Fluctuation characteristics and influence factors of rice price in Guangdong

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Abstract: Guangdong Province is a large province of rations consumption and the abnormal fluctuations in food prices will affect its steady development. In this paper, the largest grain product in Guangdong Province - Rice is selected as the research object, and the price fluctuation characteristics is analyzed by the time series decomposition method. We try to answer the following two questions: First, what are the characteristics of price fluctuation of rice in Guangdong Province? Second, what causes the rapid rise in rice prices in the short term? The paper identifies and analyzes the fluctuation rules and characteristics of rice price in Guangdong and summarizes main influence factors for short-term drastic fluctuation in rice price by time series decomposition method based on the monthly price data in 1998-2015. The results show that the rice price in Guangdong has the following characteristics for a long time: overall rising, short-term drastic fluctuation, obvious periodic fluctuation and weakened seasonal fluctuation; random shocks drive and restrain the rice price, where external factors have serious influences on price fluctuation in some years, while the influence of random components on rice price has been obviously weakened since the second half of 2012; main factors influencing the fluctuation in rice price include market supply and demand, production cost and grain policies. In view of this, it is suggested in the paper that future price fluctuation should be predicted by utilizing the long-term trend and the periodic characteristics of the rice price, attention be paid to such factors causing abnormal fluctuation in rice price, market monitoring be strengthened and effective measures be taken to mitigate short-term drastic fluctuation in rice price.

1. Introduction
Rice, as the main food of Guangdong residents, presented a new trend with frequent price fluctuation and enlarged fluctuation range over the past more than ten years. During 2001-2015, the fixed base consumer price index (CPI) of rice in Guangdong rose from 97.9\% to 207\%. In 15 years, there were 7 years when the year-on-year index of rice consumer price was more than 5\% and the index was even up to 22\% in 2004; the price of indica rice surged to a historic high in 2011. Under the conditions of market economy, reasonable fluctuation of the grain price is an objective reflection of the relationship between supply and
demand, and the rise in the grain price is the value regression of low price that maintaining for many years. However, the short-term price fluctuations in rice prices are far beyond consumer's psychological expectations, food security issues aroused wide concern in all sectors of community again. To this end, short-term fluctuations in rice prices are worth exploring in depth. There are many researches on grain price fluctuation in China, and the researches are focused on the fluctuation characteristics, influencing factors and the impacts on price and so on.

The results of the study based on the ARCH model by Luo and Liu [1] show that China’s grain price fluctuation has significant ARCH effects as a whole, but the prices of indica rice, japonica and soybean did not present significant heteroscedastic effects. Miao [2] found that China’s rice market price has obvious ARCH effect and its fluctuation present clustered, asymmetric and sustainable features by the study of the ARCH model. Huang’s research [3], by the use of Global Trade and Energy Analysis Model (GTAP-E), showed that global energy prices, biomass liquid fuels, market speculation and national policy intervention are the main factors that caused the sharp rise and drop of the price of international agricultural products in the past three years. Zhang [4] thought that external impacts can expand the price fluctuation of primary agricultural products for 3~5 times in a short term. The grain industry chain of rice, wheat, etc. is mainly affected by the impacts of climate and natural disasters on industry production, and the degree of interpretation by such impacts for price fluctuation of both rice and wheat is about 95%. Su [5], by using GARCH model and VAR model, found that the risk of long-term fluctuation of grain price in China mainly comes from the change of domestic production cost and the change of international grain price. Wang and Li [6] considered that grain price fluctuations are both affected by the external factors like market supply and demand, production cost and internal factors like domestic policies, conduction of international market and so on. Deng [7], by using the ARCH model, found that the fluctuation of grain price in China has the ARCH effect and the "leverage effect", and the grain price fluctuation has a significant positive correlation with currency growth rate and depreciation of US dollar. Fang [8] thought that random shocks and cycle changes had a greater impact on rice price fluctuation before 2005 and the impact of random shocks on rice price fluctuation was significantly reduced after 2006. Shi and Hu [9] considered that the external random shocks had negative effects on grain prices and the effects were most serious during 1998-2003, and the grain price fluctuation presented a significant periodic characteristic and was affected by random factors. Huang [10], by using limited distributed-lag regression model, found that the rise of breakdown of food prices will be driven by price transmission of grain prices. The above studies were mainly conducted by using time series method, including ARCH model, VAR model, Beveridge-Nelson decomposition technology and H-P filter method etc. [11-15]. The current researches focus on the study of national and overall grain price fluctuation, but the fluctuation of grain prices is different in different regions and varieties. Guangdong Province is a large province of rations consumption and the abnormal fluctuations in food prices will affect its steady development. In this paper, the largest grain product in Guangdong Province - Rice is selected as the research object, and the price fluctuation characteristics is analyzed by the time series decomposition method. We try to answer the following two questions: First, what are the characteristics of price fluctuation of rice in Guangdong Province? Second, what causes the rapid rise in rice prices in the short term?

