Identification and Management of Price Bubbles in Chinese Soybean Futures

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Abstract. Utilizing daily data from 2019 to 2022, the GSADF method was employed to test the price volatility in the soybean futures market and Granger causality test was employed to analyze the internal relationship of price bubbles among them. The results indicate the presence of price bubbles in all four product categories in China's soybean futures market in recent years. The risk levels and characteristics vary among the four products, with the highest to lowest risk levels being Soybean Oil, Yellow Soybean 1, Soybean Meal, and Yellow Soybean 2. Long-duration bubbles are predominant in Soybean Oil and Yellow Soybean 1, while short-duration bubbles prevail in Yellow Soybean 2 and Soybean Meal. The price risk in the soybean oil futures market is relatively independent. The price risk of yellow soybean 1 is influenced by the fluctuations in yellow soybean 2 and soybean meal prices. There is a bidirectional contagious relationship between the price risks of yellow soybean 2 and soybean meal. Based on the research findings, effective responses to the risks of price bubbles in soybean futures should include the establishment of an early warning system, the development of a comprehensive information disclosure system, and the adoption of a regulatory strategy focusing on gradation and key areas.

Keywords: Soybean Futures, Price Bubbles, GSADF Test

1 Introduction

The agricultural futures market originated from the hedging demands of agricultural products and has been a focal point for hedgers and speculators as a crucial component of China's futures market. The " No. 1 Central Document " for 2023 mentioned the further expansion and deepening of the integration of "Insurance + Futures" in the agricultural sector, aiming to enhance the scope and depth of its application in rural areas. In 2021, the "14th Five-Year Plan" outlined the necessity of promoting the comprehensive development of the entire agricultural industry chain for the modernization of agriculture and rural areas. It is evident that the agricultural futures market has gained an increased amount of attention from the Party and the nation.

J. Liao et al. (eds.), *Proceedings of the 2024 2nd International Conference on Digital Economy and Management Science (CDEMS 2024)*, Advances in Economics, Business and Management Research 292,
https://doi.org/10.2991/978-94-6463-488-4_16

In recent years, more studies have focused on the dynamics of agricultural price bubbles. Liu Guodong (2018) utilized the SADF series bubble detection method, analyzing monthly data to discover speculative bubbles in the Chinese ginger market[1]. Zhang Youwang et al. (2022) examined monthly price data for Chinese green onions, ginger, and garlic from 2008 to 2021, employing GSADF to identify price bubbles in all three commodities[2]. In the soybean market, Huang Huilian (2019) employed the SADF bubble detection method to examine price bubbles in the Chinese Yellow Soybean 1, soybean oil, and soybean meal futures markets[3]. The study pointed out the existence of multiple price bubble processes in China's soybean industry chain futures market, with varying durations and significant differences. Jiang Chunlin (2020) used the SADF method to test the price bubbles of agricultural commodity futures and further analyzed the characteristics of price bubbles[4]. The study found that the longest bubble length occurred in the soybean oil futures market, while the shortest bubble length was observed in yellow corn.Li Yue (2023) proposed an improved upper bound unit root test method to measure the duration and intensity of price bubbles[5]. Analysis of Product 1 and Product 2 revealed that both products had a certain degree of price bubbles, with Product 1 having high investment value.

Previous research, while focusing on price changes in the soybean market, often extracted features related to price bubbles, conducting studies on the existence of price bubbles for individual products. Most studies aimed to expand the time range, utilizing monthly or weekly data. The innovation of this paper lies in focusing on a category of futures products with certain similarities, namely soybean futures, using daily data. By employing price bubble methods, this study aims to more effectively capture short-term volatile phenomena, derive more sensitive bubble analysis results from the development of product prices themselves, and provide a reference for effective and sensitive market extreme price risk warnings.

