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A Study Of Volatility Transmission Across Spot And Future Markets Of Soybean

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Abstract

India is fourth largest producer of soybean in the world with majority share coming from Madhya Pradesh and contributes significantly to the Indian edible oil pool. Beside demand and supply, seasonal variations also affect the price volatility of soybean. The purpose of the study is to investigate the volatility transmission across spot and future markets of soybean traded in Indian commodity market. Volatility transmission determines how price signals flows from one market to other causing unanticipated price variations. The daily spot prices of soybean are collected from Nagpur, Kota and Indore spot exchanges whereas daily closing prices of highly liquid contracts of soybean are collected from NCDEX platform for the time period January 2010 to December 2021. The ARCH and GARCH (1, 1) models establish the presence of varying conditional volatility over a period of time and persistent volatility shocks in the prices of soybean. The estimates of Johansen cointegration test predict a long-run cointegration between future and spot prices of Kota exchange whereas the prices of Nagpur and Indore spot exchange do not shows a long-run co-movement with the future markets of soybean. The results of Pair-wise Granger Causality Tests predict uni-directional volatility transmission from Kota spot market to future market of soybean. The test results predicts that volatility transmission is absent between Nagpur spot market and futures as well as Indore spot market and futures. No volatility transmission has been estimated among different spot markets of soybean. The findings of the study are helpful to the market participants to hedge their financial risk and for researchers and policy makers to design appropriate hedging tools for risk management.

Novelty-Many studies have been conducted on currencies, stocks, metals and energy derivatives but a very few studies have been done on agriculture commodities particularly soybean. We couldn't find any study which tries to explore volatility transmission across markets of soybean traded in Indian commodity market in recent times.

Keywords: Volatility Transmission, Cointegration, Pair-wise Granger Causality, Spot and Futures markets, Indian Commodity Markets.

1. Introduction

Agriculture represents the culture, civilization and economy of Indian people and its history dates back to 9000 B.C when we started cultivating Barley, Jujube and wheat along with domestication of cattle. Today, Indian economy is heavily dependent on agriculture and is the world's second-largest producer of agricultural commodities. Agriculture employs 52% of the country's workforce and accounts for 19.9 % of the nation's GDP in FY 2020-21 which demonstrates the significant role of agricultural sector in the overall economic prosperity of the country. Many factors influence the fluctuation of commodity prices, including weather conditions, production strikes, agricultural diseases, technological advancements, and international trade unions besides demand and supply constraints.as argued by Micha Falkowski (2011). Producers, traders, and processors (market participants) are exposed to commodity price risk in which unexpected changes in commodity prices due to many uncontrollable factors can result in unanticipated losses to them. Financial experts consider volatility a proxy for risk making volatility in commodity prices a major concern for any economic stability and prosperity. Volatility increases risk to market participants, which deters them from participating in commodity markets. Since, agriculture is the backbone of Indian economy, understanding the mechanism of price formation and volatility transmission between the futures and spot markets is a major concern for the market participants, academicians, researchers and policymakers around the world. The study will not only help us to understand price discovery and volatility transmission but also assist us to design and implement appropriate policies, market regulations and hedging techniques to manage price risk arising out of uncertain movements in prices of soybean. It is in this backdrop, the present study has been taken up.

