An Empirical Study of the Introduction of Hog Futures on Stabilizing Hog Prices

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Abstract—Hog prices in China are highly volatile and cyclical, in 2021 hog price has dropped down to below 10 yuan per pound, which has a huge impact on hog farmers and consumers. This study investigates the stabilizing effect of the newly listed hog futures on spot market in China. A static historical volatility model and GARCH model are adopted in this study. The data in this paper is from Wind and Security Research Centers. The results from static historical volatility model and time series techniques show the listing of hog futures leads to increased volatility of hog spot price in a short term.

Keywords-Hog futures, spot market, price volatility, coefficient of variation, GARCH model

1 INTRODUCTION

On January 8th 2021, the Chinese hog future was listed on the Grand Mercantile Exchange which is supposed to be a positive contribution to improve the price formation mechanism of hogs, and help the development of hog industry. From 2006.07 to 2020.12, there is great volatility in Chinese hog price together with 4 hog cycles, the biggest drop among each downturn of the cycle was 50%. [1]Analysts and policymakers frequently use future prices in financial markets to gauge market expectations. It is theoretically believed that a well-functioning futures market has a stabilizing effect on the spot market, Stephen J. Turnovsky found out that the futures market both stabilizes the long-run spot rate as well as lowering its long-run mean， which is helpful to the volatile Chinese hog market. [2] But from January 2021 to July, hog price has decreased by 57%.[1]

There is evidence in most cases that these are not pure expectations.[3] Sergey V. Chernenko, Krista B. Schwarz and Jonathan H. Wright found out that they are also affected by risk premia, which is often time-varying. These forward and futures rates should not be interpreted as the rational expectations of market participants, unless it is assumed that the historical time series are unrepresentative of what should be expected in the future.

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Also, the unexpected futures trading volume can cause spot price volatility, which may be explained by the low rate of information dissemination from futures market, high transaction costs or the friction associated with the spot market and the not-well-organized spot market which is not electronically traded and has a low transparency.[4]

There is also evidence that the introduction of the future may violate the spot prices. The more dependent on imports, the stronger the violation may be.[5] It is proved that commodities like palm oil, pulp, which rely highly on import, may strengthen their spot price fluctuation after the introduction of the futures. In this paper, a similar research will be done on this factor.

Normally static historical volatility models are used to analyze the role of futures markets in stabilizing the spot market by comparing the changes in spot price volatility of futures varieties before and after their listing. The advantage of this method is that it is more intuitive, but lacks more rigorous theoretical support.[6]

In this paper, the GARCH model is established for the hog price, and the parameters are estimated. Through the analysis of the parameters, the impact of the introduction of hog futures on spot is obtained. The ARCH model （Autoregressive conditional heteroskedasticity model） solves the problem caused by the second assumption of time series variables (constant variance). The GARCH model is called the generalized ARCH model. In general, under ideal conditions, the second moment in the weak stationary condition of the time series is a constant and independent of time. [7]The linear model such as ARIMA can be used to simulate the financial time series well. However, the modeling effect of ARIMA and other models on financial event sequence is very poor, because of the heteroscedasticity of financial event sequence. GARCH model can accurately simulate the volatility changes of time series, and is widely used in financial and empirical studies. It enables people to accurately grasp the volatility and simulate the heteroscedasticity of time series.

This paper adopts a combination of the above methods to empirically study the stabilizing effect of hog futures on the spot market: firstly, a more intuitive static historical volatility model is used to initially analyze the changes in spot price volatility before and after the listing of hog futures; secondly, a GARCH model is used to further study the stabilizing effect of hog futures on the spot market from a more rigorous empirical perspective.

2 COMPARATIVE ANALYSIS OF SPOT PRICE FLUCTUATIONS BEFORE AND AFTER HOG FUTURES LISTING

This section analyzes spot price fluctuations before and after the hog futures market by selecting volatility indicators for comparison. Spot price data are selected for the period from July 2006 to July 2021.

