study contained peaked or concentrated observations in comparison to normal distribution. Perusal of estimates of standard deviation (Table 4), revealed that the values were below ‘one’, barring eastern zone retail price (pre-lockdown), north eastern zone retail as well as wholesale prices (pre- and post-lockdown). The implication is that the daily prices tend to be very close to the mean with the exception of afore mentioned regions. Similar trend was noticed in the estimates of

⁹ https://punjab.gov.in/wp-content/uploads/2020/06/Agri-procurementt-during-COVID_Digital-release_June-2020-2.pdf.

⁸ https://downloads.usda.library.cornell.edu/usda-esmis/files/zs25x844t/0p097999b/p6419q779/grain.pdf.
The risk in wheat prices as indicated by the Cuddy-Della Valle index ranged from 0.87 (south zone retail prices: pre-lockdown) to 11.77 (north eastern retail prices: pre-lockdown). GARCH estimates in Table 4 indicate that at national level the extent of volatility in retail as well as wholesale prices declined drastically post-lockdown period. Harvest and supply surge shall be attributed to the declined price volatility. Region wise estimates showed that barring a few, rest of the zones exhibited a low level of price volatility. Growth (computed as Compound Annual Growth Rate: CAGR) represents the general direction of change in prices for a specific time period and is influenced by demand and supply factors [56]. The growth trend was found to be negative and very low in all the selected series post-lockdown sans south zone retail prices. The CAGR ranged from –0.01 to 0.04% during pre-lockdown and 0 to –0.16% during post-lockdown. The analysis indicates that both retail and wholesale prices witnessed some marginal changes during the pandemic period, attributed to supply disruption despite a record wheat production of 107.59 million tonnes (MoA&FW 2020)\(^1\) during 2019-20.

Impact of lockdown on retail and wholesale prices: Lockdown has disrupted the food markets extensively. We captured the impact of lockdown on wheat prices using interrupted time series analysis and the results are presented in Figs. 4-5 and Table 5. ITSA showed that prices have increased both at retail and wholesale level. Our analysis indicated that the retail prices of wheat have increased immediately post-lockdown in west, north-east and south zones as well as at all-India level. However, looking into the coefficient of “level” variable in

\(^1\) https://eands.dacnet.nic.in/Advance_Estimate/4th_Adv_Estimates2019-20_Eng.pdf.
Table 5 shows that the significant price increase was evident in west and north-east zones only. Retail prices declined immediately in north and east zone despite the coefficients turned non-significant. Further, the retail prices in all the zones had a significant negative trend post-lockdown as evident from the coefficient of “trend” variable. In addition, the declined retail prices seem to continue further.

Analogous to the retail prices pattern, wholesale prices also witnessed an immediate and significant increase in west and north-east zones but declined significantly in south zone. Indeed, a recent study [25] captured a significant spike in commodity prices immediately after lockdown. Similarly, wholesale prices also started to decline significantly alike retail prices post-lockdown corroborating the evidence from recent research [1]. Decline in wheat prices is possibly due to the excess supply led by record harvest in March–April (Rabi 2019–20) and contingent measures by the Government like self-reliance policy initiatives and reforms [57], and staggered but record procurement [58] of 38.99 million tonnes in 2020. This is corroborated with the fact that the minimum wheat wholesale price fell below the support price in the north zone (₹19.01 per kg) post-lockdown. The data also support the above discussion as on June 1, 2020, the central pool wheat stock was 55.83 million tonnes (36% higher than the previous month); the wheat wholesale price index decreased from 162.50 in April to 158.6 in June 2020 due to increased arrivals. The price has no spike further owing to surplus production during 2019-20 leading to increased import duty (from 30% to 40%) to prevent any crash in prices.

Structural break in retail and wholesale prices: The structural break in retail and wholesale prices, if any, was assessed since the nationwide lockdown was announced on March 24, 2020 (8:00 p.m.) with no time for response (related to production-consumption or demand-supply) as

![Fig. 5. Impact of COVID-19 induced lockdown on wholesale wheat prices.](https://fci.gov.in/procurements.php?view=87)

![Fig. 5. Impact of COVID-19 induced lockdown on wholesale wheat prices.](http://www.agriwatch.com/)

11 [https://fci.gov.in/procurements.php?view=87](https://fci.gov.in/procurements.php?view=87).
12 [http://www.agriwatch.com/](http://www.agriwatch.com/).
it came to effect from March 25, 2020 (12 a.m.), Clemente-Montaness-Reyes single additive outlier model for unit root testing was carried out to capture the sudden (structural) change in the price series and the results are presented in Figs. 6 and 7. Our analysis showed that the structural break in wholesale as well as retail prices – big sudden change – ranged from December 2019 to June 2020 corroborating the findings of [1]. Further, there was no evidence of sudden disruptions (structural break) due to lockdown on long-term price trend since there was no evidence of breakpoints in the selected price series on or immediately after 25-03-2020 (i.e., imposition of lockdown) (Table 6).

