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Price relationship and volatility dynamics in soybean spot and futures markets in India

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Abstract
The research paper entitled "Dynamic Study of Futures Trade of Soybean in India" aims to investigate the correlation between Soybean spot and futures prices, as well as the characteristics of price volatility in selected Soybean markets from 2012 to 2021. This study utilized secondary data sourced from NCDEX for futures prices and AGMARKNET for spot prices, focusing on the principal APMC markets of Indore, Ujjain, and Latur. To analyze the relationship between spot and futures prices, Karl Pearson's correlation coefficient was applied, while the ARCH-GARCH model was utilized to evaluate price volatility and its persistence. The findings indicated that the average Soybean futures price stood at ₹3,870.57 per quintal, whereas the average spot prices were ₹3,654.61, ₹3,593.99, and ₹3,724.70 per quintal in Ujjain, Indore, and Latur, respectively. A robust positive correlation was identified between futures and spot prices, with correlation coefficients of 0.93, 0.95, and 0.94 for Indore, Latur, and Ujjain, respectively, all significant at the 1 percent level, suggesting a high degree of market integration.
The ARCH-GARCH analysis indicated a high level of persistent volatility in the spot markets, with $\alpha+\beta$ values of 1.14 for Indore and 1.22 for Latur. Conversely, the soybean futures market exhibited an $\alpha+\beta$ value of 0.75, reflecting a relatively stable and less persistent volatility, with shocks diminishing over time. In summary, the study underscores the strong integration between Soybean spot and futures markets, while the persistent volatility in spot markets emphasizes the necessity for effective price-risk management and hedging strategies for farmers, traders, and other market participants.

Keywords: Soybean, futures trade, spot price, NCDEX, Price volatility, ARCH-GARCH

Introduction
Soybean (Glycine max L.) ranks among the most significant oilseed crops in India, accounting for approximately 40-45 percent of the total area dedicated to oilseed cultivation and playing a crucial role in both the agricultural and industrial sectors of the economy. The states of Madhya Pradesh, Maharashtra, and Rajasthan collectively contribute to nearly 90 percent of the nation's Soybean production, which is primarily utilized for the extraction of edible oil and as a fundamental component in the animal feed industry. Given that Soybean prices are affected by both domestic and international market dynamics, they experience frequent fluctuations due to variations in production levels, weather conditions, market arrivals, government policies, and global trade trends, resulting in substantial uncertainty for farmers, traders, and processors.
The commodity futures markets offer a structured platform for price discovery and risk management, allowing market participants to hedge against unfavorable price changes through standardized contracts. In India, soybean futures are predominantly traded on the National Commodity and Derivatives Exchange (NCDEX), which was established in 2003. The futures market serves a dual purpose: it facilitates price discovery by integrating available market information into anticipated future prices, and it provides risk management options, enabling farmers, traders, and processors to secure prices in advance. However, trading of Soybean futures on NCDEX was suspended on 20 December 2021, limiting the availability of continuous futures trading data beyond that date.
It is vital to comprehend the current status of soybean futures trading, the degree of integration between spot and futures prices, and the nature of price volatility in both markets to evaluate the efficiency of the futures market and its relevance to farmers, traders, processors, researchers, and policymakers. Therefore, the specific objectives of the study are

to study the relationship between spot and futures prices of Soybean and to examine the price volatility in spot and futures prices of Soybean.

Methodology

The study was conducted in India, covering selected Soybean spot markets at Indore, Ujjain and Latur, along with Soybean futures traded on NCDEX. The data was collected for a period of 10 years, i.e., from 2012 to 2021. Secondary data were collected from reliable sources, with spot prices obtained from AGMARKNET and futures prices from NCDEX. Supporting information was collected from government reports, research papers, journals and official publications.

Analytical Tools

1. Correlation Coefficient (r)

To fulfil the objective, Karl Pearson's Correlation Coefficient (r) was used to measure the degree and direction of the linear relationship between Soybean spot prices (X) and futures prices (Y):

$$r = \frac{\sum(X-\bar{X})(Y-\bar{Y})}{\sqrt{\sum(X-\bar{X})^2 \sum(Y-\bar{Y})^2}}$$

WHERE, r = Correlation coefficient, X = Value of the Spot price, Y = Value of the Futures price, $\bar{X}$= Mean (average) of X, $\bar{Y}$= Mean (average) of Y, Σ (Sigma) = Sum of whole period. The value of r ranges between -1 and +1; a value closer to +1 indicates a strong positive association and efficient price transmission between the spot and futures markets, while a value near zero indicates a weak or negligible relationship.