2.1 Selection of volatility indicators

Price volatility is an important indicator of the degree of price movement and is generally measured by the coefficient of variation (CV). The coefficient of variation is the ratio of the standard deviation to the mean, reflecting the magnitude of series fluctuations as a proportion of the mean and can be used to study the degree of volatility of different mean series. [8] The standard equation is shown in formula (1).

$$CV = \sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}} \Big/ \bar{x} \quad (1)$$

2.2 Analysis of hog spot price fluctuation

2.2.1 General analysis

In order to facilitate comparative analysis, the annualized monthly volatility is calculated by multiplying the monthly volatility by$\sqrt{12}$. Table 1 shows the basic statistics of the annualized monthly spot price volatility before and after the listing of hog futures. It can be observed that during the 173-month period before the listing of hog futures, the percentage of months with annualized monthly spot price volatility greater than 10% was 29%. During the 7-month period after the listing, the percentage of months with annualized monthly spot price volatility greater than 10% was 71%. The percentage of months with spot price volatility greater than 10% after the listing of hog futures increased by 42 percentage points compared with that before the listing. Overall, it seems that the spot price volatility has increased significantly after the listing of hog futures from the perspective of annualized monthly volatility.

TABLE 1 STATISTICS OF THE ANNUALIZED MONTHLY SPOT PRICE VOLATILITY BEFORE AND AFTER THE LISTING OF HOG FUTURES

Indicators	CV>10%		CV<10%	
	months	percentage	months	percentage
before hog future listing 2006.06-2020.12 (173 months)	50	29%	123	71%
after hog future listing 2021.01-2021.07 (7 months)	5	71%	2	29%

Source: Wind

2.2.2 Period analysis

Considering the special character of hogs as a commodity——hog cycle, it will be more substantial to analyze the spot price fluctuation in each different cycles. Table 2 present the period of the past 3 hog cycles in China. Each big cycle lasts on average 4 years, and contains both a upward and a downturn.

TABLE 2 PERIOD OF THE PAST 3 HOG CYCLES FROM 2006.06 TO 2019.02

hog cycle	06.06-10.04		10.05-15.03		15.04-19.02	
	Upward	Downturn	Upward	Downturn	Upward	Downturn
	06.06-08.06	08.07-10.04	10.05-11.08	11.09-15.03	15.04-16.05	16.06-19.02

Source: wind, Western Securities R&D Center

The time of hog futures listing was just during the start of the downturn of the current cycle. It is more precise to compare that fluctuation rate when it is separated in each downturn period. Table 3 shows the statistics of the annualized monthly spot price volatility in every downturn

before and after the listing of hog futures. Overall, it still seems that the spot price volatility has increased significantly after the listing of hog futures from the perspective of annualized monthly volatility in each relevant period.

TABLE 3 STATISTICS OF THE ANNUALIZED MONTHLY SPOT PRICE VOLATILITY IN EVERY DOWNTURN BEFORE AND AFTER THE LISTING OF HOG FUTURES

Cycle period	Before hog futures			after hog futures
	08.07-10.04	11.09-15.03	16.06-19.02	21.01-21.07
Number of months (CV>10%)	7	9	9	5
Percentage (in downturn)	31.82%	20.93%	27.27%	71.43%

Source: wind, Western Securities R&D Center

3 EMPIRICAL ANALYSIS OF LIVE HOG SPOT PRICE FLUCTUATION BASED ON GARCH MODEL

3.1 Data selection and basic statistical analysis

Data are selected from weekly spot hog prices from July 2006 to July 2021. Using logarithmic rate of return data for empirical analysis, because the rate of return series often has better statistical characteristics and the model fitting is better. The specific calculation formula of the rate of return is:

$rt = \ln(pt / pt-1) \times 100$ .pt is the spot price of hogs in week t.

