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Comparison of U.S.-China Futures and Spot Market Price Conduction: Based on the Study of Wheat Market

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Abstract: In-depth exploration of the difference of price transmission capacity between Chinese and world agricultural futures market is beneficial to understand the efficiency of Chinese futures market. Studying its transmission mechanism can deepen the understanding of the characteristics of wheat market price fluctuations, which is important to further guide the development of China's futures market and ensure China's wheat industry to develop healthily. This paper uses the VAR model and ARMA-GARCHX model to analyze and compare the prices of futures and spot market in China and the United States from the perspective of yield and volatility transmission. The results show that futures and spot market prices of China and the United States have a mutual guiding relationship, and the price guidance role of the United States in both markets is stronger than China. Then, compared with the spot price, the transmission of futures prices is more comprehensive and significant. Considering the results, China needs to deepen the reform of the futures market and implement precise policies to enhance the ability of market price discovery.

Keywords: futures market, spot market, price transmission, U.S.-China comparison

1. Introduction

China is a large country in wheat production and consumption, and the wheat industry occupies a pivotal position in the world, whose output, import, and consumption are in the forefront of the world. However, the production and operation of China's agricultural product market is scattered, the spot market is not standardized enough, and the futures market is not mature enough, so it is difficult to form a scientific and reasonable price, resulting in a violent fluctuation in wheat prices, and the risks faced by various market entities in the wheat industry chain have also increased. Therefore, it is particularly important to grasp the price conduction principle of wheat futures and spot market, deepen the understanding of wheat market price risks, and ensure the stable development of China's wheat industry. Theoretically, there are many factors that affect the price of wheat futures market and spot market in the short term, such as the supply and demand relationship of wheat commodity, national macroeconomic policies, international environment [1]. However, if the market system is perfect, the operation of futures prices and spot prices should tend to be consistent in the long run. At the same time, as futures contracts approach expiry, futures prices should converge on spot prices.

However, the development of China's wheat futures market is still in its infancy, only a little more than ten years, and it is a leapfrog development that the government draws on the market experience of foreign developed regions and undertakes the development of the spot market, which is a

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mandatory institutional change. This is different from developed countries such as the United States, whose futures markets are built on the premise of free market competition, rely on the power of market supply and demand to regulate prices, and naturally develop, which is an induced institutional change [1].

In this case, by comparing with the US wheat market, the paper mainly focus on how the price transmission between Chinese wheat futures and spot market performs and whether the price transmission functionality is fully utilized. Therefore, this paper compares and analyzes the price transmission efficiency of Chinese and US wheat futures markets and spot markets by constructing VAR models and ARMA-GARCHX models, reflecting the change law and market efficiency of China's wheat market.

2. Literature Review

There are many research papers study the relationship between the futures and spot markets, involving a variety of agricultural products, mainly focusing on the relationship between the futures market represented by soybeans, cotton and other agricultural products and the spot market, and the comparative relationship between domestic and foreign markets. Yu Jianbin used monthly data from 2002 to 2005 to conduct the Granger causal test on spot and futures price in China and the United States, and the results showed that at a significant level of 5%, the prices of the soybean futures and spot market in China and the United States guide each other, and the United States performs better than Chinese [1]. Similarly, Asha Nadig and T. Viswanathan, in their study of the Indian pepper spot market, applied the Granger causal test and also concluded that there is bilateral causality between spot prices and future prices of pepper. The spot price is granger cause of future price and vice versa, and one variable can be used to predict the other variable." [2]. Xia Tian and Cheng Xiaoyu studied the relationship among the spot price of domestic soybeans, the soybean futures price of the Dalian Mercantile Exchange (DCE) and the Chicago Board of Trade (CBOT), and the results showed that there is a long-term equilibrium relationship among them, and the short-term price deviation can be corrected by its own price constraint mechanism, and the three have a mutual influence and mutual guidance relationship [3]. It can be explained by theory that the wheat spot price consists of the futures price and the basis, i.e. spot price = future price + basis, where the futures price plays a major role, and the change of basis is relatively stable relative to the change of the futures price, so when the long-term trend deviates, the short-term adjustment of the futures price can promote its recovery to the equilibrium state. Akanksha Gupta and Poornima Varma demonstrated a stronger flow of information from futures to the spot market through cointegration and error correction models, confirming the price discovery function of futures. Through the results of the Granger causal test, it is obtained that there is a two-way fluctuation spillover effect in both markets, and futures trading activity is both the cause of spot volatility and the result of spot volatility [4].

