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Research Article

Bubbles in Agricultural Commodity Markets of China

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We employ the generalized supremum augmented Dickey–Fuller test to examine whether there are multiple bubbles in Chinese agricultural commodities. The proposed approach is suitable for time series data and identifies the origination and termination of multiple bubbles. The results indicate the existence of bubbles for some agricultural commodity prices, such as garlic, ginger, corn, and wheat prices, that deviate from their intrinsic values upon market fundamentals. The bubbles in the garlic and ginger market are related to speculative activities. The other bubbles, in the corn and wheat market, are associated with the rising oil price, international market, and the negative effect of stockpiling policy. The authorities should recognize bubbles and observe their evolutions, leading to Chinese agricultural commodity price stabilization. These findings suggest corresponding measures to be implemented. China should establish a unified market information release platform to avoid speculative activities and formulate a market-oriented agricultural policy to enhance competitiveness among the international markets.

1. Introduction

This paper examines the existence of bubbles in Chinese agricultural commodity prices and investigates the origination and termination of multiple bubbles. Agricultural commodities are not only people's daily necessities but also the primary processing of industrial raw materials and strategic military products. For the past few years, the price of Chinese agricultural commodities has been subject to frequent fluctuations, mainly for the fresh agricultural commodities that have experienced excessive "roller coaster"-like fluctuations. The prices of fresh agricultural commodities suddenly increased after 2008, leading to restrains regarding the improvement of household consumption and social welfare. Some new and original terms outlined in Chinese such as "suan ni hen" (cruel garlic), "jiang ni jun" (checkmated by ginger) and "xiang qian cong" (rushing green onion), which all reflect the surge in the prices of these goods. The prices of agricultural commodities deviate from fundamentals, which lead to a potential bubble crisis in the Chinese agricultural market. If the prices of agricultural commodities fluctuate sharply in future, it will inevitably induce market panic and even collapse. Countries will be unstable on the strength of the impact generated by soaring agricultural prices on inflation, income distribution, and poverty. Hence, it is vital for the government to possess a comprehensive recognition of fluctuations in the price of Chinese agricultural commodities.

As the price volatility of agricultural commodity may have a far-reaching impact on the overall economic sense, the exploration of the investigation regarding which forces impact the value of agricultural commodity price is of great significance. The first cause is that the demand for agricultural commodities puts up its price. The income and population in developing and emerging countries increased recently, causing a great demand for agricultural commodities. But, the agricultural commodity production increased slowly compared with demand, which drives the price to a high place. Another significant factor is that agricultural commodities and feed crops for the production of biofuels increased rapidly, leading to the integration of food and energy markets. The inelastic corn demand by the biofuel sector has resulted in dramatic price fluctuation. For example, it is argued that the oil price is the major driving force behind the price fluctuations in the agricultural commodity. Apart from the above factors, the impact of speculation on the price fluctuations of agricultural commodities is increasing. Along with market fundamentals, trend-following behaviour (i.e., hoarding and speculation) has played an important role in the increasing fluctuations and level of agricultural commodity prices, which attributes the soaring agricultural commodity price partly to "speculative bubbles" [1].

China is playing an increasingly significant role in the world agricultural market, as a country with rapid economic growth and a large population. From the perspective of special features of Chinese agricultural commodity market, it is necessary to further discuss the price trends and whether there are bubbles. Besides, if there are significant differences between small and primary agricultural commodity markets, then we should compare these two markets' differences among bubbles' reason and duration. This paper contributes to the literature in three ways by focusing on special characteristics of Chinese agricultural commodity market, by showing there are differences in cause of bubble formation between small and primary agricultural commodity markets. Finally, the specification of our supremum augmented Dickey–Fuller (SADF) and GSADF tests allows us to locate bubbles in the Chinese agricultural commodity market. Through these empirical tests, we find there are bubbles in garlic, ginger, corn, and wheat markets, which is related by speculation, oil prices, international markets, and domestic agricultural policies.

The paper proceeds as follows. In Section 2, we retrospect the literature with the bubbles in the agricultural commodity market. Section 3 displays the bubble model. Section 4 analyses the methodology, which facilitates the detection of potential bubbles. In section 5, we describe data and empirical results, and Section 6 finally concludes.