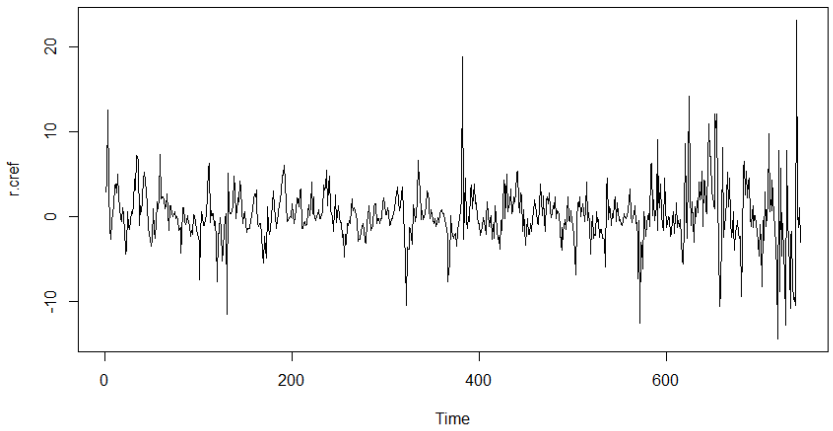

Figure 1. return rate sequence of hog price

Figure 1 shows the return rate sequence of hog price. It can be seen from the figure that the return rate sequence of hog price is characterized by aggregation distribution, that is, a large fluctuation is often followed by a larger fluctuation, and a small fluctuation is often followed by a small fluctuation, indicating that the return rate sequence may have heteroscedasticity.

3.2 Stationarity test of sequence (Unit root test)

Through the ADF test, the unit root test P value < 0.01. It means that at a given significance level of 99%, the null hypothesis of the existence of a unit root is rejected. The results of the ADF test indicates that the return rate series of piglets does not exist a unit root and is a stationary time series, so that subsequent modeling can be carried out.

3.3 ARMA model selection ARMA

The following table shows the autocorrelation coefficient and partial autocorrelation coefficient of different lag order of the return rate sequence of hog price. It can be seen from the table that there is no significant autocorrelation of the return rate sequence of hog price, and the autocorrelation coefficient rapidly tends to 0 with the increase of the lag order, and the partial autocorrelation coefficient rapidly tends to 0 after the first order. So the model might be roughly the ARMA (1,1) model, which is presented in Table 4.

TABLE 4 CORRELATION COEFFICIENT TABLE OF DIFFERENT LAG NUMBERS

Lag order	Autocorrelation	Partial
1	0.392	0.392
2	0.264	0.13
3	0.149	0.01
4	0.117	0.035
5	0.083	0.014
6	0.089	0.04
7	0.014	-0.055
8	0.027	0.016
9	-0.022	-0.041
10	-0.036	0.03

Further, the extended autocorrelation coefficient diagram of sequence of hog price. was obtained.

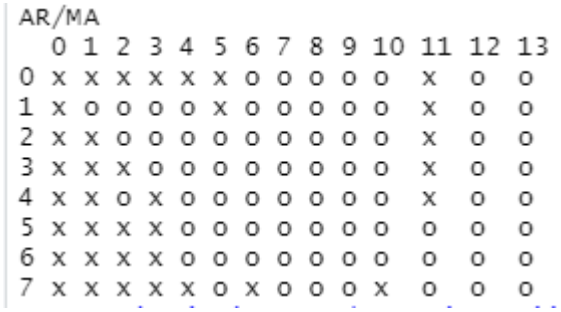

Figure 2. Extended autocorrelation coefficient

As can be seen from the Figure 2, the return rate sequence of hog price may be more consistent with the ARMA (1,1) model or higher order ARMA model.