2 Model Introduction and Data Source

The Generalized Supremum Augmented Dickey-Fuller (GSADF) method is an improvement upon the Supremum Augmented Dickey-Fuller (SADF) method, employing a non-fixed starting point for the testing window, which enhances flexibility and effectiveness in detecting consecutive bubbles compared to the SADF method. Considering the data generation process as shown in Formula (1):

$$Pt = dT^{-\eta} + \theta P_{t-1} + \varepsilon_t \qquad \varepsilon_t \sim i.i.d\ N(0,\sigma 2) \tag{1}$$

Here, d is a constant, T represents the sample size, η is a locating coefficient controlling the magnitude of intercept and drift (η > 0.5), and εt is the error term satisfying the assumption of independent and identically distributed (i.i.d.) errors. The null hypothesis of the test is H0: $\theta = 1$, indicating that the asset price series follows a random walk process. The alternative hypothesis H1: $\theta > 1$ suggests that the price series exhibits explosive upward movements, indicating the presence of a bubble. The empirical model can be obtained through cointegration transformation of Formula (1):

$$\Delta P_t = \alpha_{r1,r2} + \beta_{r1,r2} P_{t-1} + \sum_{i=1}^{k} \varphi_{r1,r2}^{i} \Delta P_{t-1} + \varepsilon_t \quad (2)$$

In this case, the unit root hypothesis transformation is H0: $\beta_{r1,r2} = 0$, and H1: $\beta_{r1,r2} > 0$. Here, k represents the lag order, r_1 denotes the recursive starting point, and r_2 denotes the recursive endpoint. Let r_w represent the optimal rolling window, expressed as a proportion of the total sample, and satisfying $r_w = r_2 - r_1$,with r_0 as the initial window size. The ADF statistic can be expressed as follows at this point:

$$ADF_{r1,r2} = \beta_{r1,r2} / se(\beta_{r1,r2}) \quad (3)$$

The ADF statistic is fixed with r_1 at the beginning of the test sequence and r_2 at the end of the test sequence. The GSADF statistic, on the other hand, has a more flexible window. While ensuring the minimum window width, it calculates all possible ADF values and selects the maximum as the GSADF statistic. In order to determine the existence of price bubbles, GSADF method is employed; then, the BSADF method is used to identify the starting and ending points of the bubbles. The expressions for GSADF and BSADF statistics are as follows:

$$GSADF_{(r0)} = sup\{ADF_{r1}^{r2}\} \quad r_2 \in [r_0, r_1], r_1 \in [0, r_2 - r_0] \quad (4)$$

$$BSADF_{r2}(r_0) = sup\{ADF_{r1}^{r2}\} \quad r_1 \in [0, r_2 - r_0 + 1] \quad (5)$$

The BSADF method involves fixing r_2 at the end of the sequence and, while ensuring the minimum window width, continuously changing the position of r_1 backward. Calculate the corresponding maximum ADF value and compare it with the critical value. When the BSADF value first exceeds the critical value, it is recorded as the bubble's starting point, and when the BSADF statistic first falls below the critical value, it is recorded as the bubble's bursting point (r_f). Therefore, the BSADF statistic at this point is:

$$r_e \text{ and } r_f \text{ can be expressed as}$$

$$r_e = inf\{r_2 : BSADAF(r_0) > cv_{r_2}^{y}\} \, r_2 \in [r_0, 1] \quad (6)$$

$$r_f = inf\{r_2 : BSADAF(r_0) > cv_{r_2}^{y}\} \, r_2 \in [r_e, 1] \quad (7)$$

The datas were collected from the Dalian Commodity Exchange, encompassing daily settlement prices for Yellow Soybean 1, Yellow Soybean 2, soybean meal, and soybean oil from January 2019 to December 2022.As daily different contracts correspond to different trading prices in the futures market, the settlement price for the day is determined by selecting the contract with the highest trading volume or the most representative contract. The data frequency is daily, and holiday gaps were excluded, resulting in a sample size of 972 for each category, totaling 3888 data points.

3 Empirical Analysis

3.1 Existence Test for Price Bubbles

The GSADF method was employed to test for the existence of bubbles in the soybean futures market. Following the approach outlined in Philips (2015), the minimum window width is taken as r_0 $(0.01 + 1.8/\sqrt{T})$, where T represents the sample size[6]. The initial window width was found to be 66, and the critical values were obtained using Monte Carlo simulations with 1000 replications in MATLAB. The test results are presented in Table 1.

