



## Price dynamics in Indian wholesale wheat markets: Insights and implications

AMIT THAKUR<sup>1</sup>, POULAMI RAY<sup>1</sup>, KAMLESH KUMAR ACHARYA<sup>1</sup>, ABHIJIT DAS<sup>1</sup>, RAJ JAISWAL<sup>1</sup>,  
UNNI RAVISHANKAR<sup>1</sup>, RAJU R<sup>1</sup> and SENDHIL R<sup>1\*</sup>

ICAR-Indian Institute of Wheat and Barley Research, Karnal, Haryana 132 001, India

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### ABSTRACT

Wheat is an integral part of food as well as nutrition security holding a significant share in the consumption basket. Hence, any extreme deviations in the staple food price will affect the prospects of the economy. In the context, we analysed the price dynamics and price volatility in Indian wholesale wheat markets using compound annual growth rate, instability indices, and Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model. The study sourced monthly data (July 2002 to June 2019) from the AGMARKNET portal for 15 states. Research findings indicated that the wholesale price, as well as divergence between maximum and minimum price, was highest in the case of Kerala implying the non-production region. Monthly price indices (highest as well as lowest in Haryana respectively during December: 109.90 and July: 91.48) exhibited a clear-cut seasonality attributed to the wheat arrivals post-crop harvest. Barring Maharashtra, the growth and variation in seasonal price indices were positive and relatively low respectively across markets. Corroborating the price trend, Kerala exhibited the highest volatility as evident by the GARCH model estimates, followed by Gujarat, Haryana and Chhattisgarh. *Inter alia*, volatility in wheat prices is directly linked to regional production. The study advocates for effective dissemination of market information such as price forecast, demand and supply to counter the price volatility as well as decision making for profitable agri-business.

**Keywords:** GARCH, Price dynamics, Price volatility, Seasonal price index, Wheat

Fluctuation in prices, a natural phenomenon of commodity markets, is an indication of response to the changes in demand and supply. Whereas volatility depicts the randomness in a variable which disrupts the usual behaviour of the time series (Lama *et al.* 2016). Price volatility plays a crucial role in promulgating policies with dynamic political and economic context (Kalkuhl *et al.* 2016). *Inter alia*, extreme weather events, oil price shocks, production and demand shocks among core factors that exogenously affects food prices (Tadesse *et al.* 2014), and can transform into social risks. Hence analysing the price volatility in agricultural commodities and its underlying factors assumes significance (Cermak *et al.* 2017) for improving the market performance and policy development (Lama *et al.* 2016, Kalkuhl *et al.* 2016). Food price volatility affects the stakeholders per se along the commodity value chain. Periods with higher volatility can benefit some sections of the economy (Chavas *et al.* 2014) but in the long-run, it leads to an overall welfare loss (Aizeman and

Pinto 2005). For instance, price fluctuations mostly affect the low-income household (Von and Tadesse 2012) which reduces their likelihood towards dietary diversification, as consumers cannot easily substitute a staple food item with another when the price increases.

Globally, wheat is the most widely cultivated crop covering 217 million ha with 764 million tonnes output (USDA 2020) that feeds nearly 2.5 billion people. In India, wheat is cultivated in around 30 million ha (Ramadas *et al.* 2019) and consumption has reached 95.62 million tonnes (Sharma and Sendhil 2015) contributing nearly 50% of protein and calorie requirements (Tripathi and Mishra 2017). Price uncertainty, being an economic threat, can deprive the poor households away from adequate access to wheat and lead to rise in poverty, hunger, malnutrition, and food insecurity (Gustafson, 2013). In the context, a comprehensive study on analysis of price dynamics and trends in volatility in wheat is crucial to draw policy implications for market functionaries (Horo *et al.* 2016).

### MATERIALS AND METHODS

Monthly wholesale wheat prices spanning from July 2002 to June 2019 for 15 selected states in India were collected from the AGMARKNET portal. The selection of states was based on the percentage share in total production (Sendhil *et al.* 2019).

*Test for homogeneity in variance:* Prior subject to

Present address: <sup>1</sup>ICAR-National Dairy Research Institute, Karnal, Haryana; <sup>2</sup>ICAR-Indian Agricultural Research Institute, New Delhi; <sup>3</sup>ICAR-Indian Institute of Wheat and Barley Research, Karnal, Haryana. \*Corresponding author e-mail: r.sendhil@icar.gov.in.

analytical techniques, all the price series were tested for its homogeneity in variance ( $\sigma^2$ ). Among the available tests, Levene's methodology is widely used since it is less sensitive to the departure of series from the normal distribution. Initially, the observational quality of the price data was examined by observing the time plot, distinguishing the outliers (if any) and proceeded with the test for homogeneity in variance using Levene's approach (Levene 1960).