Most existing literature analyzes the relationship between Chinese agricultural futures and spot market for soybeans, only from a certain angle and lack of systematization and comprehensiveness, because there are many influencing factors for changes in agricultural futures and spot markets, and the market relationship is complex, and multi-angle analysis is required to deeply understand its change law. In addition, when analyzing the relationship between agricultural futures market and spot market, it is merely a qualitative study and does not comprehensively discuss the transmission of return and volatility in the price.

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3. Study Design

3.1. Data Source and Data Processing

This paper selects daily data of wheat spot price and futures price from Jan 5, 2015 to Dec 31, 2019 (excluding non-trading day prices). The data is from Choice Financial Terminal software. Among them, China's wheat futures data comes from the Dalian Commodity Exchange futures contract price, and the U.S. wheat futures are from the Chicago Board of Trade (CBOT) data, to avoid the non-stationarity of the price series, the data is logarithmzed and processed by first-order differentiation to obtain the logarithmic price and logarithmic yield of Sino-US wheat futures spot, as shown in the following formula:

$$P_t' = \ln(1 + P_t) \quad (1)$$

$$R_t = \ln(1 + P_t) - \ln(1 + P_{t-1}) \quad (2)$$

3.2. Root of Unity Test (ADF)

Before performing time series modeling analysis, it is necessary to test the sequence stationarity, otherwise pseudo regression will mislead the research results. The unit root test methods to judge whether the sequence is stationary, and this paper uses ADF test method to test the stationarity of the sequence. Based on the result conducted by ADF in Stata, Table 1 shows the p-value of the logarithmic price and logarithmic price return of Sino-US wheat spot futures, which finds that the p-value of the logarithmic yield of Chinese and American wheat futures and spot price is 0.000. Based on this result, it is sufficient to deny that the variable has a unit root, and the data series for spot and futures logarithmic price yield in China and the United States are stable, so it is statistically significant.

Table 1: Stationary Test.

	t	P
Spot goods, Ln price		
China	-1.785	0.7119
US	-11.450	0.0000
Futures, Ln price		
China	-4.654	0.0008
US	-3.768	0.0183
Spot goods, Return		
China	-12.443	0.0000
US	-38.331	0.0000
Futures, Return		
China	-24.149	0.0000
US	-23.419	0.0000

3.3. VAR Model

To illustrate the price transmission relationship between the spot and the futures market, this paper constructs VAR model for wheat futures and spot price logarithmic yield in China and the United States. In the model, there are two separate time series variables, represented by s_t, p_t, resulting in a triradiate VAR(p) model.

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$$s_t = \alpha_1 + \emptyset_{11}s_{t-1} + \cdots \emptyset_{1p}s_{t-p} + \beta_{11}f_{t-1} + \cdots + \beta_{1p}f_{t-p,} + e_{1t} \quad (1)$$

$$f_t = \alpha_2 + \emptyset_{21}s_{t-1} + \cdots + \emptyset_{2p}s_{t-p} + \beta_{21}f_{t-1} + \cdots \beta_{2p}f_{t-p} + e_{2t} \quad (2)$$

$$\begin{bmatrix} s_t \\ f_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \begin{bmatrix} \emptyset_{11} & \dots & \emptyset_{1p} \\ \emptyset_{21} & \dots & \emptyset_{2p} \end{bmatrix} \begin{bmatrix} s_{t-1} \\ \vdots \\ s_{t-p} \end{bmatrix} + \begin{bmatrix} \beta_{11} & \dots & \beta_{1p} \\ \beta_{21} & \dots & \beta_{2p} \end{bmatrix} \begin{bmatrix} f_{t-1} \\ \vdots \\ f_{t-p} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} \quad (3)$$

In this article, s_t and f_t represent spot prices and futures prices respectively, and the latter is its equivalent matrix form. To clarify, in the first equation, $\alpha_1 + \emptyset_{11}s_{t-1} + \cdots \emptyset_{1p}s_{t-p}$ represents a linear function of past lags of spot price, while $\beta_{11}f_{t-1} + \cdots + \beta_{1p}f_{t-p} + e_{1t}$ represents past lags of future price, e_{1t} is the error term. As a result, the variable spot price return is modelled using historical values of the variable and the other variable. Similarly, the structure of the equation for the future price is the same, but the variable on the left of the equation and coefficients are changed.