To determine the appropriate order of lag, the AIC criterion is usually used. When selecting the lag order of the variable, the smaller the AIC value, the better. Through the calculation of models with different lag orders, it is concluded that when ARMA (1,1) model is adopted, the sum of AIC values is the smallest, and the statistics are significant. Therefore, ARMA (1,1) model is selected, which is exhibited in formula (2).

$$r_t = c + \varphi r_{t-1} + \varepsilon_t - \theta \varepsilon_{t-1} \tag{2}$$

3.4 ARCH effect test ARCH

ARMA (1,1) model is used to estimate the return rate sequence of hog price, and generate the residual series. The ARCH effect on the residual series is tested.

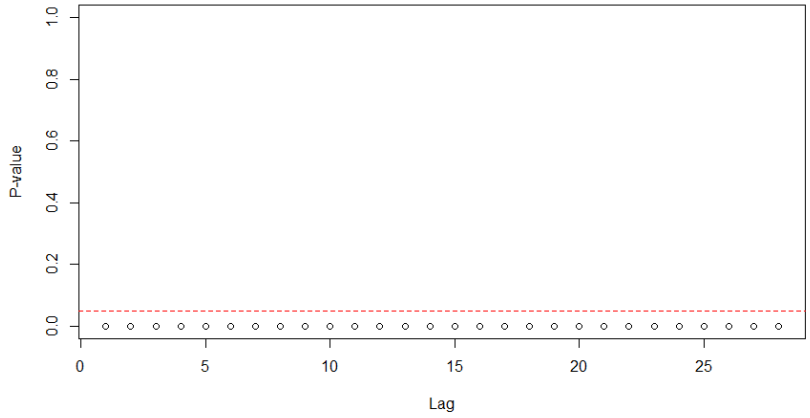

Figure 3. McLeod-li test results

Through the McLeod-li test, it can be seen from Figure 3 that McLeod-li test is significant at the significance level of 5%, which provides strong evidence for ARCH effect of the data, that is, heteroscedasticity exists in residual series.

3.5 GARCH model test GARCH

In view of the ARCH effect in the yield sequence of live pigs, GARCH model can be considered to model the sequence.

GARCH model can solve heteroscedasticity of residual sequence well. At the same time, according to the constraint conditions of the coefficient of GARCH model and the minimum AIC value principle, after several calculations, the GARCH(1,1) model is finally selected to describe the estimation of the return rate sequence of hog price.

After GARCH(1,1) model was adopted to fit the return rate sequence of hog price, generalized mixed test was carried out on the standard residual square of GARCH model. The test results are as follows

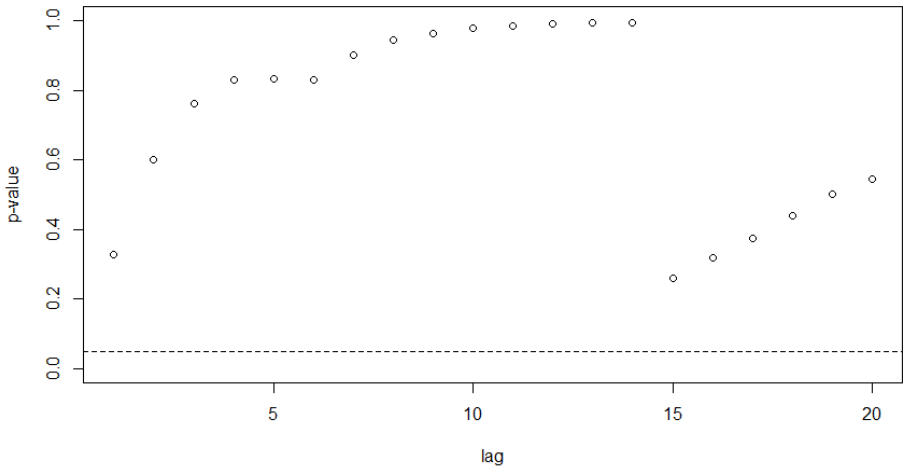

Figure 4. generalized mixed test results

It can be seen from the Figure 4 that the p-value of the generalized mixed test lags more than 5% in the order 1-20, and the generalized mixed test is significant, indicating that the square of residual is not correlated with time. Therefore, the GARCH(1,1) model provides an excellent fit for the return rate sequence of hog price

In order to determine whether the GARCH(1,1) model eliminates the influence of autoregressive conditional heteroscedasticity, ARCH-LM test is carried out. The test result shows that the P value is 0.3558> 0.05, that is, at a given significant level, it is considered that the return rate sequence of hog price does not have ARCH effect, so the GARCH(1,1) model adopted is appropriate.