2. Literature Review

With regard to agricultural commodities, empirical results are ambiguous for a different country's agricultural market. Gilbert [2] concentrates on the U.S. agricultural commodity price shocks and discovers the existence of speculative bubbles in the soybean market, expecting the same situation for the wheat and corn markets too. Sanders and Irwin [3] prove the existence of an index-induced food price bubble for soybean prices, except other 11 agricultural commodities. Liu et al. [4] could not prove that the cyclically and partially explosive speculative bubbles for five commodities do exit, without soybeans. Etienne et al. [5] suggest that all 12 agricultural commodity markets include corn, wheat, and coffee and others experiment multiple periods of price explosiveness. On account of (symmetric) cointegration, these results are proved by Liu and Tang [6] who apply the duration dependence test. Gutierrez [7] proves that speculative bubbles exist in rough rice, corn, and wheat prices and register less evidence for soybean prices. Adämmer and Bohl [8] employ the momentum threshold autoregressive (MTAR) method to explore whether there are bubbles in the U.S. wheat, soybeans, and corn markets and the hypothesis that bubbles exist in the wheat market, except for corn and soybeans, is supported by the obtained empirical results.

For Chinese agricultural commodity markets, Wang and An [9] prove that there is no price bubble in China's wheat market over a long period of time, but exists in a short period of time. Yin et al. [10] inspect the pork price bubble in different regions of China, and their result demonstrates that the regional pork price bubble does exist. Wang et al. [11] reveal that there are bubbles in the egg market, belonging to the positive bubbles, in which the average price of a bubble is greater than the price of the starting point. Li and Li [12] hold that there are bubbles in 10 different Chinese agricultural commodities, except for wheat.

3. Bubble Model

Bubble model has been generally employed in lots of associated research studies. Due to the deviations between prices of commodities and their basic values, there may be bubbles. According to the bubble model, the Chinese agricultural commodity price can be represented as follows:

$$P_t = P_t^f + b_t, \quad (1)$$

where P_t^f stands for the fundamental price of the Chinese agricultural market and b_t represents the bubble part. Therefore, P_t is resolved into the basic P_t^f and the bubble b_t, through log-liner estimation. In accordance with equation (1), the basic part P_t^f affects the P_t entirely in the case of b_t inexistence. However, the price of the Chinese agricultural commodity P_t is influenced by b_t. On this occasion, the agricultural commodity price is higher than its essential values, which can be explained by equation (1).

In detecting periodic bubbles, other methods performed in previous literature have limitations. For example, it is inefficient to consider the traditional unit roots in judging bubbles [13]. And, the MTAR model is simply employed to check whether periodic bubble behaviours exist [14]. The GSADF test is employed to investigate and locate periods of bubble behaviours, on account of these deficiencies. And, this method gives a precise detection of bubbles by using the unfixed window size in the recursive regression. As a result, in researching multiple bubble behaviours, this approach prevails over former ones [15].

4. Methodology

For the purpose of conquering the restriction, the SADF test expressed by Phillips et al. [16] is provided with the consideration of explosive behaviour. The recursive regressions associated with continuous right-sided unit root tests are applied in the SADF test. By a forward recursive test procedure, Phillips et al. [16] research this phenomenon, and their method which is better than sup tests and right-side ADF is as follows:

$$p_t = dT^{-\eta} + p_{t-1} + \varepsilon_t, \quad (2)$$

where p is the Chinese agricultural commodity price, T is the sample's size, d represents a constant, $\varepsilon_t \sim NID\,(0, \sigma^2)$, and $\eta > 1/2$. An asymptotically negligible drift, as well as a random walk process, is considered by equation (2). We assume that r_w represents the window size and $r_2 = r_1 + r_w$, where r_1 is the starting point and r_2 is the ending point. The regression equation forms are demonstrated as

$$\Delta p_t = \alpha_{r_1,r_2} + \beta_{r_1,r_2} p_{t-1} + \sum_{i=1}^{k} \varphi^{i}_{r_1,r_2} \Delta p_{t-i} + \varepsilon_t, \quad (3)$$

where $\varepsilon_t \sim NID\,(0, \sigma^2_{r_1,r_2})$ and k stands for the lag order. $T_\omega = [T_{r_\omega}]$ represents the number of observations in the regression. In conformity to the regression, $\text{ADF}^{r_2}_{r_1}$ is the corresponding ADF statistic. $H_0 : \beta = 1$ is the null hypothesis of the unit root. Meanwhile, $H_1 : \beta > 1$ is the alternative hypothesis.