*Seasonal variation in prices:* The seasonal variation in wheat prices was calculated using the 12-months ratio to the moving average method. For measuring the extent of variation in seasonal indices, the coefficient of average seasonal price variation (ASPV), intra-year price rise (IPR) and coefficient of variation (CV) have been used as outlined in Sendhil *et al.* (2019) and Horo *et al.* (2016).

*Price instability:* Cuddy Della Valle instability index (CDVI) (Cuddy and Della Valle 1978) has been used and it is a refinement of the CV. Over the scale-dependent variables such as standard deviation, this approach is preferable. The CDVI is calculated as outlined in Sendhil *et al.* (2019) and the instability is categorized as low: 0-15, medium: 15-30, and high: > 30 (Sihmar 2014).

*Compound annual growth rate (CAGR):* The compound annual growth in monthly wholesale prices of wheat was estimated using the formula given in Gujarati (2013).

*Price volatility: GARCH model and ARCH-LM test:* Commodity markets typically show volatile prices as per the flow of market information, hedging and speculation, and physical transaction of commodities. These characteristics validate the use of the information-based process to model the pattern of volatility (Vasisht and Bhardwaj 2010). The Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model was employed to measure the extent of volatility (Lama *et al.* 2015) in monthly wholesale prices for the selected states. In addition to differentiating between predictable and unpredictable price components, GARCH enables the variance of an unpredictable item to be time-variable (Bollerslev 1986). Initially, the Auto-Regressive Integrated Moving Average (ARIMA) filtration analysis was performed to determine the best fit ARCH term and then the best order GARCH model was fitted (Vasisht and Bhardwaj 2010). GARCH models of higher order, referred to as GARCH ( $p, q$ ), were estimated by selecting either  $p$  or  $q$ , or both greater than one (Jordaan *et al.* 2004) and represented as:

$$Y_{it} = a_0 + b_1 Y_{it-1} + b_2 Y_{it-2} + \varepsilon_{it}$$

$$\sigma_{it}^2 = \omega + \sum_{i=1}^p \beta_i \sigma_{t-i}^2 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2$$

where,  $Y_{it}$  is the monthly wholesale price in  $t^{\text{th}}$  period of  $i^{\text{th}}$  commodity,  $p$  is the order of the GARCH and  $q$  is the order of the ARCH. The summation of the coefficients ( $\alpha_i + \beta_i$ ) indicates the degree of persistence in volatility. A value closer to one shows that volatility persist for a longer time and greater than one indicates an explosive series, *i.e.*, meandering away from mean. After fitting

the model to capture the volatility in prices, ARCH-LM (Lagrange Multiplier) test was carried out to identify the serial correlation in residuals, if any.

## RESULTS AND DISCUSSION

The trend represents the general direction of change in prices over a period of time and is influenced by the change in factors affecting demand and supply. The initial Levene's test results indicated that all the price series across 15 states were significant rejecting the null hypothesis of equal variance. Post Levene's test, the price data (204 observation per state) were plotted to see the pattern over years and across states. The time plot indicated an increasing trend in prices for all markets corroborating the findings of Sendhil *et al.* (2018). Kerala registered the highest fluctuation and is attributed to no-wheat production in the state. The commodity has to reach from surplus regions to states wherein demand exists for consumption.

Monitoring the behaviour of prices in spatially separated markets is helpful for developing an efficient market. Wheat production being seasonal (November to April), demonstration of spatial and temporal variations in prices occurs very often. Summary statistics (Table 1) clearly depicted that the average wholesale prices were highest in Kerala (₹20.0/kg), followed by Karnataka (₹16.3/kg) and Maharashtra (₹15.2/kg) which means that demand for wheat in these states has been increasing more rapidly in comparison to production and/or supply.

The lowest minimum price was registered in Punjab (₹4.5/kg) and is attributed to surplus production (Ramdas *et al.* 2012). The study also revealed that the selected price series for all the states were positively skewed (ranging from 0.0 to 1.1), except Jharkhand with -0.1 indicating the distribution tails was short on the left side as compared to the right. Estimates of kurtosis showed that, out of 15 states, 13 were negative, with the exception of Kerala and Odisha. In general, agricultural commodity prices exhibit a non-stationary pattern with leptokurtic distribution (Sendhil *et al.* 2014) implying a relatively flatter curve than a normal distribution along with a wider peak. The highest standard deviation in wholesale prices was noticed in Kerala (₹5.2/kg), followed by Karnataka (₹5.1/kg) and Maharashtra (₹4.9/kg) which is in a similar pattern following the average wholesale prices in wheat.