2. Review of Literature

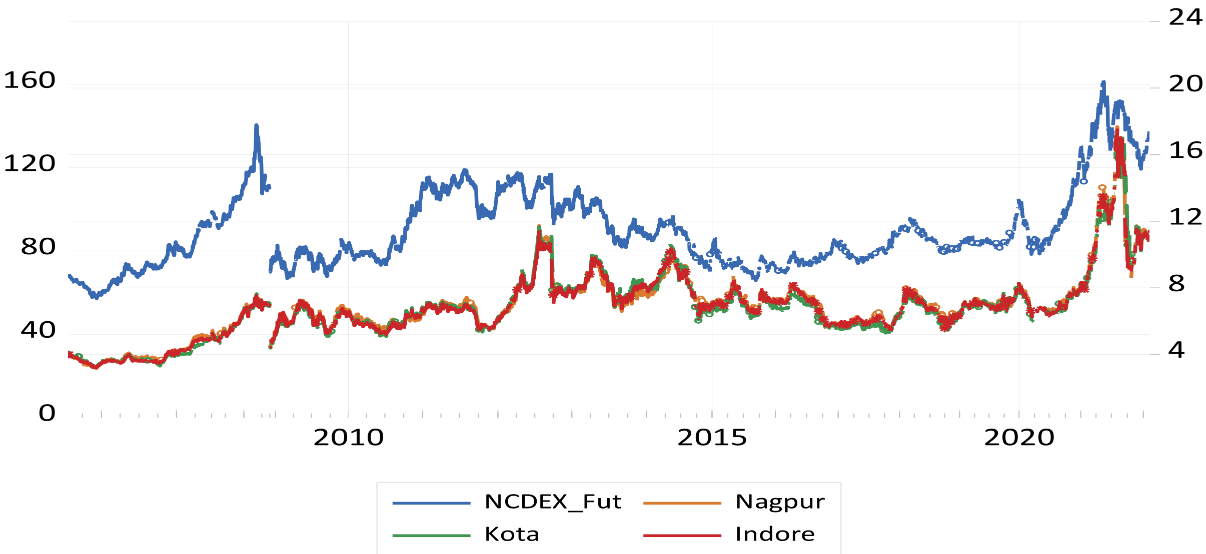
There are diverse views on volatility transmission in agriculture commodities which has been presented by different researchers, academician and policy makers. The paper has briefly presented the researches which has notable contribution in the area of volatility transmission.