Table 1. Existence Test of Soybean Futures Price Bubble

Variety	GSADF Value	90%CV	95%CV	99%CV	Existence of Bubble
Yellow Soybean 1	3.2041	2.1205	2.3864	2.9383	YES
Yellow Soybean 2	2.2471	2.1205	2.3864	2.9383	YES
Soybean Meal	2.3089	2.1205	2.3864	2.9383	YES
Soybean Oil	4.0064	2.1205	2.3864	2.9383	YES

From Table 1, it is observed that the GSADF values for Yellow Soybean 1 and soybean oil exceeds the 99% confidence level CV. For Yellow Soybean 2 and soybean meal, the GSADF values surpasses the 90% confidence level CV. The results are significant, indicating the presence of price bubbles in the soybean futures market.

3.2 Analysis of Price Bubble Characteristics

This study analyzes the characteristics of price bubbles using "bubble length," "bubble frequency," and "bubble intensity." The initiation time points of bubbles are determined using the BSADF statistic, and the bubble duration is calculated based on Formulas (6) and (7). Following Etienne's perspective[7], this study sets the minimum duration for a price bubble at 3 days. The characteristics of price bubbles for each futures market are obtained and summarized in Table 2.

Table 2. Characteristics of Soybean Futures Market Price Bubble

Variety	Bubble Length	Bubble Frequency	Bubble Intensity
Yellow Soybean 1	101	10	21
Yellow Soybean 2	39	6	10
Soybean Meal	77	9	17
Soybean Oil	164	13	27

From Table 2, it is evident that the frequency and intensity of price bubbles in the soybean futures market exhibit a similar pattern, with soybean oil having the highest frequency and intensity, followed by Yellow Soybean 1, soybean meal, and Yellow Soybean 2. Among these, Yellow Soybean 1 has the longest bubble duration, accounting for 20.79% of the total bubble length, followed by Yellow Soybean 2 (25.64%), soybean meal (22.08%), and soybean oil (16.46%). To provide a more detailed and intuitive depiction of the price bubble situations for Yellow Soybean 1, Yellow Soybean 2, soybean meal, and soybean oil, Figure 1 presents line charts of their price series, BSADF value series, and the 95% confidence level CV value series from early 2019 to the end of 2022.

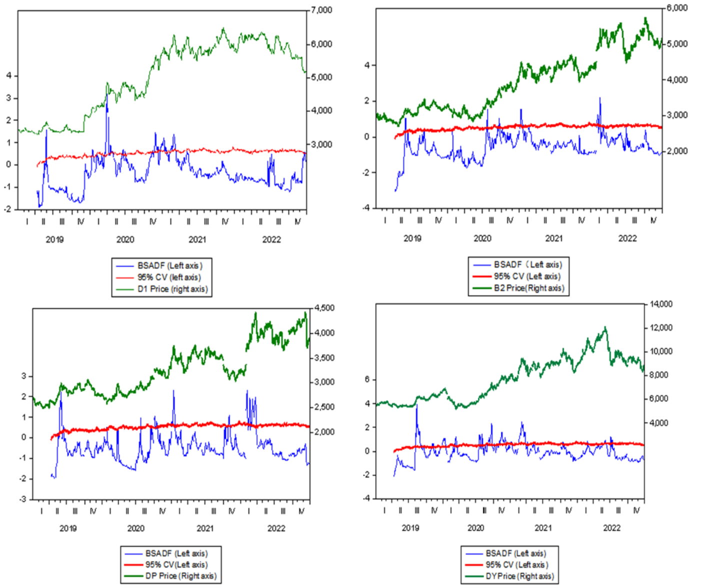

Fig. 1. Distribution of Price Bubbles in Various Soybean Futures Markets

From Figure 1 and the accompanying analysis, it is evident that Yellow Soybean 1 experienced multiple bubble events in 2020 and 2021, totaling nine occurrences. Based on whether the duration exceeded ten days, five short bubble events occurred in January, April, June, and July of 2020, and two long bubble events took place from March to April and from November to December of 2020. In February to March of 2021, one long bubble event occurred. Additionally, there was one long-lasting bubble event lasting 21 days from the end of 2020 to the beginning of 2021, accounting for 68.32% of the total bubble duration. This indicates that Yellow Soybean 1 predominantly experienced long-lasting bubbles.