*Seasonal variation in wheat prices:* For making any economic decision related to agricultural commodity prices, seasonal index needs to be calculated as the behaviour of prices gets influenced by the production season. It is clear that the seasonal index was highest in December (109.90) and lowest in July (91.48) for Haryana wholesale market (Table 1). Inter market comparison indicated that the seasonal indices were highest during the months of January to March, as the supply of wheat decreases in general prior to harvest. Haryana and Punjab markets showed the highest seasonal price index variation as compared to others. The seasonal price index for all the markets in July is low due to the surge in arrivals of wheat to the respective markets

Table 1 Summary statistics and seasonal indices for wholesale prices (AY 2002-03 to 2018-19)

Particulars	Chhattis- garh	Gujarat	Haryana	Jharkhand	Karnataka	Kerala	Madhya Pradesh	Maha- rashtra	New Delhi	Odisha	Punjab	Rajasthan	Uttar Pradesh	Uttara- khand	West Bengal
<i>Summary statistics (n = 204)</i>															
Maximum*	22.0	24.4	21.4	21.2	26.9	40.4	20.1	29.1	22.1	30.8	23.4	19.7	19.3	21.3	19.9
Minimum*	5.5	7.7	5.4	7.1	7.0	8.3	6.6	7.5	6.7	6.2	4.5	6.3	5.8	5.2	5.9
Average*	11.8	13.9	12.1	14.3	16.3	20.0	12.7	15.2	13.0	13.9	11.9	12.3	12.0	12.0	12.3
S.D.*	3.9	4.3	4.0	4.1	5.1	5.2	3.8	4.9	4.2	4.7	4.1	3.8	3.7	4.0	3.9
Skewness	0.3	0.2	0.0	-0.1	0.2	0.0	0.1	0.4	0.2	1.1	0.1	0.0	0.1	0.1	0.2
Kurtosis	-0.9	-1.1	-1.1	-1.3	-0.8	0.2	-1.2	-0.5	-1.0	2.2	-1.1	-1.2	-1.1	-1.0	-1.2
<i>Seasonal indices</i>															
July	96.3	96.3	91.5	96.5	96.0	94.9	95.1	98.2	93.0	93.9	97.0	95.9	94.1	93.7	92.6
August	98.4	97.0	92.8	95.6	98.8	98.3	96.7	98.7	94.3	98.3	95.2	96.8	96.0	95.1	95.8
September	100.2	96.1	95.6	97.1	99.4	101.9	97.6	97.9	95.4	95.9	93.5	97.2	96.9	96.3	98.2
October	97.2	97.3	104.5	98.7	97.5	107.7	97.3	98.8	97.5	96.8	92.6	97.8	98.5	97.1	99.1
November	105.4	102.6	109.3	101.2	99.4	101.4	102.0	102.5	101.5	94.5	103.2	102.0	101.0	99.2	101.3
December	101.5	102.7	109.9	101.6	99.4	98.8	101.7	105.1	102.5	100.8	107.0	102.9	102.8	101.2	103.5
January	97.9	106.8	106.9	102.0	101.9	99.1	103.9	106.9	104.2	101.1	108.9	104.8	104.7	103.6	106.4
February	107.7	100.9	102.2	102.5	103.2	97.5	102.8	102.4	103.5	106.7	105.3	104.6	105.5	106.1	107.7
March	99.6	100.4	97.5	103.5	99.5	98.5	101.4	94.2	102.0	103.8	102.0	99.7	104.5	107.3	103.6
April	96.4	99.2	96.6	101.8	101.3	100.3	101.1	96.5	99.0	103.0	97.9	98.0	96.9	100.5	96.7
May	97.0	100.7	97.4	99.5	100.6	101.3	101.1	98.5	105.3	103.0	98.5	99.6	99.5	100.3	97.0
June	102.4	100.0	95.8	100.1	103.1	100.4	99.3	100.3	101.6	102.1	99.0	100.7	99.6	99.7	98.1

\* Expressed as ₹/kg and S.D. denotes standard deviation.