The ADF model is estimated by the SADF test constantly on a forward expanding sample sequence. r_w spreads from r_0 to 1, which represents the size of the window. r_0 stands for the smallest window size. Relatively, 1 is the largest one, equal to the total sample size. And, the beginning point r_1 is usually fixed at 0. Based on the equation $r_2 = r_1 + r_w$, the ending point r_2 is equal to r_w. $\text{ADF}^{r_2}_{0}$ statistic is indicated by the sample spreading from 0 to r_2. Therefore, the SADF test is shown as SADF (r_0) and defined as $\sup_{r_2} \in [r_0, 1]\text{ADF}^{r_2}_{0}$.

The SADF method would become inefficient as various periods of bubbles are included in the time series [17]. When the number of bubbles is larger than two and the sample is long enough, the shortcomings would become apparent. To overcome the shortcomings, the GSADF test allows the variation of the beginning and ending point of the recursion [17]. Except for altering the ending point r_2 from r_0 to 1, the variation range of beginning point from 0 to $r_2 - r_0$ is permissible in the GSADF method. Meanwhile, the GSADF statistic is defined to be the largest ADF statistic by Phillips et al. [17], and it is denoted by GSADF (r_0) as follows:

$$\text{GSADF}(r_0) = \sup_{r_2 \in [r_0,1], r_1 \in [0, r_2 - r_0]} \left\{ \text{ADF}^{r_2}_{r_1} \right\}. \quad (4)$$

When an intercept is included in the regression model and the null hypothesus is a random walk, the limit distribution of the GSADF test statistic is characterized as follows:

$$\text{ADF}^{r_2}_{r_1} = \left\{ \frac{(1/2) r_w \left[w(r_2)^2 - w(r_1)^2 - r_w \right] - \int_{r_1}^{r_2} w(r)\mathrm{d}r \left[w(r_2) - w(r_1) \right]}{r_w^{1/2} \left\{ r_w \int_{r_1}^{r_2} w(r)^2 \mathrm{d}r - \left[\int_{r_1}^{r_2} w(r)\mathrm{d}r \right]^2 \right\}^{1/2}} \right\}, \quad (5)$$

where $r_w = r_2 - r_1$, which belongs to a standard Wiener process. The purpose of using Monte Carlo simulation is to get the asymptotic critical values. Assume that the intervals $n_1, n_2, \ldots, n_N$ are equally spaced in the limited points. And, at each point, a Gaussian random variable with mean 0 and variance 1/N will be produced. In order to reach the finite sample distribution, we employ the bootstrap technique, which can detect explosive process.

5. Data and Empirical Results

We employ the weekly data of garlic, ginger, green onion, rice, corn, and wheat covering the period that starts from 2009 to 2017. The 2009 No. 1 Central Document of China holds that the market mainly determines the price of the agricultural commodity. During this sample time, the economic fundamentals that could cause bubbles were changed by the negative effect of the financial crisis and some agricultural commodities' abnormal price volatility happened. Garlic, ginger, and green onions are the most important condiments in China, and their price fluctuated periodically, belonging to small agricultural commodities. In addition, rice, corn, and wheat are the three major grain crops in China, their yield and import volume being in the forefront in the world, belonging to primary agricultural commodities. We investigate the wholesale price for small agricultural commodities and the purchase price index of primary agricultural commodities, which are from the National Bureau of Statistics (NBS).