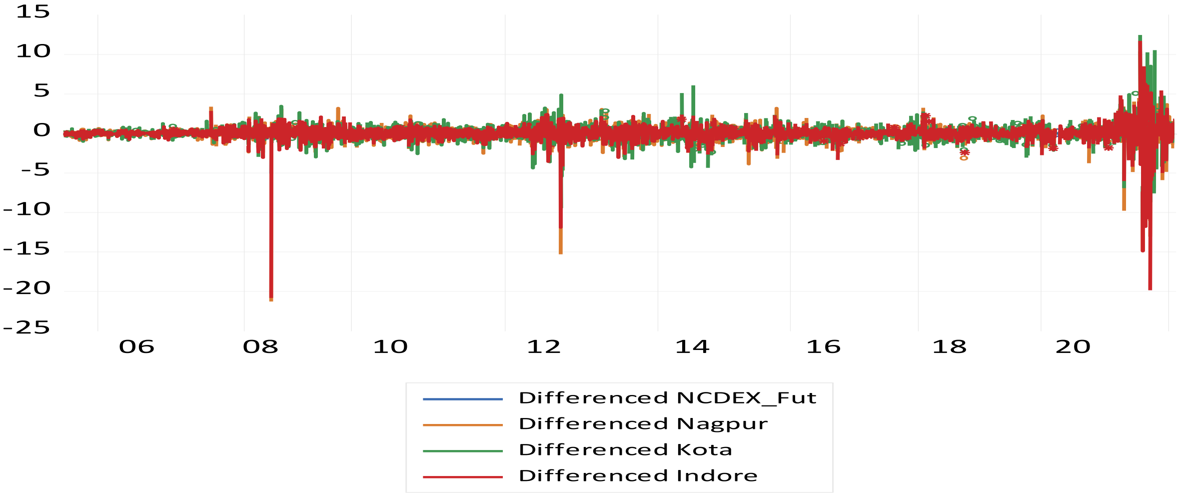
Kaura and Rajput (2021) has analysed the price discovery in the spot and future prices of different commodities using VAR model and found a powerful role of spot markets in price discovery process. **Rout et al. (2021)** while analyzing price discovery and volatility transmission in agriculture commodities also found that the spot markets emits the pricing signals and leads in price formation. **Sendhil et al. (2013) and Huynh et al. (2020)** found that the future markets leads in price discovery and contribute to the volatility in the spot markets in metals and agriculture commodities. **Thenmozhi and Maurya (2020)** also examined the short and long-run dynamics of volatility in maize, soybean, and wheat spot and futures markets, as well as soybean prices and showed that there is volatility spillover from wheat futures to soybean futures in the short run, and from soybean futures to maize, soybean, and wheat futures in the long run. **Dhineshni and Dhandayuthapani (2016)** examined the price discovery mechanism between the spot and future markets of five agriculture commodities (chilli, Coriander, zeera, pepper and turmeric) being traded on NCDEX and found a bi-directional causal relationship between the spot and future price of all the five commodities. **Datta and Sarker (2015)** analysed the relationship between the spot prices and introduction of future trading in turmeric and concluded that future trading in commodities do not cause any volatility in their respective spot prices. **Aggarwal et al. (2014)** examined the price discovery and risk management in six agriculture commodities viz. pepper, soya oil, caster seed, sugar, wheat, rubber and highlighted certain bottleneck for improving risk management efficiency of future markets like high settlement cost, unreliability of warehouse receipts, few delivery centers etc. **Shakeel and Puranka (2014)** examined the price discovery mechanism in spot and future markets of agriculture commodities viz. soybean, chana and caster and concluded that both the markets are equally efficient and price discovery takes place in both the markets simultaneously. **Chhajed and Mehta (2013)** studied price discovery behavior of nine agriculture commodities viz. cardamom, wheat, crude palm oil, chana, potato, soybean, rubber, jute and mentha oil and found a bi-directional causal relationship. **Reddy et al. (2014)** examined the volatility spillover to understand hedging opportunities in agriculture and metals commodities. The spot market is found highly efficient in metal commodities except aluminum and agriculture commodities except barley, chana and soybean. **Athma and Rao (2013)** analysed relationship between the spot and future prices of Comdex Index of Multi-Commodity Exchange which is a constituent of three indices i.e. MCX Agri, MCX Metal and MCX Energyand estimated a dominant role of future market in price discovery. **Sehgal et al. (2013)** found quite encouraging results and price discovery was confirmed for three indices and eight commodities with greater role of commodity future markets in price discovery process. **Kumar and Pandey (2013)** examined volatility transmission four agriculture commodities including soybean. The study found that thinly traded contracts are unable to forecast future spot price which means price discovery takes place in future market only when liquidity of contract is high. **Vijayakumar et al. (2012)** examined spot and futures markets for spices have established a long-run equilibrium relationship in terms of pricing behavior between the two markets and concluded that spot prices of spices lead to their respective future price in price discovery. **Seghal et al. (2012)** examined the price discovery in ten agriculture commodities and shows the existence of a bi-directional causal relationship between the spot and future prices of all the commodities except turmeric. **Jackline and Deo (2011)** studied lead-lag relationship between the spot and future prices of lean hogs and pork bellies market and has predicted a perfect equilibrium between the spot and future markets and a bi-directional causality relationship. **Shihabudheen and Padhi (2010)** studied price discovery and volatility spill over in gold, silver, soybean, caster seed, jeera and sugarand concluded that future markets are more efficient in price discovery in comparison to the spot markets. **Iyer and Pillai (2010)** analysed the price discovery in six commodities i.e. gold, silver, copper, nickel, rubber, and chanaand found that the price discovery is taking place in future market in five commodities. During the review of literature the study has noticed that most of the studies are done in developed countries on currencies, stocks, bullions, base metals and soybean whereas we have found limited studies exploring volatility transmission in context to Indian agriculture commodities **(Li and Zhang, 2009; Bhattacharya and Das, 2002).**

3. Research Methodology

3.1 Data

The study has used daily spot and future prices of soybean for estimation of volatility transmission across future and spot markets of Soybean. We have used daily closing future prices of highly liquid contract traded on NCDEX and daily closing spot prices of soybean traded on national spot exchanges of Nagpur, Kota and Indore from January 2010 to December 2021.





3.2 Econometric Methods

The study has employed Augmented Dickey-Fuller Test (ADF) and Phillips-Perron (PP) Test to estimate the Stationarity in the spot and future prices of soybean. The dataset is found to be non-stationary at level which is converted into stationary time series. The ARCH and GARCH (1, 1) models has been used to establish the presence of time varying conditional volatility and persistence of volatility shocks in the prices. For estimating long-run cointegration between the spot and future markets the study has employing Johansen's Cointegration Test. The research has employed Pair-wise Granger Causality Tests to analyse the volatility transmission across the spot and future markets of soybean.

The present study empirically investigates the following hypotheses

1. H1: The variance in the prices of soybean does not depend upon its past variance.
2. H2: The spot and future markets of soybean are not cointegrated.
3. H3: No volatility transmission takes place between the spot and future markets of soybean.