2. ARCH-GARCH Models

To fulfil the objective, price volatility in Soybean spot and futures prices was examined using the Autoregressive Conditional Heteroskedasticity (ARCH) model of Engle (1982) and its extension, the Generalized ARCH (GARCH) model of Bollerslev (1986).

$$Y_t = Yo+Y_1Xn +.....+YkX_{kt} +e \ldots\ldots\ldots 1$$

Where, Y_t = Dependent variable at time t (future price or spot price), X_{1t}, X_{2t},...,X_{kt}= Independent variables, Y_o, Y_1,..., Y_k= Coefficients, et =Random error term.

$$\sigma^2_t = \omega+\alpha e^2_{t-1}+\beta\sigma^2_{t-1}..... 2$$

Where, σ^2_t = Conditional variance at time t, ω= Constant term, α= ARCH parameter representing the effect of previous period's squared residual (news effect), β = GARCH parameter representing the effect of previous period's conditional variance (volatility persistence), e^2_{t-1}= Lagged squared error term, σ^2_{t-1}= Previous period's conditional variance. A sum (α+β) close to or exceeding one indicates highly persistent volatility that dissipates slowly, whereas a sum below one indicates that shocks decline over time and the series is comparatively stable.

Results and Discussion

1. Relationship between spot and future price of Soybean.

To fulfill the objective of the study, namely examining the relationship between spot and future prices of Soybean, the results obtained using the Correlation Coefficient method for NCDEX future prices and spot prices of Latur, Ujjain and Indore APMC markets are presented as under.

Table 1: Descriptive statistics of future and spot price of Soybean

Sr.no	Price	N	Mini.	Max.	Mean	Median	Mode	Std. Dev.	C.V.%	Skew ness	Kurt osis
1	Future	120	2451.5	10081	3870.57	3675	3819	1083.12	27.98	2.9	11.1
2	Spot1 (Ujjain)	120	2368.85	8858.37	3654.61	3423.54	NA	1022.84	27.98	2.86	9.59
3	Spot2 (Indore)	120	2332.9	8812.63	3593.99	3474.72	NA	926.85	25.78	2.91	11.62
4	Spot3 (Latur)	120	2329.67	8964.38	3724.7	3570.97	NA	1087.95	29.20	2.61	8.28

The table that the average Soybean future price was ₹3,870.57 /quintal, while the average spot prices were ₹3,654.61 in Ujjain, ₹3,593.99 in Indore and ₹3,724.70 in Latur. The future price had a CV of 27.98%, indicating moderate variability, while Latur recorded the highest variability among spot markets (29.20%). All prices showed positive skewness and high kurtosis, indicating non-normal price distributions.

Table 2: Simple Correlation Coefficient between Spot and future price of Soybean

Simple Correlation Coefficient, N=120, Prob, >IrI under H0: Rho = 0				
Spot Prices (indore)	**Spot Prices (Indore)**	**Spot Prices (Latur)**	**Spot Prices (Ujjain)**	**Future price**
Spot Prices (latur)	0.98***	1		
Spot Prices (ujjain)	0.97***	0.99***	1	
Future price	0.93***	0.95***	0.94***	1

Note: *** indicates significance at the 1 per cent level ($p < 0.01$)

The table indicates a strong and positive relationship among Soybean spot and futures prices. The correlation between futures and spot prices was 0.93 with Indore, 0.95 with Latur, and 0.94 with Ujjain, all significant at the 1% level (***). This indicates strong price integration between the futures and spot markets.

2. Price volatility in spot and future price of Soybean.

To fulfil the objective of the study, namely examining the volatility of spot and future prices of Soybean, the results obtained using the ARCH-GARCH model for NCDEX future prices and spot prices of Latur, Ujjain and Indore APMC markets are presented as under.

Table 3: Auto regressive conditional ARCH with spot price as dependent for Soybean (Latur 2012-2021)

GARCH = C(3) + C(4) × RESID(-1)² + C(5) × GARCH(-1)				
Particulars	**Coefficent**	**Std. error**	**Z-statistics**	**Prob.**
Mean equation				
C	9.3	15.8	0.59	0.56
Future Price	0.32	0.04	8.49	0
Variance Equation				
C	6347.75	4002.93	1.59	0.11
α:RESID(-1)²	0.81	0.15	5.24	0
β:GARCH(-1)	0.41	0.09	4.6	0
Mean dependent var	33.76	S.D. dependent var		417.65
S.E of regression	354.53	Akaike info criterion		13.95
Sum square	14706025	Schwarz criterion		14.06
Log likelihood	-824.95	Durbin-Watson stat		1.66
R-squared	0.28	Hannan-Quinn criteria		13.99

The GARCH results indicate that Soybean futures prices had a significant positive effect on the mean equation (0.32). Both ARCH (α = 0.81) and GARCH (β = 0.41) coefficients were positive and significant, indicating significant and persistent price volatility. The sum of α + β = 1.22 (>1), suggesting highly persistent volatility in soybean futures prices during the study period.