With a minimum window size of 10 months, we utilize the SADF and GSADF tests to detect the bubble periods in the Chinese agricultural commodity market. SADF and GSADF statistics are registered in Table 1. The null hypothesis is rejected that H_0: $r = 1$ at 10% significance critical values (i.e., $2.103 > 2.039$, $2.374 > 1.953$, $3.897 > 1.799$, and $2.261 > 1.968$). The results prove that the price of garlic, ginger, corn, and wheat has explosive subperiods upon SADF and GSADF tests.

Appling the GSADF test, we graph the estimations of the Chinese agricultural commodity price in Figure 1. The upper line stands for the price of each agricultural commodity. The middle one is the 90% threshold. The bottom curve represents the GSADF statistic. According to this discussion, we can draw the conclusion that multiple bubbles do exist in the Chinese agricultural commodity markets.

As a robustness check, we incorporate more strict requirements for the detection of bubbles by assuming longer minimum window sizes. Table 2 shows results for sizes for 20 months. Overall, these results are identical since the unit root hypothesis is rejected for garlic, ginger, corn, and wheat

Table 1: Bubble detection results in Chinese agricultural commodity markets for 10 months.

	Garlic		Ginger		Green onion		Rice		Corn		Wheat	
	SADF	GSADF	SADF	GSADF	SADF	GSADF	SADF	GSADF	SADF	GSADF	SADF	GSADF
C.V.	1.823**	2.103*	1.573*	2.374**	1.021	1.621	1.013	2.089	1.452*	3.897***	2.766***	2.261**
90%	1.041	2.039	1.110	1.953	1.108	2.047	1.092	2.230	1.113	1.799	1.098	1.968
95%	1.231	2.129	1.671	2.325	1.445	2.323	1.285	2.336	1.491	2.064	1.532	2.097
99%	1.887	2.581	2.084	2.875	1.829	2.453	1.518	3.380	2.412	2.473	1.868	2.453