Yellow Soybean 2 had only one long bubble event of 10 days in January 2021. The remaining five short bubble events were relatively evenly distributed across other years, occurring once in June 2019, twice in July and September 2020, and twice in February 2022. The total duration of long bubbles accounted for 25.64%, indicating that Yellow Soybean 2 primarily experienced short-term bubbles.

Soybean meal exhibited a prevalence of short bubbles, with only two long bubble events. The two long bubble events occurred in January 2021 and March 2022, lasting 11 days and 17 days, respectively. The remaining short bubble events took place twice in May and June 2019, twice in October 2020, once in November 2021, and twice in February 2022. The total duration of long bubbles accounted for 36.36%.

The price bubble characteristics of soybean oil are somewhat similar to those of Yellow Soybean 1, with bubble events concentrated in 2020, totaling seven occurrences. During 2020, there were three long bubble events. The first occurred from December 2019 to January 2020, the second occurred from August 31 to September 23, and the last one lasted the longest, spanning the entire November to early December, with a duration of 27 days. Two long bubble events occurred in other years, namely in August 2019 and from February to March 2021. Short bubble events were more dispersed. The total duration of long bubbles accounted for 56.1%, indicating that soybean oil primarily experienced long-lasting bubbles.

Building upon the obtained price bubble sequences, Granger causality analysis is employed to explore the internal causal relationships within the soybean futures market. The experimental results found that there is no apparent Granger causality relationship between soybean oil and the other three soybean futures market price bubble sequences, while the remaining three soybean futures markets exhibit mutual influence on each other's price bubble sequences. Specifically, Yellow Soybean 1 does not significantly constitute Granger causality for Yellow Soybean 2 and soybean meal, but its price bubble is significantly influenced by the price bubbles of Yellow Soybean 2 and soybean meal. Additionally, Yellow Soybean 2 and soybean meal futures markets exhibit bidirectional Granger causality, indicating that they mutually affect and trigger each other's futures price bubble sequence fluctuations. In summary, in China's soybean futures market, the price risk of soybean oil futures is relatively independent, the price risk of Yellow Soybean 1 is influenced by the fluctuations of Yellow Soybean 2 and soybean meal, and there is a bidirectional transmission relationship between the price risks of Yellow Soybean 2 and soybean meal.

4 Conclusion

The conclusions of this paper indicate that since 2019, there have been price bubbles in the futures markets of four categories of products in recent years. On the one hand, there are certain differences among the four categories of product futures markets. The price bubbles in the Yellow Soybean 1 and Soybean Oil futures markets are more significant, with long-term bubbles being dominant. In contrast, the price bubbles in the Yellow Soybean 2 and Soybean Meal futures markets appear less frequently, with short-term bubbles being dominant. The overall degree of bubbles, from highest to lowest, is as follows: Soybean Oil, Yellow Soybean 1, Soybean Meal, and Yellow Soybean 2. On the other hand, Granger causality tests reveal that in China's soybean futures markets, price fluctuations in Yellow Soybean 2 and Soybean Meal affect the price risk of Yellow Soybean 1, and there is a bidirectional contagion relationship between the price risks of Yellow Soybean 2 and Soybean Meal. The price risk in the Soybean Oil futures market is relatively independent.

5 Discussions

Shortcomings and Improvement: Although the specificity of price bubbles in the soybean futures market was analyzed, and the feasibility of establishing an early warning system was demonstrated, the study did not provide a concrete implementation path. In the future, for the establishment of the early warning system, more detailed aspects such as alarm criteria and warning mechanisms need to be addressed to provide an implementation roadmap. Through the Granger causality test, internal relationships within the soybean futures market were identified, but the study did not measure the intensity of price risk contagion. For a more accurate study of price risk contagion, it is necessary to determine the strength of price risk contagion.

Acknowledgement

Fund Projects:①National Natural Science Foundation of China project, Research on Pricing and Sharing Mechanisms of Agricultural Income Risks under the "Insurance+Futures" Model - Taking Jiangxi Rice as an Example(72063001).②Key Research Base Project of Philosophy and Social Sciences in Jiangxi Province:Study on the Spillover Effect of Geopolitical Risks on the foam of Nonferrous Metal Prices(23ZXSKJD04)

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