3.6 GARCH model estimation GARCH

GARCH (1,1) model was adopted for estimation analysis. Meanwhile, In order to test the effect of hog futures market on the fluctuation of the hog spot price, a dummy variable D_t was introduced into the model, and the value of D_t is 0 or 1. The value of D_t is 0 before the market of hog futures, and 1 after the market of hog futures. The dummy variable is introduced through the conditional variance to test the impact of the listing of the live pig futures on the fluctuation of its spot price.

In the model estimation results, if λ is less than 0, it indicates that the market of live pig futures reduces the fluctuation of spot price, which, on the contrary, indicates that the market of live pig futures does not reduce the fluctuation of spot price.

Accordingly, the adjusted GARCH (1,1) model is as follows in formula (3), (4) and (5):

$$r_t = c + \varphi r_{t-1} + \varepsilon_t - \theta \varepsilon_{t-1} \tag{3}$$

$$\varepsilon_t | I_{t-1} \sim N(0, \sigma_t^2) \tag{4}$$

$$\sigma_t^2 = C + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 + \lambda D_t \tag{5}$$

The parameters of the above model are estimated and the parameters are obtained. The results of the established model are as follows in formula (6) and (7):

Mean value equation:

$$r_t = 0.000329 + 0.679583 r_{t-1} + \varepsilon_t - 0.124359 \varepsilon_{t-1} \tag{6}$$

Variance equation:

$$\sigma_t^2 = 0.000088 + 0.189285 \varepsilon_{t-1}^2 + 0.682077 \sigma_{t-1}^2 + 0.001881 \lambda \tag{7}$$

The coefficient of λ is greater than 0, indicating that the futures listing does not attenuate the volatility of hog prices, but rather exacerbates it.

4 VOLATILITY EXACERBATION ANALYSIS

4.1 High import dependence

From both static and empirical analysis on the effect of live hog spot price fluctuation, it is demonstrated that the fluctuation of hog spot price has been violated after the listing of hog futures. It contradicts to a normal theory that the listing of futures will stabilize the fluctuation of spot price. But there are studies found that some of the commodities which highly rely on import may violate after the listing of its futures.[5] Commodities like paper pulp which highly rely on import may lose their power of bargaining, therefore the price is not a rational price and far more than a reasonable price. The listing of the futures may utilize its function of price

discovery, which leads to a drop in spot price and strong violation in short term. When the price comes back to a reasonable price, the volatility may become weaker.

Figure 5 shows the import quantity from 2008.01 to 2021.04, the import quantity is always in an increasing trend. In 2020, China's pork imports totaled 4,303,552.68 tons, up 53.66% year-on-year. During the last Swine Fever, a great amount of pork has been imported in order to solve the local problem of demand over supply. In such cases, the hog price can go to an irrational price, and the hog futures listing can cause a strong violation of spot price.