***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

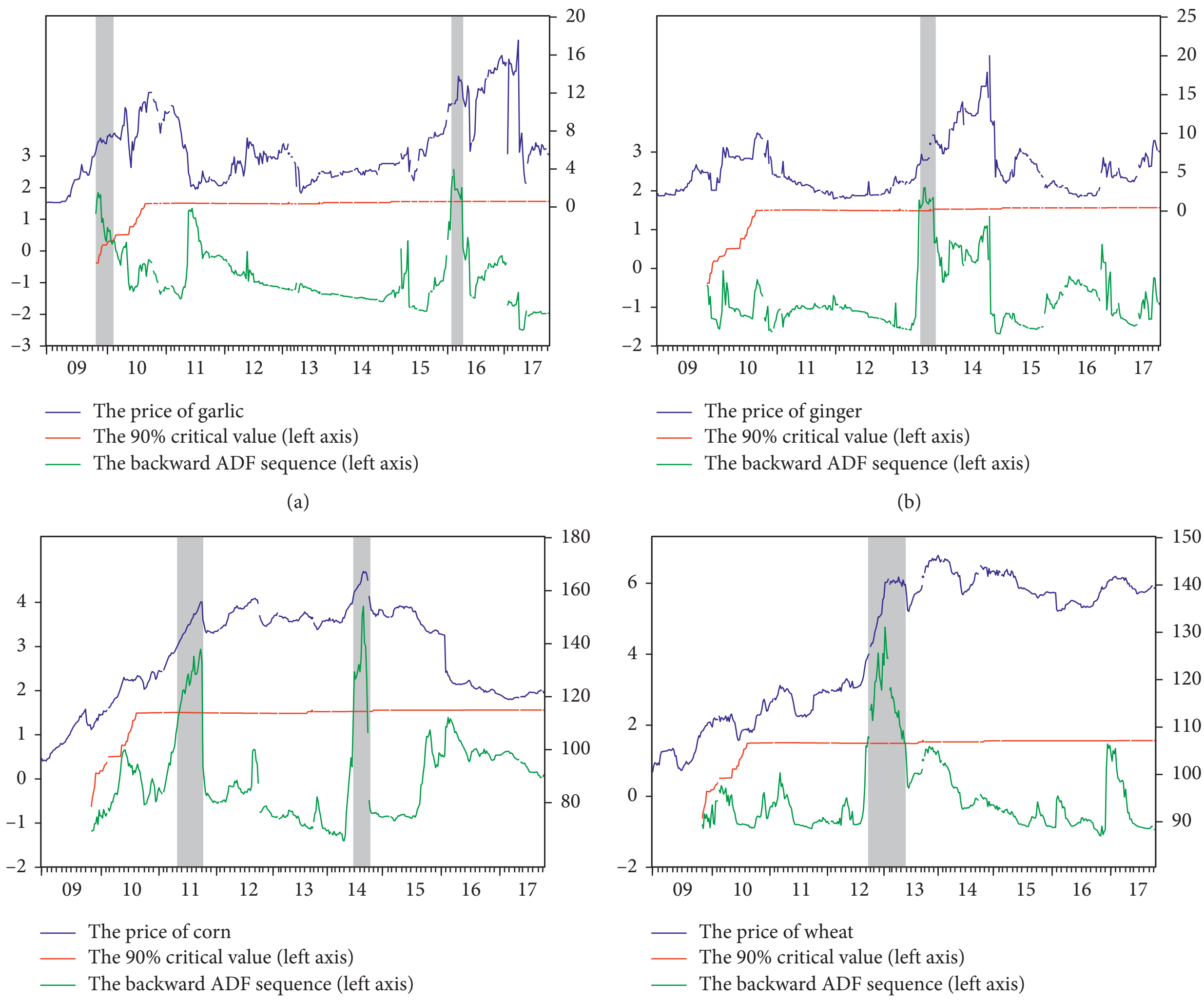

Figure 1: The GSADF test of the price of the agricultural market, including garlic, ginger, corn, and wheat markets.

Table 2: Bubble detection results in Chinese agricultural commodity markets of 20 months.

	Garlic		Ginger		Green onion		Rice		Corn		Wheat	
	SADF	GSADF	SADF	GSADF	SADF	GSADF	SADF	GSADF	SADF	GSADF	SADF	GSADF
C.V.	1.823***	2.103***	1.573**	2.374***	1.021	1.621	1.013	2.089	1.452**	3.897***	2.766***	2.261***
90%	0.976	1.763	0.836	1.083	1.028	1.839	1.024	2.139	0.933	1.063	0.968	1.306
95%	1.034	1.962	1.053	1.763	1.076	2.013	1.087	2.275	1.087	1.968	1.019	1.935
99%	1.352	2.051	1.849	2.061	1.129	2.027	1.139	2.976	1.769	2.031	1.573	2.023

***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

markets. Therefore, it is important to highlight that the existence of bubbles in these four agricultural markets is robust under alternative minimum window sizes.

For the garlic market, the first bubble originated in October 2009 and burst in January 2010. As we can observe from Figure 1, the price of garlic jumped from 3.6 yuan to 12 yuan half a kilogram, an increase of 233%. The demand for garlic is growing, but the slow production response that leads to the growth of garlic supply cannot keep up with the rapid growth of demand. The garlic demand has increased in the spring of 2009 due to the outbreak of influenza A (H_1N_1) virus while the supply of garlic has declined due to the low temperature. Meanwhile, the bubble in the garlic market is associated with speculative behaviours and price manipulation, except for the supply and demand. Furthermore, China implements "four trillion monetary" policy after 2009, and active speculative funds are invested into assets in markets with lower risk. With the expectation that garlic prices may continue to increase in the future, garlic growers, consumers, and traders have been induced to either reduce garlic supply or to increase stocks, which will cause higher prices in the short run. The garlic market is easy to be manipulated due to its characters. Information asymmetry between farmers and consumers promotes middlemen hoarding and pushing up the price. Conversely, the garlic growers had increased the plantation due to its high price in 2009, which increased the supply in the spring of 2010. Therefore, this is the reason of the burst of the bubble in January 2010. The second bubble appeared in January 2016 and burst in April 2016. The cause of this bubble is associated with the disparity between the restricted garlic supply and growing demand. China lacks a large scale planting of garlic, the scattered planting being the dominant one. Meantime, unlike other agricultural commodities, the garlic is planted in a few areas, which causes the production vulnerable to natural disasters. As heavy snow happened at the beginning of 2016, a substantial drop in the yield of garlic was caused. With respect to the growing demand side, the people's need for the garlic has risen during the spring festival because garlic is the most important condiment for Chinese families. Thus, the garlic price deviates from its interior value and results in a bubble due to the difference between the increasing demand and limited supply. A large supply of new garlic increased after April 2016, which leads to the bubble bursting quickly.