2. Fluctuation trend of rice price in Guangdong

2.1. Data sources

In this paper, rice price of Guangdong is selected as the research object. As the consumption of indica rice accounts for 70% of rice consumption in Guangdong Province, the early indica and late indica are selected as the representative study objects and the monthly price (¥/t) (the data comes from China Grain Network
2.2. Descriptive statistical analysis of rice price fluctuation

The price fluctuation rate is indicated by the sequential growth rate of rice prices in neighboring months, the formula is: \( R_t = (P_t - P_{t-1})/P_{t-1} \times 100\% \), where \( P_t \) and \( P_{t-1} \) presents the rice price of month \( T \) and month \( T-1 \) respectively. It can be seen from Table 1 that the price fluctuation of early indica rice and late indica rice in Guangdong is generally higher than the national average in the sample range. Among which, the average value of the price fluctuation rate of early indica rice and late indica rice was 0.4622% and 0.5491% respectively and the standard deviation was 3.89299% and 4.37975% respectively, both were higher than the average and standard deviation of the price fluctuation rate of the national early rice and late indica rice.

Table 1. Basic statistical characteristics of price fluctuation sequence data of early indica rice and late indica rice.

| Variable                        | Area   | Min     | Max     | Mean       | Std. Deviation | Skewness | Kurtosis |
|---------------------------------|--------|---------|---------|------------|----------------|----------|----------|
| Price fluctuation rate of early indica rice | Guangdong | -10.05% | 23.93%  | 0.4622%    | 3.89299%       | 1.513    | 7.661    |
|                                 | National| -8.69%  | 19.79%  | 0.4184%    | 2.74848%       | 2.904    | 17.200   |
| Price fluctuation rate of late indica rice | Guangdong | -10.00% | 24.25%  | 0.5491%    | 4.37975%       | 1.760    | 7.077    |
|                                 | National| -8.00%  | 17.44%  | 0.4199%    | 2.67219%       | 2.779    | 15.487   |

2.3. Fluctuation characteristics of rice price in Guangdong

2.3.1. The rate of increase of rice price is greater than the rate of decline. It can be seen from Table 1 that the maximum fluctuation rate of early indica rice and late indica rice in Guangdong is 23.93% and 24.25% respectively, and the minimum value is -10.05% and -10.00% respectively, which indicates that the increase rate of rice price is greater than the rate of decline. This is because the national food protection policy has a restrained effect on the degree of decline in rice prices to a large extent.

2.3.2. The rice price presented a trend of fluctuated rising with obvious fluctuation in some years. The price of early indica rice in Guangdong increased from 1836.82 ¥/t in 1998 to 3997.78 ¥/t in 2015, with an average annual growth rate of 4.68%, which is slightly higher than the national average rate (4.53%) of early indica rice; The price of late indica rice increased from 1971.18 ¥/t to 4964.5 ¥/t, with an average annual growth of 5.58%, which is 1% higher than that of national average price over the same period. Among the sample range, there were 27 months when the price fluctuation rate of early indica rice is more than 5% and 7 months when the price fluctuation rate is more than 10%, and the rate was 23.93% in March 2004. And there were 31 months when the price fluctuation rate of late indica rice is over 5% and 8 months when the price fluctuation rate is over 10%, and the rate was 24.25% in January 2005. The price fluctuation rate of late indica is slightly higher than that of early indica rice.