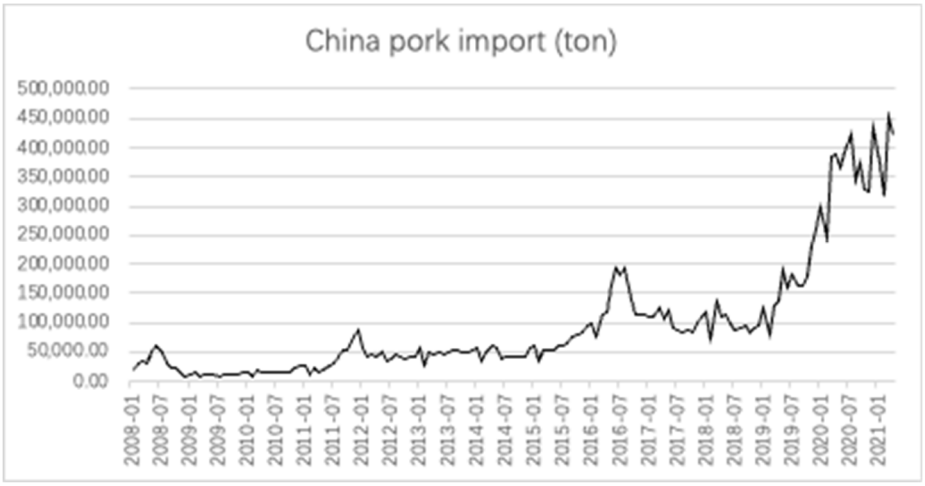

Figure 5. China pork import 2008.01-2021.04

Source: Wind

4.2 Low concentration of Chinese hog market

Chinese hog market has a low concentration, in 2020, China's hog breeding enterprises CR10 was only 12%. Figure 6 shows that among the leading enterprise MuYuan achieved 18.115 million, with a market share of only about 3.4%. There is still a lot of growth room for the head enterprise, industry concentration is more fragmented.

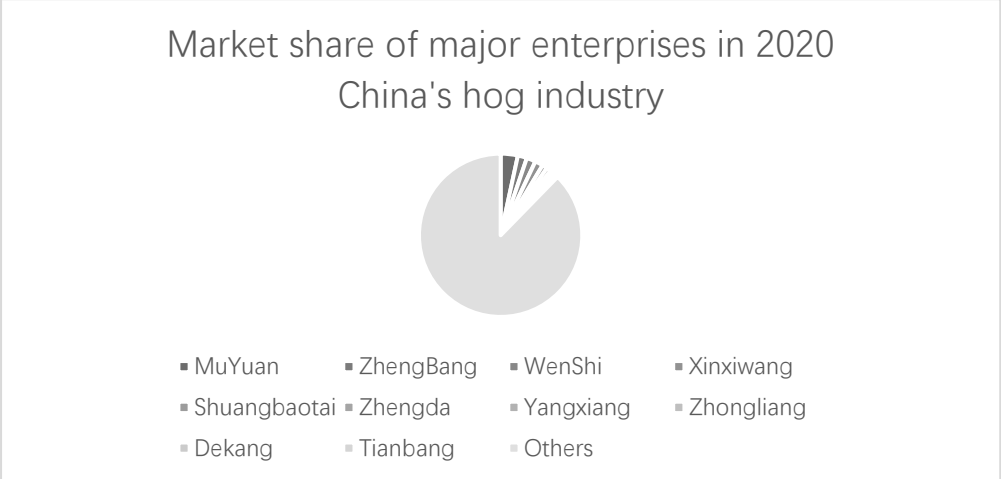

Figure 6. Market share of major enterprises in 2020 China's hog industry

Source: Database of China Business Industry Research Institute

Such a low market concentration gives the hog industry great chaos, which sets an obstruction to the market transparency. Such an obstruction poses a challenge to future analysts and therefore it is hard to fully utilize the price discovery function and leads to increased volatility of hog spot price.

5 CONCLUSIONS

The listing of hog futures leads to increased volatility of hog spot price. That seems contrary to a common belief that futures may decrease the volatility of spot price. But in terms of hog futures, which is of high import dependence and the price is irrational, the listing of hog futures may cause stronger volatility in a short term, but may decrease that volatility in a long term when the price returns rational. Besides, the low concentration of Chinese hog industry poses a great challenge to the futures analysts, which may also cause increased volatility of hog spot price in China.

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