For the ginger market, the bubble was noticed in July 2013 and burst in October 2013. The reasons for the bubble in the ginger market are similar to the garlic market. The ginger has a high supply elasticity; consequently, growers will increase the planting area when the price rises. Meanwhile, the production of ginger is concentrated in Shandong province and the storage period is longer, which made it is easy to be speculated by the middlemen. They buy a lot of ginger at a lower price, and then, they would drive up the prices with ginger growers and will sell all ginger when the price reaches a high level. These reasons have led to a rise in the price of ginger and a bubble in July 2013. The middlemen sold out the old ginger, and a large supply of new ginger increased in the market after October 2013, which causes the bubble to burst quickly.

For the corn market, the first bubble started in May 2011 and burst at the end of October 2011. The oil market price fluctuation is the reason for this bubble, during this short period. According to the National Bureau of Statistics of China, the growth of price indices of fertilizers and oil for agricultural machines exceeded more than 90% from 2002 to 2013. The agricultural and fuel commodity prices were supposed to be strongly interdependent because of the expansion of biofuels. Furthermore, the changes of oil price have an impact on the price of the agricultural commodity after the financial crisis, by adding the costs of various energy-intensive inputs, such as chemical fertilizer and transportation costs [18]. The second bubble collapsed in June 2014 and burst in October 2014 in the corn market. The reason for this bubble can be explained by the negative effect of stockpiling policy. In order to protect the interests of farmers and secure the corn prices relatively stable, the Chinese government has implied the stockpiling policy at the corn market in order to ensure that they would have buyers and encourage them to continue growing crops since 2006. The stockpiling policy for the corn market to promote food production, farmers' income at the same time, also released a negative effect, such as the high market price. In March 2014, the government announced that the stockpiling policy for the corn market would be cancelled in 2016, which suppressed the high price and resulted in bubble bursting quickly after October 2014.

For the wheat market, the bubble began in September 2012 and burst in June 2013. The price of wheat jumped from 125.38 yuan to 140.02 yuan per ton, an increase of 11.68% during this period. A possible reason is related to the extreme weather (severe drought) in the U.S., which caused the decline of wheat production in the international market. And, the price of international wheat rose sharply since 2012, causing the high price of Chinese domestic wheat. Due to quality problems, the wheat from China lost the competition with those from the U.S., Canada, and other countries, causing an inferior international trade position. Therefore, China must import large quantities of wheat from other countries, passively each year. And, the prices of China's wheat can only passively follow the international markets without strong international pricing power after the entrance of the World Trade Organization [19]. Furthermore, the price of fertilizer and pesticides has increased since 2010, which caused the high cost of wheat plantation. The Chinese government started to implement agricultural subsidy for the wheat market since 2012, in order to guarantee the wheat growers' income and improve their enthusiasm for planting. A large supply of new wheat appeared in the market in June 2013 and the price falls down, which caused the bursting of the bubble.

For green onion, the production is easily affected by bad weather, as is for garlic and ginger, but the biggest difference with them is short storage period in room temperature and high cost for storage and transport. This is why green onion is difficult to speculate and generate bubbles. Rice is the first grain crop with the highest yield in China; it has always been in the dominant position in grain production and consumption. The international rice trade volume is less than corn and wheat, which is the reason for no bubble in the rice market.