2.3.3. The trend of rice prices is basically in line with that of the whole country, but the price is generally higher than the national average over the same period. It can be seen from Figure 1, price fluctuation in rice market in Guangdong presented a similar trend to that nationwide - fluctuating while rising. During 1998-2003, the prices of early indica rice and late indica rice in Guangdong were low,
fluctuating around 1500 ¥/t, which was very slightly different from the national average; in 2004, the prices of early indica rice and late indica rice broke through the barrier of 2000 ¥/t, respectively being 2370.04 ¥/t and 2394.53 ¥/t, with a respective year-on-year increase of 50.01% and 39.95%; after 2004, the price of indica rice remained high, in particular, the price of late indica rice was much higher than that of early indica rice and the national average in the same period; to 2015, the prices of late indica rice and early indica rice in Guangdong were respectively 4964.5 ¥/t and 3997.78 ¥/t which were respectively 18.96% and 4.41% higher than the national average prices (4173.36 ¥/t and 3828.93 ¥/t).

Figure 1. The Trend of indica rice price in Guangdong from January 1998 to December 2015.

3. Fluctuation decomposition of rice price in Guangdong

3.1. Time series decomposition principle
Changes of economic time series are mainly affected by four factors: trend, periodic factors (Cycle), seasonal factors (seasonal) and irregular components (irregular). Time series decomposition is designed to separate the seasons, trends, cycles and irregular components in the time series, and then analyze the statistical characteristics of the components. Seasonal fluctuations in the economic time series of monthly or quarterly that selected as time observation units show a significant trend and they tend to cover or confuse other objective changes in economic development. Therefore, when using the monthly time series to analyze the economic phenomenon, the original time series data need to be adjusted seasonally and eliminate the influence of the seasonal fluctuations (caused by the climate, social system and customs, etc.) to show the hidden trend cycle components. In this paper, the time series \(Y_t\) are decomposed into trend cycle components \(TC\), seasonal components \(S\) and irregular components \(I\) by the CensusX12 season adjustment method first. Based on this, the H-P filtering method is used to separate the trend cycle components to obtain the long-term trend factors and the short-term fluctuation cycle factors. The fluctuation regularity and characteristics of rice price are identified and analyzed. In this paper, the multiplication model is used to adjust the time series of rice price seasonally. In order to facilitate the analysis, the multiplication model is converted into the additive model, that is \(\ln Y_t = \ln T_t + \ln C_t + \ln S_t + \ln I_t\).

3.2. Results analysis
Seasonal fluctuations in rice prices are weakening. From the isolated seasonal factor series (Figure 2), it can be seen that the prices of early Indica rice and late Indica rice present seasonal fluctuation characteristics, and the effect on the price of early indica rice is significantly greater than that of late indica rice. The prices of early indica rice and late indica rice in Guangdong show the characteristic of seasonal fluctuation, which has obviously greater influence on the price of early indica rice than that of late indica rice. As shown by seasonal factors, in each year, January ~ June is the high-sales season of indica rice, where the peak appears around March; July ~ December is the low-sales season of indica rice, where the prices of early indica rice and late indica rice drop to the lowest points respectively around August and October. After 2007, the effect of seasonal components on the price of Indica rice reduced significantly. Figure 3 shows the series of indica rice after the logarithm and the trend of the price sequence after the seasonal adjustment, which can be seen that seasonal factors has a little effect on the price of indica rice.

Figure 2. Seasonal factor series of early indica rice and late indica rice.

Figure 3. Price sequence trend of early indica rice and late indica rice.