Table 1: Descriptive Statistics

	NCDEX_FUT	SPOT_NAGPUR	SPOT_KOTA	SPOT_INDORE
Mean	11.480	53.277	52.379	52.760
Median	10.834	53.315	51.710	52.232
Maximum	19.543	139.710	134.941	138.367
Minimum	7.343	23.650	24.096	23.718
Std. Dev.	2.367	15.873	16.189	15.880
Skewness	1.014	1.303	1.287	1.263
Kurtosis	3.784	7.325	6.816	7.231
Jarque-Bera	760.898	4103.423	3409.230	3907.586
Probability	0.000	0.000	0.000	0.000
Sum	44336.210	205756.400	202288.100	203760.900
Sum Sq. Dev.	21635.350	972813.300	1011961.000	973642.300
Observations	3862.000	3862.000	3862.000	3862.000

4. Estimating Stationarity

Stationarity of dataset is an important prerequisite for time series estimations. The has used ADF test and PP test for checking the Stationarity in the dataset as follows;

4.1 Augmented Dickey-Fuller (ADF) Test

This test is considered one of the authentic tests for estimating stationary in time series data due to their ability to incorporate general ARIMA (p, q) with uncertain orders.

The hypothesis of the test is:
Null hypothesis (H_0) is $\delta=0$
Alternate hypothesis (H_1) $\delta<0$

$$\Delta Y_t = \mu + \delta Y_{t-1} + \sum^{n} i\alpha_i \Delta Y_{t-1} + \varepsilon_t$$

Where μ is a constant or drift term, t denotes the coefficient on a time trend, $\varepsilon_t$denotes error term (white noise). 'n' denotes the largest lag used and Δ is first difference operator.
The value of test statistics (t-stat.) can be calculated as.

$$DF_T = \frac{\hat{\delta}}{SE(\hat{\delta})}$$

Where, DF_T represents the test statistics

Table 2: Estimates of Augmented Dickey-Fuller Test (ADF)

Markets	ADF Test	t-statistics	Critical Value	P-value**	Co-efficient
NCDEX_FUT	Level	-2.080	-2.862	0.252	-0.001
	First Difference	-59.922	-2.862	0.000	-0.966
SPOT_NAGPUR	Level	-2.131	-2.862	0.232	-0.002
	First Difference	-67.903	-2.862	0.000	-1.091
SPOT_KOTA	Level	-1.699	-2.862	0.431	-0.001
	First Difference	-61.076	-2.862	-0.988	0.000
SPOT_INDORE	Level	-1.7160	-2.862	0.423	-0.001
	First Difference	-65.141	-2.862	0.000	-1.052

4.2 Phillips-Perron (PP) Test

It is another most important test to estimate Stationarity in a dataset. The test was given by Phillips & Perron (1988) and can be expressed as;

$$\Delta Y_t = \delta Y_{t-1} + \varepsilon_t$$

The hypotheses of the test are:
Null hypothesis (H_0) is $\delta=0$
Alternate hypothesis (H_1) $\delta<0$
The ADF test introduces lags of ΔY_t as regressor in the equation whereas non-parametric correction in the t-statistics are made by PP test thus making it a better estimator to handle autocorrelation and heteroscedasticity in the dataset (Gupta, S., & Bhardwaj, S. 2018).

Table 3: Estimates of Phillips-Perron (PP) Test

Markets	PP Test	t-statistics	Critical Value	P-value**	Co-efficient
NCDEX_FUT	Level	-2.195	-2.862	0.208	-0.001

	First Difference	-60.044	-2.862	0.000	-0.966
SPOT_NAGPUR	Level	-2.203	-2.862	0.205	-0.002
	First Difference	-67.736	-2.862	0.000	-1.091
SPOT_KOTA	Level	-1.485	-2.862	0.541	-0.000
	First Difference	-55.744	-2.862	0.000	-0.917
SPOT_INDORE	Level	-1.463	-2.862	0.552	-0.001
	First Difference	-59.084	-2.862	0.000	-0.975

As shown in table 2 and table 3, the estimates of both the tests suggest that the data is not stationary at level. The dataset has been converted into stationary time series by taking their log differences. The study has used vector auto regression (VAR) Schwarz Information Criterion (SIC) developed by statistician Gideon Schwarz for selecting the appropriate lag length.