In summation, from the above empirical analysis, we can make a comparison between small and primary agricultural commodity markets form the following three aspects. First, due to the distinct pricing mechanism, reasons for bubble burst between these two markets are different. For the small agricultural commodity market, the bubbles are mainly related to speculative activities, while for the primary agricultural commodity market, bubbles can be explained by the rising oil price, increasing biofuel demand, international agricultural market, and domestic policies. Second, compared with the small agricultural commodity market, the duration of bubbles in the primary agricultural commodity market is longer, which can be explained by different production and sale cycles. Finally, bubbles in the small agricultural commodity market can reflect the domestic economy performance (i.e., inflation); however, bubbles in the primary agricultural commodity market show the uncertainty of international markets. When meeting the Chinese agricultural commodity price bubble, we are supposed to depend on bubble models to explore the reason for the deviation between prices and its intrinsic value. Then, relevant policies should be carried out to avoid the passive effects of Chinese agricultural commodity price bubbles.

6. Conclusion

This paper detects bubbles in Chinese agricultural commodity markets, including the effect of the global financial crisis and the implementation of agricultural policies, while the agricultural commodity bubbles mostly happened during the circle of price fluctuations, such as the price of garlic soared sharply during 2009-2010 and 2016, the price of ginger rose quickly in 2013, the price of corn increased in 2011, and a steep hike in the price of wheat observed during 2012-2013. This phenomenon can be explained by the increase in demand, concentration on supply, and global financial crisis. For the small agricultural commodity market, in order to avoid the speculation, the government should strengthen the supervision, set up a more sensitive management system. To be specific, in order to enhance information guidance, a unified market information release platform for agricultural commodities is supposed to be established, which can stable the farmers' rational planting. For the primary agricultural commodity market, their price is complicated due to its dependence on the international market and the stockpiling policy. In order to get rid of the interdependence of the international market, farmers of the primary agricultural commodity should rely on science and technology to improve its yield based on domestic production. At the same time, the government is supposed to minimize the policy distortions in the market in order to avoid the negative effect of stockpiling policy for wheat and corn markets.

Table 3: The results of the evaluation of superexponential growth for the Chinese agricultural commodity price.

Test statistic	Garlic	Ginger	Green onion	Corn	Wheat	Rice
$RMS_1(i)$	0.125	0.123	0.118	0.138	0.126	0.126
R squared	0.932	0.832	0.507	0.851	0.906	0.639
$RMS_2(i)$	0.124	0.129	0.074	0.126	0.118	0.085
R squared	0.885	0.904	0.813	0.827	0.910	0.736
$D(i)$	0.393*	0.358*	0.196	0.296*	0.276*	0.156

*denotes that the D value is greater than 0.25, i.e., we can conclude the existence of bubbles.

Appendix

For the sake of identifying whether there are bubbles in the Chinese agricultural commodity market, we apply the D test approach [20]. It can check the bubble behaviour by making out the superexponential growth. Equation (A.1) represents the standard exponential growth, while equation (A.2) shows the superexponential growth:

$$p(t) = a + bt + \varepsilon_1, \tag{A.1}$$

$$p(t) = c + \mathrm{d}t + et^2 + \varepsilon_2, \tag{A.2}$$

where $p(t)$ denotes Chinese agricultural commodity's prices at time t. By fitting the price series of the Chinese agricultural commodity i ($i = 1, 2, 3, 4, 5, 6$, signifying garlic, ginger, green onion, corn, wheat, and rice, respectively), the root mean square of the residuals $RMS_1(i)$ and $RMS_2(i)$ can be received from equations (A.1) and (A.2), respectively. Further, the D values can be computed as follows:

$$D(i) = \frac{[RMS_1(i) - RMS_2(i)]}{RMS_1(i)}. \tag{A.3}$$

Using the D test approach, we detect the bubbles in Chinese agricultural commodity price series (including garlic, ginger, green onion, corn, wheat, and rice, respectively) during the sample 2009–2017 through equations (A.1)–(A.3). Table 3 demonstrates the results, and $D(i)$ is the D value for the Chinese agricultural commodity price of six different Chinese agricultural commodities i based on equation (A.3). Table 3 shows some results.

According to Table 3, the values of $D(i)$ for garlic, ginger, corn, and wheat are greater than 0.25. In accordance with this, a conclusion can be drawn that there is remarkable superexponential growth in garlic, ginger, corn, and wheat price series during 2009–2017, namely, there are significant bubbles in these four agricultural commodities during this period.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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