3.2.1. The long-term trend component of rice price took a dominant place. Figure 4 shows the trend sequence (Trend) and the cycle component (Cycle) that has been decomposed by H-P filter. According to
the trend sequence diagram (Trend), since 1998, the prices of early indica rice and late indica rice in Guangdong have shown the following long-term trend: the price showed a downward trend from 1998 to the first half of 2001 and showed a long-term trend of continuous rise from the second half of 2001. This is closely related to the rigid demand of indica rice consumption of Guangdong residents and the change of population growth. In order to facilitate the analysis, this paper will convert the calculated monthly data of long-term trend factors to annual data, and calculate the ratio of long-term trend components to the price. The value of a trend component may be higher than or lower than the actual price of current period as the actual price includes the impact of random shocks and cycle component changes. When C>100%, it is indicated that random shocks and cycle components have restrained effect on price, and when C<100%, it is indicated that random shocks and cycle components have a driven effect on price. It can be found from Table 2 that the value of C was close to 100% in most years of the sample range, and the price of indica rice was mainly dominated by the trend component; The C value of the individual years such as 2000, 2003 and 2010 was obviously higher than 100%, and the random shocks and cycle components restrained the price of indica rice; The C value of 2011 was obviously lower than 100%, and random shocks and cycle components contributed to the rise of indica rice prices.

![H-P Filter decomposition of price trend cycle sequence of early indica rice and late indica rice.](image)

**Figure 4.** H-P Filter decomposition of price trend cycle sequence of early indica rice and late indica rice.

**Table 2.** Long-term trend composition and proportion of early indica rice and late indica rice.

| Year | Price of early indica rice ($y_{1t}$) | Price of late indica rice ($y_{2t}$) |
|------|----------------------------------------|---------------------------------------|
|      | Lg ($y_{1t}$)  | $T_{1t}$ | $C_{1t} = T_{1t} / Lg (y_{1t})$ | Lg ($y_{2t}$)  | $T_{2t}$ | $C_{2t} = T_{2t} / Lg (y_{2t})$ |
| 1998 | 7.514  | 7.500 | 99.82% | 7.583  | 7.570 | 99.82% |
| 1999 | 7.442  | 7.390 | 99.30% | 7.540  | 7.477 | 99.16% |
| 2000 | 7.205  | 7.288 | 101.15% | 7.315  | 7.381 | 100.89% |
| 2001 | 7.289  | 7.257 | 99.57% | 7.360  | 7.340 | 99.72% |
| 2002 | 7.271  | 7.311 | 100.54% | 7.338  | 7.381 | 100.58% |
| 2003 | 7.362  | 7.447 | 101.16% | 7.440  | 7.515 | 101.01% |
3.2.2. The rice price presents a trend of obvious periodic fluctuation. During the 18 years since 1998, the prices of early indica rice and late indica rice in Guangdong have experienced two most obvious price increases. The first time: From July 2003 to May 2004, Guangdong early indica rice prices rose from 1456.67¥/t to 2620¥/t with an increase of 79.86%; From July 2003 to March 2004, Guangdong late indica rice prices rose from 1460¥/t to 2635¥/t, or with an increase of 80.48%. The second time: From March 2010 to November 2011, early indica rice prices rose from 3,000¥/t to 4175¥/t with an increase of 39.17%; From March 2010 to December 2011, late indica rice prices rose from 3600¥/t to 5400¥/t, with an increase of 50%. According to the periodic determination of the principle of "trough-trough", the price fluctuation of early indica rice and late indica rice in Guangdong during the sample range can be divided into five complete cycles (Table 3 and Table 4). The average cycle length is 35 months and 38 months.

| Cycle  | Time Span        | Duration (month) | Rise (month) | Peak          | Decrease (month) | Trough      |
|--------|------------------|------------------|--------------|---------------|------------------|-------------|
| First  | Feb.1998- Aug.2000 | 31               | 8            | Sept. 1998    | 23               | Aug. 2000   |
| Second | Sept. 2000- Jul.2003 | 35               | 14           | Oct. 2001     | 21               | Jul. 2003   |
| Third  | Aug.2003- Jun.2006 | 35               | 11           | Jun. 2004     | 24               | Jun. 2006   |
| Fourth | Jul. 2006- Feb.2010 | 44               | 16           | Oct. 2007     | 28               | Feb. 2010   |
| Fifth  | Mar.2010-Sept.2012 | 31               | 19           | Sept. 2011    | 12               | Sept. 2012  |
Table 4. Price fluctuation cycle of late indica rice from January 1998 to December 2015.