Then, through Stata statistical software, four pulse images are obtained by using the logarithmic return of futures and the logarithmic return of spot price as pulse variables and response variables in the Chinese and American markets.

3.4. ARMA-GARCHX Model

The ARMA-GARCHX model can assess the returns and volatility of wheat spot and futures prices. This article divides this model into two parts: ARMA and GARCH.

$$r_t = \emptyset_0 + \sum_{i=1}^{p} \emptyset_i r_{t-i} + \varepsilon_t - \sum_{i=1}^{q} \theta_i\, \varepsilon_{t-i} \quad (4)$$

The formula above shows the general expression of the ARMA model, where AR(p) represents the $\emptyset_0 + \sum_{i=1}^{p} \emptyset_i r_{t-i}$ part of the formula, and MA(q) represents the $\varepsilon_t - \sum_{i=1}^{q} \theta_i\, \varepsilon_{t-i}$ part of the formula. AR(p) historical rate of return data makes predictions for the future, while MA(q) makes predictions using error terms.

The volatility σ_t^2 of the ARCH model is only related to the hysteresis term of the white noise sequence ε_t^2, while the GARCH model thinks that the volatility of each time point variable of the time series is a linear addition of the squares of the residuals of the last p time points, and then added to the linear addition of the fluctuations of the last q time point variables:

$$\sigma_t^2 = a_0 + \sum_{i=1}^{p} a_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} b_j \sigma_{t-j}^2,\ \varepsilon_t = \sigma_t \mu_t \quad (5)$$

And $\{\mu_t\}$ is a sequence of independent homogeneous random variables with a mean of 0 and a variance of 1, GARCH (1,1) is equivalent to the infinite-order ARCH model, and low-order models such as GARCH (2,1), GARCH (1,2) etc. are often used for research. In this paper, GARCH (1,1) is used for estimation, and the formula is shown as follows:

$$\sigma_t^2 = a_{0,1} + a_1\varepsilon_{t-1}^2 + \beta_t m_t + b_1\sigma_{t-1}^2 \quad (6)$$

In the formula above, $a_1\varepsilon_{t-1}^2$ represents the ARCH part, $b_1\sigma_{t-1}^2$ represents the ARCH part, and $\beta_t m_t$ represents additional explanatory variables in the model in addition to the generalized formula.

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4. Empirical Results and Analysis

4.1. VAR Ordering

To find out the optimal lag order for a VAR model, the LR statistic and other information criterion of each lag should be assessed. An asterisk sign (*) appears after the data to signify the desired lag order.

Table 2: Order Identification, CN.

Lag	LL	LR	p	FPE	AIC	HQIC	SBIC
0	6866.47			2e-09	-14.3608	-14.3569	-14.3506
1	7033.72	334.51	0.000	1.4e-09	-14.7023	-14.6907	-14.6718
2	7051.41	35.39	0.000	1.4e-09	-14.731	-14.7116	-14.6801*
3	7059.6	16.369	0.003	1.4e-09	-14.7397	-14.7126*	-14.6685
4	7062.4	5.5951	0.231	1.4e-09	-14.7372	-14.7024	-14.6457
5	7066.09	7.3825	0.117	1.4e-09	-14.7366	-14.694	-14.6247
6	7070.52	8.8665	0.065	1.4e-09	-14.7375	-14.6871	-14.6052
7	7072.69	4.3382	0.362	1.4e-09	-14.7337	-14.6755	-14.5811
8	7076.9	8.4209	0.077	1.4e-09	-14.7341	-14.6682	-14.5612
9	7096.58	39.362	0.000	1.3e-09	-14.7669	-14.6933	-14.5736
10	7105.22	17.284	0.002	1.3e-09	-14.7766	-14.6952	-14.563
11	7111.4	12.352	0.015	1.3e-09	-14.7812	-14.692	-14.5472
12	7121.05	19.293*	0.001	1.3e-09*	-14.793*	-14.6961	-14.5387

Table 2 reveals that lags 12, 3, and 2 all have that sign. A comparison of AIC differences is necessary to determine the optimal lag order. The difference in AICs between lags 12 and 11 is around 0.01, while the difference between lags 2 and 3 is approximately 0.0087. As a result, lag 2 is the better option to start with. Furthermore, even though both FPE and AIC with an asterisk sign are smallest for lag 12, HQIC and SBIC suggesting other alternative orders, the present optimal lag order for VAR model should be 3.