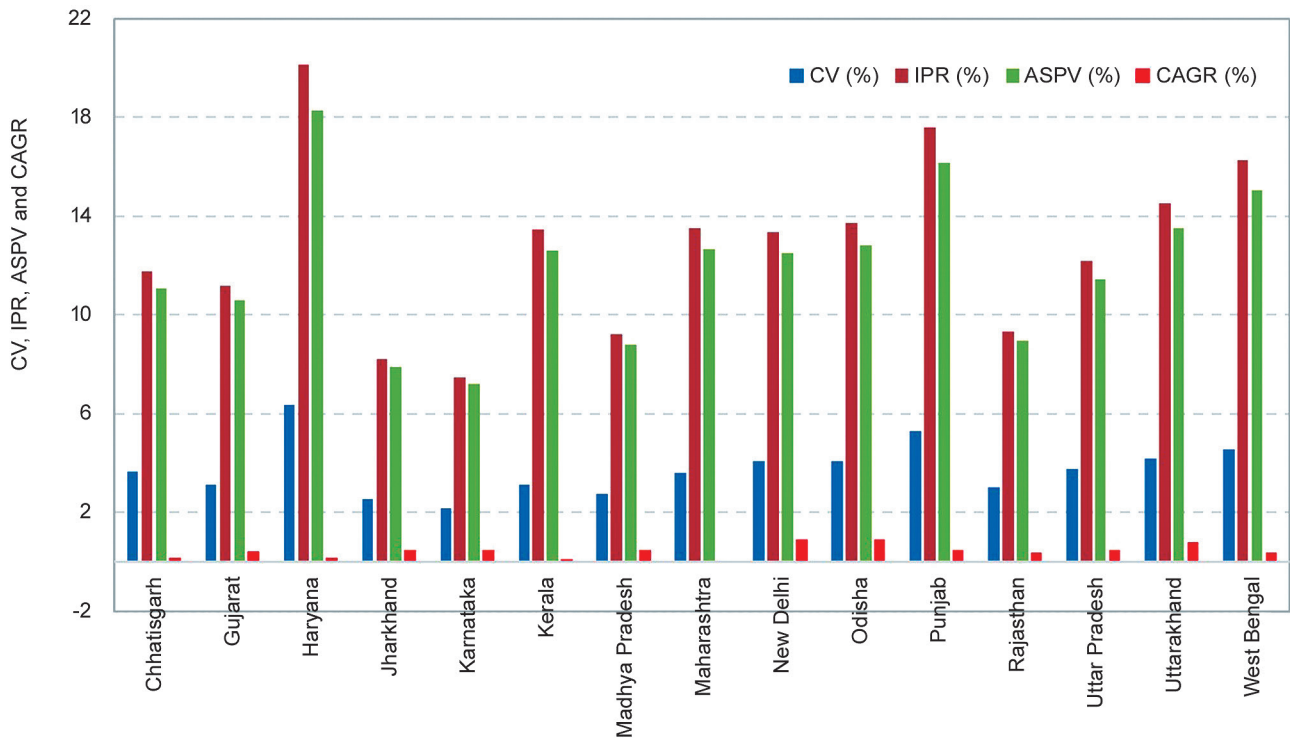


Fig 1 Growth and variation in seasonal price index.

after crop harvesting (Horo *et al.* 2016, Darekar and Reddy 2018, Cariappa *et al.* 2020).

The variation in seasonal price index (Fig 1) was highest in Haryana (6.35%), followed by Punjab (5.28%) and lowest in Karnataka (2.14%). Both intra-year price rise (IPR) and average seasonal price variation (ASPV) were found to be highest in Haryana, followed by Punjab and lowest in Karnataka. Inter wholesale markets comparison indicated that the indices of IPR and ASVP varied between 7.49-16.28%, and 7.22-18.29%, respectively. The estimate of IPR and ASVP plays an important role in taking agribusiness decisions right from production, consumption and trade (Mahalle *et al.* 2015). The compound annual growth rate (CAGR) of seasonal price index was positive for all the wholesale markets except Maharashtra (-0.04 %) as indicated earlier by Sendhil *et al.* (2018). Further, the estimated growth rates (%) were low across markets and generally found to be less than one.

The extent of volatility in wheat prices was estimated using the GARCH model for the monthly data spanning from 2002–03 to 2018–19. The best GARCH model fit was chosen based on the Schwarz criterion. Supporting the price trend analysis, Kerala registered the highest order of GARCH fit (2,1), followed by Gujarat (2,0), Haryana (2,0) and Chhattisgarh (1,1) indicating high volatility in wheat prices (Table 2). The persistence of volatility for a longer period is indicated by coefficient of  $\alpha_1 + \beta_1$  (Sendhil *et al.* 2014). In the case of Rajasthan and Maharashtra, GARCH (1,0) fit was appropriate and for the rest, the fit was found to be GARCH (0,1) exhibiting low volatility in wheat prices. The significance of ARCH and GARCH

coefficients shows the current month volatility is influenced by the past month price.