| Cycle | Time Span         | Duration (month) | Rise (month) | Peak  | Decrease (month) | Trough |
|-------|-------------------|------------------|--------------|-------|------------------|--------|
| First | Jan. 1998-Sept. 2000 | 33               | 10           | Oct. 1998 | 23               | Sept. 2000 |
| Second| Oct. 2000-Jul. 2003 | 34               | 12           | Sept. 2001 | 22               | Jul. 2003   |
| Third | Aug. 2003-Mar. 2007 | 44               | 10           | May 2004  | 34               | Mar. 2007   |
| Fourth| Apr. 2007-Feb. 2010| 35               | 6            | Sept. 2007 | 29               | Feb. 2010   |
| Fifth | Mar. 2010-Jan. 2014| 47               | 14           | Apr. 2011  | 33               | Jan. 2014   |

Figure 5. Irregular component sequence of the price of early indica rice and late indica rice.

3.2.3. Random factors have serious impacts on the price of indica rice in some years. From the irregular component sequence of the price of early Indica rice and late Indica rice (Figure 5), it can be seen that the value of irregular component is around 0 with frequent random fluctuations. And the fluctuation degree was much higher in some years. This shows that the random shocks have both positive (driven) and negative (restrained) effects on the price of Indica rice, and random factors have a severe impact on the price of indica rice. From different time periods, random factors have obviously driven effects on the price of late indica rice in June 1998, November 2003, March 2004, September–October 2007, and the proportion of random components accounted for 1.04%, 1.33%, 1.03%, 1.6% and 1.29% respectively. Random factors have obviously restrained effects on the price of late Indica rice in July 2003, December 2004 and February 2008, and the proportion of random components accounted for -1.04%, -1.61% and -1.38%. As for the price of early indica rice, there were fewer months when the irregular components presented obvious fluctuation with slight fluctuation degree. There were two years when the proportion of random components accounting for more than 1% of the original sequence value and the proportion was -1.46% in February 2004 and 1.08% in June 2010. Since the second half of 2012, with the country’s emphasis on food security issues, the impact of random components on the price of indica rice has been significantly weakened, with a fluctuating value of around 0.

4. Factors analysis on abnormal fluctuations of rice price
4.1. Supply shock
Since October 2003, Guangdong rice prices rose rapidly on the basis of low prices over a long period of time and the price of early indica and late indica rose to 1815 ¥/t and 2070 ¥/t respectively in November 2003, with a growth rate of 11.61% and 15% respectively compared to that of October in the same year. Generally, successive years of rice production reduction and tightening relationship of supply and demand contributed to the rise of rice price. Under the influence of a variety of factors like the decline of planting area and drought etc., the rice production in China has been reduced for 6 consecutive years. The production reduced from 200.735 million tons (peak) in 1997 to 160.656 million tons in 2003, with a reduction of 24.95%. The inventory fell to the lowest level since the reform and opening up. The rice production in Guangdong decreased by 25.95% from 16.8853 million tons in 1998 to 12.5038 million tons in 2003. The rice price in Guangdong remained high in 2007, with a slight rise, which was adjusted in August ~ September. The main reason was: early indica rice in main producing provinces of indica rice, namely Jiangxi, Hunan and Sichuan, suffered from drought and production reduction, which resulted in relatively tight supply of indica rice, and the domestic rice market continuously presented the characteristic of “indica rice market being more robust than japonica rice market”. In 2011, a severe drought broke out in the middle and lower reaches of Yangtze River, followed by flood disaster, which caused much more concern about production reduction of summer grain crops in the market and increased the expectation for grain price rise. During November ~ December that year, the prices of early indica rice and late indica rice in Guangdong rose to the historical high points. Therefore, the price fluctuation of rice in Guangdong is affected by rice supply shocks in the recent decade.