Table 3: Order identification, US.

Lag	LL	LR	p	FPE	AIC	HQIC	SBIC
0	3613.07			2.8e-6	-7.11541	--7.11173	-7.10571
1	3753.38	280.63	0.000	2.1e-6	-7.38401	-7.37295	-7.35491
2	3807.84	108.91	0.000	1.9e-6	-7.48342	-7.465	-7.43492
3	3840.71	65.739	0.000	1.8e-6	-7.54031	-7.51452	-7.47241
4	3858.7	35.992	0.000	1.8e-6	-7.56789	-7.53473	-7.48059*
5	3870.76	24.124	0.000	1.7e-6	-7.58337	-7.54325	-7.47707
6	3883.55	25.567	0.000	1.7e-6	-7.60108	-7.55319*	-7.47498
7	3891.12	15.143	0.004	1.7e-6	-7.60812	-7.55286	-7.46262
8	3895.58	8.9253	0.063	1.7e-6	-7.60903	-7.5464	-7.44413
9	3899.29	7.4235	0.115	1.7e-6	-7.60846	-7.53847	-7.42417
10	3904.54	10.482*	0.033	1.7e-6	-7.61091*	-7.53354	-7.40721
11	3906.59	4.1019	0.392	1.7e-6	-7.60707	-7.52234	-7.38397
12	3908.18	3.1924	0.526	1.7e-6	-7.60233	-7.51023	-7.35983

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Similarly, Table 3 reveals that lags 10, 6, and 4 all have that sign. The difference in AICs between lags 12 and 11 is around 0.002, while the difference between lags 4 and 5 is approximately 0.01. As a result, lag 4 is the better option to start with. Furthermore, even though both FPE and AIC with an asterisk sign are smallest for lag 4, HQIC and SBIC suggesting other alternative orders, the present optimal lag order for VAR model should be 4.

Following the specification of the VAR model's order, it is crucial to test the stability of the VAR model. The impulse-response function will not converge to zero, unless the VAR model is stationary. In the empirical testing of this paper, the model's applicability is determined by the unit root test and sketching a unit circle with the roots. All the roots are clearly within the circle in Figure 1, indicating that there is no longer a need to reestimate lag order, so VAR (3) and the binary VAR (4) are both efficient models.

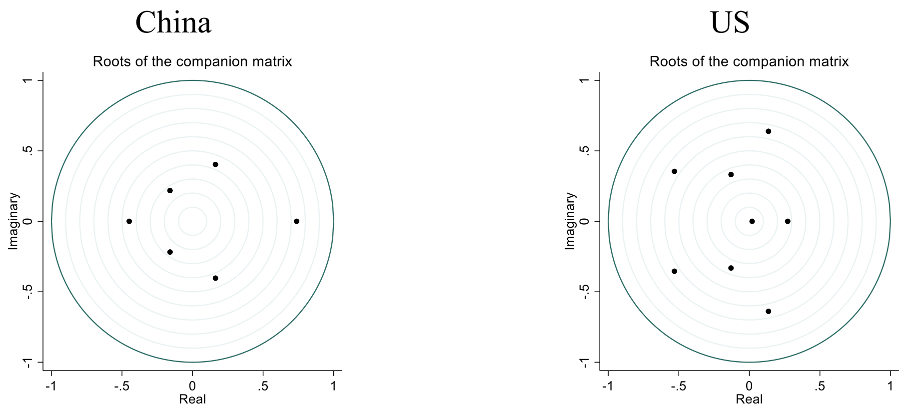

Figure 1: Unit root test.

Photo credit: Original

4.2. Impulse Response

This paper studies the pulse variables of spot and futures price logarithmic yields in the Chinese and American markets, respectively, to observe the response degree of another price in the country. Early research on China's cotton market also adopted the impulse response function analysis method and found that the cotton futures price responded to the cotton spot price more prominently, but the response is still limited. However, the cotton spot market price has a weak response to the cotton futures market price, and the one-way guidance of cotton futures price is obtained [5]. The impulse response results for both countries are shown in Figure 2.