For diagnosing the data, a test of conditional heteroscedasticity ARCH-LM test was performed on residuals to check whether there exists any ARCH effect. It was confirmed that except for Haryana, in all other states, there was no serial correlation in the residuals of fitted GARCH/ARCH series of models (Table 2).

*Price instability vis-à-vis volatility vis-à-vis growth vis-à-vis production:* Instability and volatility exhibited a similar oscillation for the study period indicating higher instability influences the volatility level positively and *vice-versa*. As indicated by the past pattern, volatility and instability were highest in Kerala, i.e. 1.22 and 19.03, respectively (Fig 2). Overall, it implies that the prices were volatile and/or unstable in less-production regions.

On the contrary, the relationship between price volatility and price growth rate infers an inverse relationship, i.e. high volatility is accompanied by low annual growth and *vice-versa*. For instance, Kerala registered the lowest annual growth but experienced the highest volatility in wheat prices. Corroborating the theory, production has a negative association with price volatility. The implication is higher the production level, the more will be the market arrivals leading to stable prices.

Agriculture commodity prices are inherently non-stationary and fluctuate often. Hence capturing the behaviour of prices becomes cumbersome. The present study has analysed the price dynamics and captured the volatility in Indian wholesale wheat markets. Findings indicated that the wholesale market in Kerala behaves quite different

Table 2 Estimates of GARCH model and ARCH-LM test

Particulars	Chhattis- garh	Gujarat	Haryana	Jharkhand	Karna- taka	Kerala	Madhya Pradesh	Maha- rashtra	Delhi	Odisha	Punjab	Rajasthan	Uttar Pradesh	Uttara- khand	West Bengal
<i>GARCH estimates</i>															
Mean equation	-0.0014	0.0036	0.0046	0.0042*	0.0057	0.0021	0.0045	0.0048	0.0034	0.0051	0.0125	0.0028	0.0070*	0.0047	0.0110*
Constant*	0.0008	0.0000	0.0000	0.0013	0.0022	0.0012	0.0013	0.0002	0.0019	0.0114	0.0080	0.0030	0.0013	0.0025	0.0015
ARCH term ( $\alpha_1$ )*	0.6310			0.4244	0.3321	0.9106	0.2647			0.4030	0.4852		0.5565	0.2853	0.3269
GARCH term ( $\beta_1$ )*	0.5220	1.9907	1.9990		-0.0447		0.9367	0.3573				-1.0090			
		-0.9930	-1.0003		0.3572										
Log likelihood	170.58	300.65	186.46	350.71	304.73	188.59	363.83	287.76	315.77	132.21	168.68	379.90	347.19	297.04	343.61
GARCH fit	(1,1)	(2,0)	(2,0)	(0,1)	(0,1)	(2,1)	(0,1)	(1,0)	(0,1)	(0,1)	(0,1)	(1,0)	(0,1)	(0,1)	(0,1)
$\alpha_1 + \beta_1$	1.153	0.998	0.999	0.424	0.332	1.223	0.265	0.937	0.357	0.403	0.485	-1.009	0.557	0.285	0.327
Volatility	High	High	High	Low	Low	High	Low	High	Low	Medium	Medium	Low	Medium	Low	Low
Schwarz's coefficient	-1.58	-2.86	-1.73	-3.38	-2.92	-1.73	-3.51	-2.75	-3.03	-1.22	-1.58	-3.66	-3.34	-2.84	-3.31
<i>ARCH-LM test coefficients</i>															
F value	0.0009	1.487	13.127*	0.0623	0.0266	0.3323	0.1434	0.1411	0.3250	0.0710	0.0406	1.2765	0.0518	0.0003	0.2718
R <sup>2</sup>	0.0010	1.4910	12.4420	0.0629	0.0269	0.3351	0.1448	0.1425	0.3276	0.0717	0.4106	1.2811	0.0523	0.0003	0.2742
<i>Test equation</i>															
Constant	1.0050*	0.9286*	0.7630*	1.0171*	1.0149*	1.0695*	0.9695*	0.9698*	1.0433*	1.0234*	1.0169*	0.9317*	1.0196*	1.0059*	1.0418*
Residual lag	-0.0022	0.0859	0.2480*	-0.0176	-0.0115	-0.0407	0.0267	0.0266	-0.0402	-0.0189	-0.0143	0.0796	-0.0161	-0.0012	-0.0368
<i>Model parameter</i>															
R <sup>2</sup>	0.0000	0.0074	0.0616	0.0003	0.0001	0.0017	0.0007	0.0007	0.0016	0.0004	0.0002	0.0063	0.0003	0.0000	0.0014
SIC	4.473	4.247	4.294	4.479	4.038	4.596	4.299	4.213	3.978	4.226	5.213	3.781	4.380	5.410	4.215
Durbin-Watson statistic	2.002	1.978	1.950	2.001	1.998	1.999	1.994	1.999	1.998	1.951	1.997	1.993	1.990	2.000	1.841