4.2. Cost driven
In 2004, Guangdong rice prices rose first and then fall and the price of early indica rice and late indica rice in March reached the highest level in the whole year, with an increase of 23.93% and 19.77% respectively compared with that in February. Generally, the rise in rice prices is still recovering. The root causes of the rise of rice prices in the 2004 were cost pull, rice production and the increasing contradiction of the supply structure among regions and varieties. From the microscopic supply factors, the rising production costs of seed, pesticide, fertilizer, machinery operation and labor have been supporting the rice price since 2004. In 2004, the production cost of early indica rice per mu in Guangdong and the country was 376.64 yuan and 383.82 yuan respectively, which was 26.87% and 32.18% higher than that in 2003. The production cost of late indica rice in Guangdong and the country per mu was 377.91 yuan and 382.13 yuan respectively, with a year-on-year rise of 25.15% and 31.39% (Table 5).

Table 5. Changes of production costs of indica rice in Guangdong and nationwide in 2004.

| Year | Early indica rice | Late indica rice |
|------|-------------------|-----------------|
|      | Guangdong | Nationwide | Guangdong | Nationwide |
| 2003 | 296.88   | 290.37     | 301.96    | 290.84     |
| 2004 | 376.64   | 383.82     | 377.91    | 382.13     |
| Rise | 26.87%   | 32.18%     | 25.15%    | 31.39%     |

Note: Data come from Collection of National Agricultural product cost benefit of Y2004-2005

4.3. Policy intervention
In April 1998, our country launched the "three policies" of grain reform (that is, purchase surplus grain from farmers without limit at protective prices, sales at profitable price and closed operation of purchasing funds). The prices of Guangdong early indica rice and late indica rice rose to 1884 ¥/t and 2133 ¥/t in June
of the same year, with an rise of 11.6% and 13.23% compared with that in May In 2004, after the liberalization of the grain purchase market and the purchase price in China, the minimum purchase price policy for paddy rice was put forward from 2004 to protect farmers' interests and grain cultivation enthusiasm. The minimum purchase price has been raised for 6 consecutive years since 2006. The purchase price increased to 1.39 yuan per catty with an increase of 92%. The policy on the market driven and support efforts continue to increase.

5. Conclusion and policy implications

Based on the empirical analysis on the price fluctuation of early indica rice and late indica rice in Guangdong Province, it can be concluded that: (1) The price of rice in Guangdong presents a trend of overall fluctuating rise and the growth rate is generally higher than the national average over the same period, which has a effect on the stability of rice market. (2) Seasonal factors have limited impact on the rice prices and seasonal fluctuations have been significantly weakened in recent years. This shows that the consumption of rice rations of Guangdong residents tends to be stable and the “effect of slack-peak seasons” for consumption is gradually reduced while the strong support of the lowest purchase price policy offsets the impacts of seasonal supply on low rice prices. (3) It can be indicated that the fluctuation of rice price is predictable to some extent from the cyclical fluctuation characteristics and the long-term rising trend of rice price. (4) Random shocks have both positive (driven) and negative (restrained) effects on the price of indica rice and random factors have a severe impact on the price of indica rice in some years. (5) The rice prices are mainly affected by market supply and demand, production costs and food policy intervention (The main factors affecting the fluctuation of rice price include market supply and demand, production costs and food policy intervention). The sharp abnormal fluctuation of rice prices will affect the development of rice industry, residents' life and national economy. Therefore, the relevant departments should attach great importance to the factors that cause abnormal fluctuations in rice prices and take effective policy measures in practice to achieve long-term stability of the supply of grain market and reasonable fluctuations in grain prices in Guangdong through protecting effective land area, improving grain yield, constructing grain source base, building grain supply system and strengthening market monitoring and early warning etc.

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