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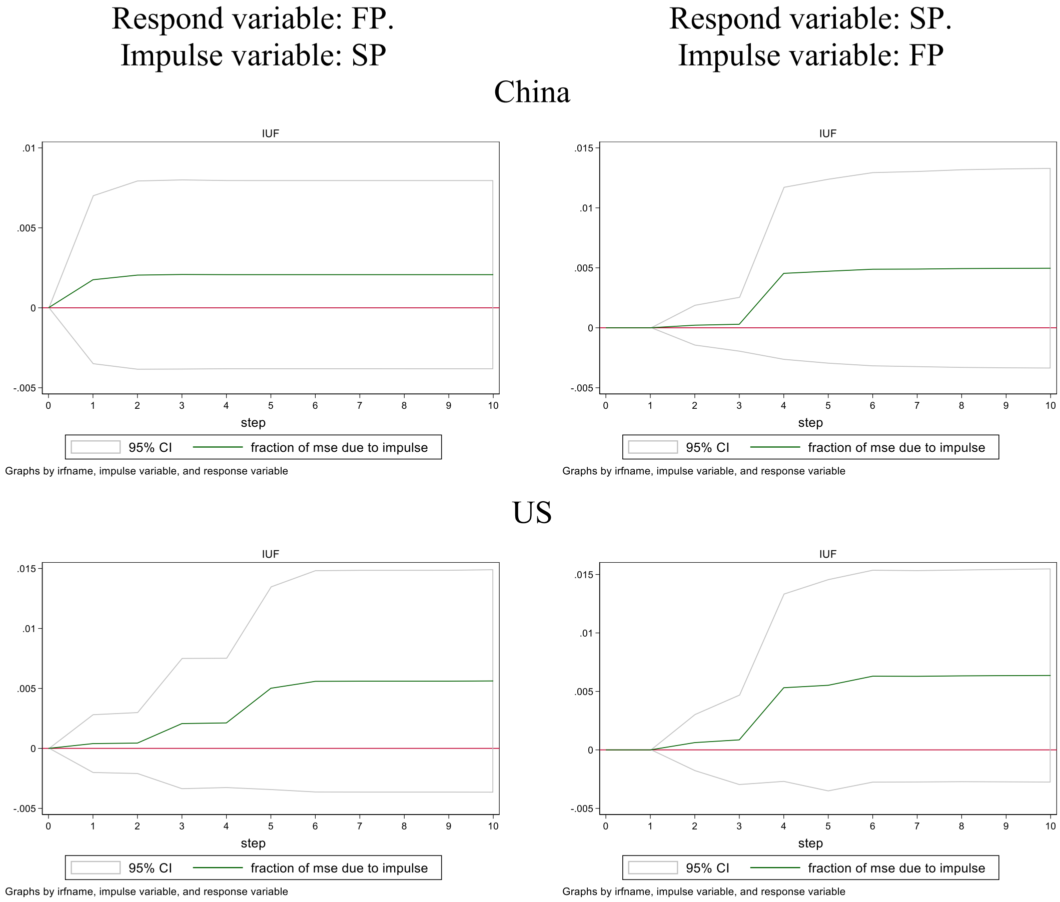

Figure 2: Cumulative response.

Photo credit: Original

The first half of Figure 2 shows the impulse-response results of the logarithmic yield of Chinese wheat spot price and futures price. As shown in the first two pulse plots of Figure 2, When the logarithmic yield of Chinese wheat futures is hit by the logarithmic price yield of China wheat spot, Chinese wheat futures logarithmic price yield reacts immediately and quickly has the greatest positive impact at t=2, The increase was around 0.2% and remained stable at a later time – at a maximum of around 0.2%. When the wheat spot logarithmic price yield is impacted by the futures price yield, it will have a positive impact on the response variable wheat spot logarithmic price yield in the lag period of 3 periods (t=3), Approaching the peak of the degree of reaction at t=4, the logarithmic yield increases by around 0.5% and maintains this value until period 10. From the empirical outcome of impulse-response, the impact of Chinese wheat futures market on spot prices more significant and noticeable compared to the opposite, with an average difference of about 0.3%, indicating that the futures price is more influential than Chinese wheat spot price. However, the efficiency of price transmission of the futures market is lower than that of the spot market, which confirms the conclusion of Chen Shuangsheng and Zhao Cong's research on Chinese wheat market that wheat futures prices have a guiding effect on wheat spot prices, however, if the long lag period is selected for analysis, this guiding effect is found to be not noticeable, indicating that the function of wheat futures price discovery needs to be strengthened [6]. Combined with the conclusion of early research, the minimum margin ratio, spot price fluctuations and delivery fees of futures trading have significant indirect effects on the price discovery ability of the futures market by affecting the activity of contract trading [7]. This paper found that the degree of spot price volatility during the same period is small, resulting