\*Indicates the significance at 1 % level of probability and SIC refers to the Schwarz information criterion.

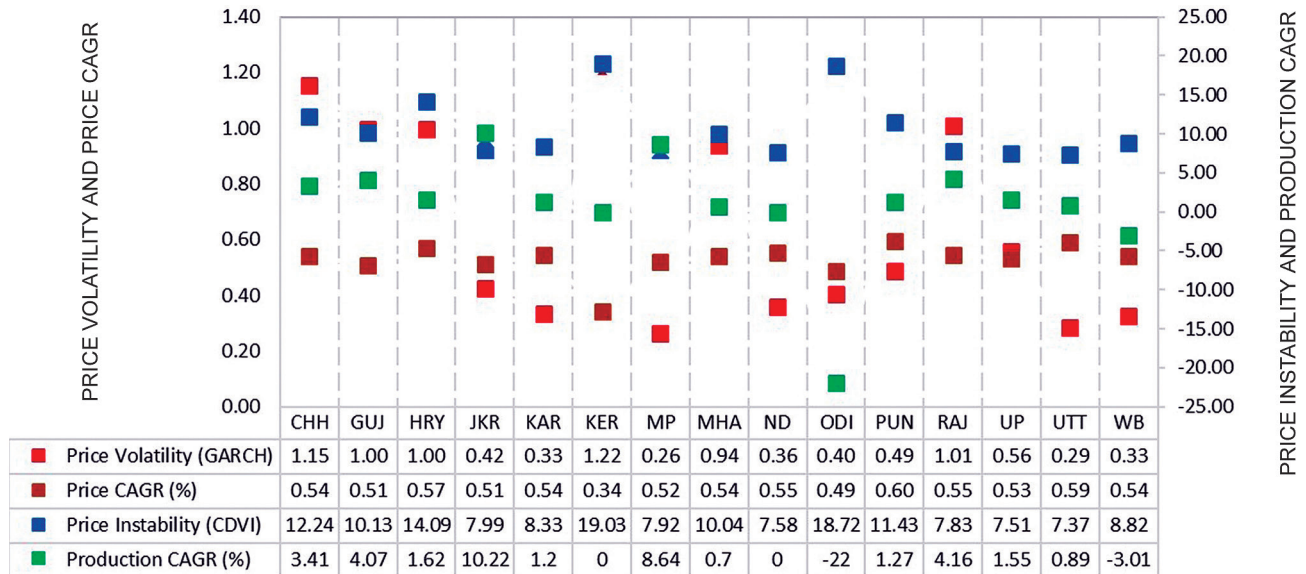


Fig 2 Relationship between price instability, volatility, price growth and production growth

from the rest as the maximum and minimum as well its divergence was highest and this is solely attributed to the non-production of wheat in the state. On contrary, regions with high production, the price level and variation were lower in general. The monthly price indices exhibited a clear-cut seasonality implying volatility is largely influenced by the market arrivals, i.e. after crop harvest. Volatility estimated by the GARCH model indicated that Kerala wholesale market prices were highly volatile, followed by Gujarat, Haryana and Chhattisgarh. In a majority of the wheat markets, the present month price volatility is influenced by the past month level. The implication is current period volatility is an important risk and underlying factor in deciding the future agricultural commodity supply. Several economic reasons shall be attributed to the price volatility. *Inter alia*, regional production followed by market arrivals influence the randomness in a price change. Regions wherein no or low production witnessed higher volatility and *vice-versa*. The study concludes that market intelligence and effective dissemination of information to the stakeholders will check the price volatility as well as decision-making for profitable agri-business, especially on sowing, stocking and transportation from surplus to deficit region(s).

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