5. Estimating Volatility

Volatility transmission determines how price signals flows from one market to other causing unanticipated price variations. Before the estimation of GARCH model the data series has been analyzed for ARCH (q) effect. If there is no ARCH effect there is no need of running GARCH model.

5.1 ARCH Effect

The model for testing of ARCH (1) effects is as;

$$\hat{u}_t^2 = b_0 + b_1\hat{u}_{t-1}^2 + e_t$$

Where, Null Hypothesis $b_1 = 0$ (homoscedastic) and Alternate Hypothesis $b_1 \neq 0$ (heteroscedastic)

According to TABLE 4**,** the values of F-stat, R^2 and Prob. shows that the dataset of soybean has heteroscedasticity which depends on its lagged effects (autocorrelation). Thus, confirming an ARCH effect in dataset.

Table 4: Estimates of Heteroscedasticity Test: ARCH Effect

SPOT_NAGPUR			
F-statistics	Prob.	R^2	Prob.
125.7729	0.0000	121.8484	0.0000
SPOT_KOTA			
F-statistics	Prob.	R^2	Prob.
85.3251	0.0000	82.5813	0.0000
SPOT_INDORE			
F-statistics	Prob.	R^2	Prob.
118.1504	0.0000	115.6524	0.0000
NCDEX_FUT			
F-statistics	Prob.	R^2	Prob.
93.84434	0.0000	90.83396	0.0000

Similarly, the study has employed GARCH (p, q) model to estimate the volatility of soybean prices as;

$$h_t = \alpha_0 + \sum_{i-1}^{p} \alpha_i \varepsilon_{t-i^2} + \sum_{j-1}^{q} \beta_j h_{t-j}$$

The coefficients of the constant variance term, the ARCH and GARCH parameters are positive and statistically significant. All the coefficients of the conditional variance specifications meet the stability condition of the GARCH model as;

$$0 < \alpha_i < 1, 0 < \beta_j < 1 \text{ and } \alpha_i + \beta_j < 1$$

The estimates of the study clearly establish the presence of varying conditional volatility over a period of time and persistent volatility shocks in the prices of soybean. Hence, null hypothesis **H_1 is rejected.** It suggest that the effect of present shocks play an important role remain in the forecasts of future variance.

6. Johansen's Cointegration Test

This test was named after the Professor Soren Johansen who is well known for his contribution to the theory of cointegration. It is used to analyses the long run cointegration in time series data and the rationale behind the use of this test came from the robustness of the model.

The Johansen's Cointegration Test has following hypothesis.

Null Hypothesis (R=0), no cointegration

Alternate Hypothesis (R=1), cointegration

$$\Delta Y_t = \Pi \, Y_{t-1} + \sum_{i=1}^{k-1} \Gamma \Delta Y_{t-1} + Bx_t + \varepsilon_t$$

Here $\Delta Y_t = Y_t - Y_{t-1}$, ε_t denotes error term or white noise, T_i and Π represents the co-efficient matrix. The lag length k can be selected by following VAR lag length criteria.

Table 5: Estimates of Johansen's Cointegration

Markets	**H_0 : R**	**Trace Statistics**		**Max-Eigen statistics**		**Decision**
		λ trace	**Prob.****	**λ max**	**Prob.****	
NCDEX_FUT INDORE	0	64.054	0.000	57.584	0.000	R=1 accepted non-cointegration
	1	6.470	0.403	6.470	0.403	
NCDEX_FUT KOTA	0	187.117	0.000	178.289	0.000	R=1 reject non-cointegration
	1	8.827	0.191	8.827	0.191	
NCDEX_FUT NAGPUR	0	11.57489	0.1785	9.313050	0.2610	R=1 accepted non-cointegration
	1	2.261843	0.1326	2.261843	0.1326	

Note: Significant at: *0.01 and **0.05 level

Johansen's Cointegration Test was carried out on soybean prices at lag 4. As presented in Table 5, both the Johansen λ trace and λ max test has predicted that the p-value is less than 5%. Thus rejecting null hypothesis of non-cointegration (R=0) at 0.05 level of significance for soybean. Hence, the null hypothesis **H_2 is rejected** for NCDEX future and Kota spot predicting presence of long-run cointegration between the two markets. The null hypothesis **H_2 is accepted** for NCDEX future and Nagpur spot as well as Indore spot predicting absence of long-run cointegration.