Table 4: Auto regressive conditional ARCH with spot price as dependent for Soybean (Indore 2012-2021)

GARCH = C(3) + C(4) × RESID(-1)² + C(5) × GARCH(-1)				
Particulars	**Coefficent**	**Std. error**	**Z-statistics**	**Prob.**
Mean equation				
C	11.06	17.4	0.63	0.52
D Future Price	0.48	0.05	9.1	0
Variance Equation				
C	4272.59	2908.1	1.47	0.14
α:RESID(-1)²	0.54	0.14	3.95	0
β:GARCH(-1)	0.59	0.09	6.29	0
Mean dependent var	29.38	S.D. dependent var		413.94
S.E of regression	362.37	Akaike info criterion		13.88
Sum square Residual	15363978	Schwarz criterion		14
Log likelihood	-821.14	Durbin-Watson stat		2.23
R-squared	0.24	Hannan-Quinn criteria		13.93

The table shows that the future price has a significant positive effect on Indore spot prices (coefficient = 0.48). Both ARCH (α = 0.54) and GARCH (β = 0.59) coefficients are positive and significant, indicating significant volatility. The value of α + β = 1.13 (>1) indicates highly persistent volatility in Indore soybean spot prices.

Table 5: Auto regressive conditional ARCH with spot price as dependent for Soybean (Ujjain 2012-2021)

GARCH = C(3) + C(4) × RESID(-1)² + C(5) × GARCH(-1)				
Particulars	**Coefficent**	**Std. error**	**Z-statistics**	**Prob.**
Mean equation				
C	7.09	18.65	0.38	0.7
D Future Price	0.24	0.04	5.44	0
Variance Equation				
C	4222.03	4070.01	1.03	0.29
α:RESID(-1)²	0.58	0.16	3.6	0
B:GARCH(-1)	0.56	0.09	5.87	0
Mean dependent var	30.31	S.D. dependent var		415.45
S.E of regression	373.17	Akaike info criterion		13.89
Sum square Residual	16292753	Schwarz criterion		14.01
Log likelihood	-821.98	Durbin-Watson stat		1.58
R-squared	0.2	Hannan-Quinn criteria		13.95

The table indicates that future price has a significant positive effect on the spot price (coefficient = 0.24). Both ARCH (α = 0.58) and GARCH (β = 0.56) coefficients are positive and significant, indicating significant price volatility. The value of α + β = 1.14 (>1) indicates highly persistent volatility in the soybean spot market.

Table 6: Auto regressive conditional ARCH with future price as dependent for future price of Soybean (2012-2021)

GARCH = C(3) + C(4) × RESID(-1)² + C(5) × GARCH(-1)			
Particulars	**Coefficent**	**Std. error**	**Prob.**
Mean equation			
C	5.21×10^{-15}	5.97×10^{-14}	0.93
D Future Price	1	923743.5	1
Variance Equation			
C	5.96×10^{-27}	6.78×10^{-27}	0.38
α: RESID(-1)²	0.15	0.12	0.23
β: GARCH(-1)	0.6	0.39	0.12
Mean dependent var	32.08	S.D. dependent var	490.8
S.E of regression	9.66×10^{-14}	Akaike info criterion	-57.04
Sum square Residual	1.09×10^{-24}	Schwarz criterion	-56.92
Log likelihood	3398.78	Durbin-Watson stat	1.73
R-squared	1	Hannan-Quinn criteria	-56.99

The table shows that the ARCH (α = 0.15) and GARCH (β = 0.60) coefficients are positive but statistically insignificant. Their sum, α + β = 0.75 (<1), indicates that volatility in soybean futures prices is stable and less persistent, with shocks gradually declining over time.

Table 7: ARCH-GARCH Analysis for Future and Spot Market prices of Soybean. (2012-2021)

Parameter	Spot (Indore)	Spot (latur)	Future
Alpha (α)	0.54	0.81	0.15
Beta (β)	0.59	0.41	0.6
Sum (α+β)	1.14	1.22	0.75

The table shows that volatility was highly persistent in Indore and Latur spot markets, with α+β values of 1.14 and 1.22 (>1), respectively. In contrast, soybean futures showed lower and stable volatility, with α+β = 0.75 (<1), indicating that volatility shocks gradually decline over time.

Conclusion

The research findings indicated that Soybean futures prices experienced a positive growth rate of 0.32 percent from 2012 to 2021, whereas the quantity delivered saw a decline of 0.80 percent, exhibiting significant variability. Notably, futures prices surged towards the conclusion of the study period, achieving a peak of ₹6,528.08 per quintal in 2021. A monthly analysis revealed consistent positive growth across all months, with the most substantial increase occurring in July at 5.68%.

A strong and positive correlation was identified between futures and spot prices in the markets of Indore, Latur, and Ujjain, with correlation coefficients recorded at 0.93, 0.95, and 0.94, respectively, all significant at the 1 percent level, which underscores a strong integration within the market. The ARCH-GARCH analysis indicated a high degree of persistent volatility in the spot markets of Indore and Latur, with α+β values of 1.14 and 1.22, respectively, while the futures prices exhibited relatively stable volatility, reflected by an α+β of 0.75. In summary, the results underscore the strong integration between soybean spot and futures markets, emphasizing the necessity for effective price-risk management and hedging strategies..

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