Several economic inferences can be drawn from this analysis. Risk in price spike was obviated by the record wheat harvest and supply despite initial level of disruption in all regions. Surplus wheat led to decline in prices even below the support price in northern zone. Disruptions like closure of wholesale markets [45] hampered commodity trade followed by ending inter-regional trade [46] due to stringent lockdown measures. Further, trade-off between fall in demand due to shutdown of eateries against the initial days of panic buying was reported at retail level. Clearly, our analysis affirms that there was no large impact of lockdown on wholesale and retail prices of wheat, rejecting the hypothesis of structural break as induced by COVID-19 led lockdown.

5. Insights from government interventions for restoration of wheat sector

After studying the Government interventions during the initial stages of COVID-19 incidence in the country, we came up with two major takeaways. The immediate measures were to prevent loss of life and secure livelihood to the vulnerable, ensure food (majorly rice and wheat) through PDS, cash transfers to women, elderly and poor farmers, increasing wages under public work programme (MGNREGA), increased and staggered procurement and distribution of wheat. Second, leveraging existing infrastructure which helped carry out all the above measures in a timely and efficient way like using PDS to reach food supply to the needy, FCI and other state agency centers to procure food, providing employment and increase wages under MGNREGA for migrant workers, cash transfers through the Jan Dhan accounts (no-frill bank deposit accounts) using Aadhaar based identification of beneficiaries. In addition to these, easing movement restrictions for agricultural commodities during the lockdown, suspension of toll collections in the highways to allow inter-state movement of goods, special cargo trains and flights for distribution of essential commodities helped the stakeholders across the wheat supply chain [59]. Altogether, the relief measures and the effective use of the infrastructure built over the years played a crucial role in making wheat supply chain (in particular) and agriculture sector (in general) resilient to the COVID-19 induced shocks. Lessons learnt from this pandemic should enamour the state agencies, international relief organizations, NGOs, civil societies, etc. with experience to deal with any such disasters in future. Besides, it is imperative to build robust state infrastructure and strengthen to counter such natural onslaughts as private sector does not have the incentive, training and necessary logistics to be expected to invest in preventing or mitigating them.

6. Conclusions and policy implications

The incidence of pandemic (COVID-19) disrupted the normal functioning of wheat markets and hence an attempt was made to capture the impact of national lockdown on supply chain and on wholesale and retail wheat prices across regions. Measures taken by the Union Government to nullify the effect of pandemic has also been reviewed. Interrupted time series analysis was used to analyze the impact and the findings indicated that wheat prices have increased post-lockdown but was not significant in all regions. Price levels rebounding to pre-lockdown situation has been noticed owing to excess supply led by all-time high wheat harvest coupled with contingent interventions by the State for record procurement as well. Further, there was no evidence of structural break as well as persisting volatility in wholesale and retail price levels. We observed price changes at various magnitudes in wheat across regions attributed to disruption in various links in the supply chain, but there is no evidence of structural break owing to the resilience in wheat sector. The swift response of the government resulted in the resilience of the commodity supply chain. We suggest that the minimum disruption witnessed in wheat supply chain through government interventions like staggered procurement and logistics and the efficient leveraging of the infrastructure shall be replicated to other commodities or regions if the pandemic recurs and persists. Lessons learnt from this pandemic should enamour the state agencies, international relief organizations, NGOs, civil societies, etc. with experience to deal with any such disasters in future. Besides, it is imperative to build robust state infrastructure and strengthen them to counter such natural onslaughts as private sector does not have the incentive, training and necessary logistics to be expected to invest in preventing or mitigating them. Furthermore, to counter the price instability and volatility especially for food staples at times when physical markets are at stake, risk management techniques like futures trading [47,60] is recommended.
Fig. 6. Structural break in retail wheat prices.
Fig. 7. Structural break in wholesale wheat prices.
Table 6
Additive outlier model estimates of unit root allowing for single structural break.

| Zone            | Structural break | Unit root |
|-----------------|------------------|-----------|
| Wholesale price |                  |           |
| 1. North Zone   | May 23, 2020b    | –0.13     |
| 2. West Zone    | February 07, 2020 | –0.15     |
| 3. East Zone    | April 21, 2020   | –0.32b    |
| 4. North East Zone | June 09, 2020 | –0.69b    |
| 5. South Zone   | January 03, 2020b | –0.09     |
| 6. All India    | December 30, 2019 | –0.18     |
| Retail price    |                  |           |
| 1. North Zone   | May 05, 2020b    | –0.23     |
| 2. West Zone    | February 14, 2020 | –0.13     |
| 3. East Zone    | April 17, 2020   | –0.60b    |
| 4. North East Zone | June 05, 2020b | –0.59b    |
| 5. South Zone   | January 03, 2020b | –0.10     |
| 6. All India    | June 14, 2020    | –0.25     |

b Represents the significance at 5% level of probability.

Table 7
Annual percentage change in wheat yield in India.

| Year | Change |
|------|--------|
| 1964-65 | 2.45%  |
| 1965-66 | 2.56%  |
| 1966-67 | 2.78%  |
| 1967-68 | 2.99%  |
| 1968-69 | 3.21%  |
| 1969-70 | 3.43%  |
| 1970-71 | 3.65%  |
| 1971-72 | 3.87%  |
| 1972-73 | 4.09%  |

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