7. Pair-wise Granger Causality Test

This test has been designed by Clive Granger in 1969 to predict one time series by using prior values of other times series. The study employed Pair-wise Granger Causality Test to estimate causality behaviour across the spot and future markets of soybean.

The test is based on following two basic assumptions

a) Cause happen before effect

b) Cause has some important information related to effect.

Hypothesis of the test are

Null Hypothesis (H_0): non-existence of causal relationship

Alternate Hypothesis (H_a): existence of causal relationship

When the two variables are integrated of order 1(1) following regression model can be used to test their causal relationship.

$$Y_t = \alpha + \sum_{i=1}^{p} a_t y_{t-1} + \sum_{j=1}^{q} b_j x_{t-j} + \varepsilon_t$$

Where X Granger Causes Y, if the null hypothesis H_0: $b_1 = b_2 = \ldots = b_q = 0$ is rejected and the alternate hypothesis H_a: at least one $b_j \neq 0$, j=1,2,3…q.

$$X_t = \beta + \sum_{i=1}^{r} c_i x_{t-i} + \sum_{j=1}^{s} d_j y_{t-j} + \eta_t$$

Where Y Granger Causes X, if H_0: $d_1 = d_2 = \ldots ds = 0$ is rejected and the alternate hypothesis Ha: At least on $d_j \neq 0$, j = 1,2,3…s.

As shown in table 6, the values of F-stat and P-value predict a uni-directional volatility transmission from spot prices of Kota exchange to future prices of soybean. **Hence, null hypothesis H_3 is rejected.** The price of soybean is not only derived from the speculations in the future market but fundamental factors in the spot markets play a critical role in forming the equilibrium price. The study found that no volatility transmission takes place between the future market and spot market of Nagpur as well as Indore. The study does not establish the presence of volatility transmission among the three spot markets of soybean. **Thus, null hypothesis H_3 is accepted.**

Table 6: Estimates of Pair-wise Granger Causality Tests

Null Hypothesis (H_0)	**Lags**	**F-Stat**	**P-Value****	**Decision**
NAGPUR does not Granger Cause NCDEX_FUT	2	0.22121	0.8016	Accept
NCDEX_FUT does not Granger Cause NAGPUR		32.3724	1.E-14	Accept
KOTA does not Granger Cause NCDEX_FUT	2	3.72412	0.0242	Reject
NCDEX_FUT does not Granger Cause KOTA		58.0850	2.E-25	Accept
INDORE does not Granger Cause NCDEX_FUT	2	0.71943	0.4871	Accept
NCDEX_FUT does not Granger Cause INDORE		71.1016	5.E-31	Accept
KOTA does not Granger Cause NAGPUR	2	1.19068	0.3041	Accept
NAGPUR does not Granger Cause KOTA		157.515	5.E-66	Accept
INDORE does not Granger Cause NAGPUR	2	1.36811	0.2547	Accept
NAGPUR does not Granger Cause INDORE		58.7060	8.E-26	Accept
INDORE does not Granger Cause KOTA		159.252		

	2		1.E-66	Accept
KOTA does not Granger Cause INDORE		5.89963	0.0028	Accept

Note: Significant at: *0.01 and **0.05 level

Conclusion

Agriculture commodities which are farmed on a regular basis are more likely to exhibit high price volatility where prices declines during the harvest and rises during scarce supply causing financial difficulties and losses to the farmers. One of the important properties of financial data is volatility clustering in response to a market shock. This stochastic behaviour in time series data of soybean is clearly visible where small changes in variance and large changes in variance tries to cluster separately the phenomenon is known as volatility clustering. The study has found that there is long-run cointegration between the spot prices of Kota exchange and future prices of soybean. It has been established that there is a uni-directional volatility interactions from Kota spot prices to future prices in the commodity under investigation. Analysis of volatility transmission in soybean is very crucial for the valuation of derivatives, risk hedging, investment decisions and also affects its marginal and opportunity cost as well as value of the firm. Higher price volatility can lead to economic instability and affect the economy of the countries (Narayan, P. K., & Narayan, S. 2007). The estimate implies that besides regulating herding and excessive speculations in future markets; there is a need to focus on critical variable affecting spot price of soybean.

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