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in less attractiveness and less trading activity of wheat futures and fewer market investors participating in wheat futures trading, which makes the transmission of new information in the market less efficient, resulting in weaker price discovery ability.

The second half of Figure 2 shows an impulse response plot of the logarithmic yield of US wheat spot price and the futures price. As shown in the last two pulse plots of Figure 2, when the US wheat futures price series is hit by one standard deviation information from the spot price, the current period begins to produce a weak reaction. It began to have a significantly positive effect on the futures price in lag 2 period, with an upward amplitude of 0.2% in the second period, and a gradual upward trend from t=2 to t=5 periods, approaching the peak of the response in the 5th period, reaching a level of about 0.5%, and maintaining this level until the 10th period. When the US soybean spot price series is hit by one standard deviation information from the logarithmic yield of futures prices, it begins to react weakly at t=1 period, increasing by about 0.05%, and begins to have a significant positive effect on spot logarithmic price yield in lag period 3, and reaches a peak of response at about 0.5% at t=6 period. However, the price transmission efficiency of the wheat futures market is a little lower than spot market, Confirms the results of Shao Yongtong and Gao Wangsheng's research that when the market information share is stable, in the long-term changes in the US wheat futures and spot prices, the information share of the spot market is nearly 66.17%, while the information share of the futures market is about 33.83% [8]. This shows that U.S. wheat futures and spot prices are much less affected by the futures market than by the spot marke, consistent with the findings of this paper.

Combining the impulse-response charts of China and the United States, this paper shows that the price transmission efficiency of the US spot market is more significant than Chinese spot market, and the performance of futures market is slightly stronger than Chinese futures market. It means that the U.S. futures and spot market are more mature and efficient. In Shao Yongtong's research on Chinese and American soybean market, the empirical results through impulse response also show that the U.S. soybean market has a better price discovery function [9].

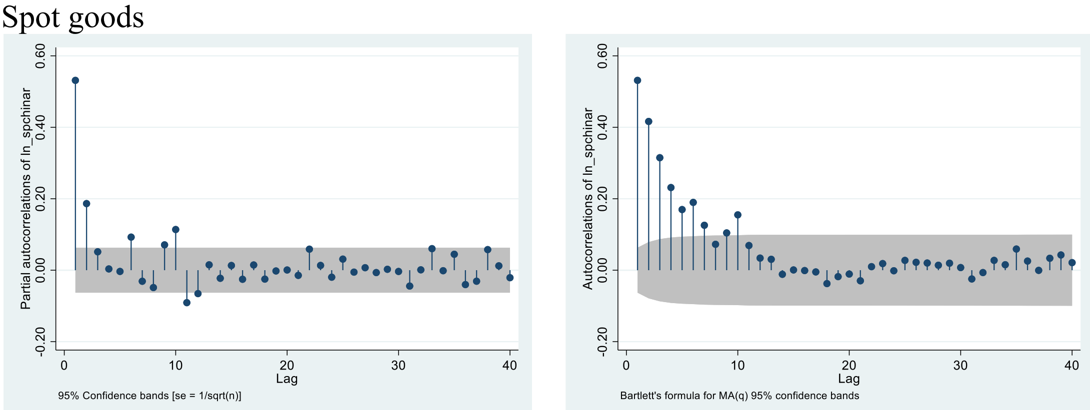
4.3. ARMA Ordering.

Considering the order of the price return in logarithm, PACF and ACF can be used to determine the lag orders for AR(p) and MA(q). Figure 3 shows that Chinese spot can be ordered using p=2 and q=2 while Chinese futures can be ordered using p=3 and q=3; The US spot market can be ordered using p=1 and q=1 while the US futures market can be ordered using p=6 and q=6.

PACF ACF

China

Spot goods



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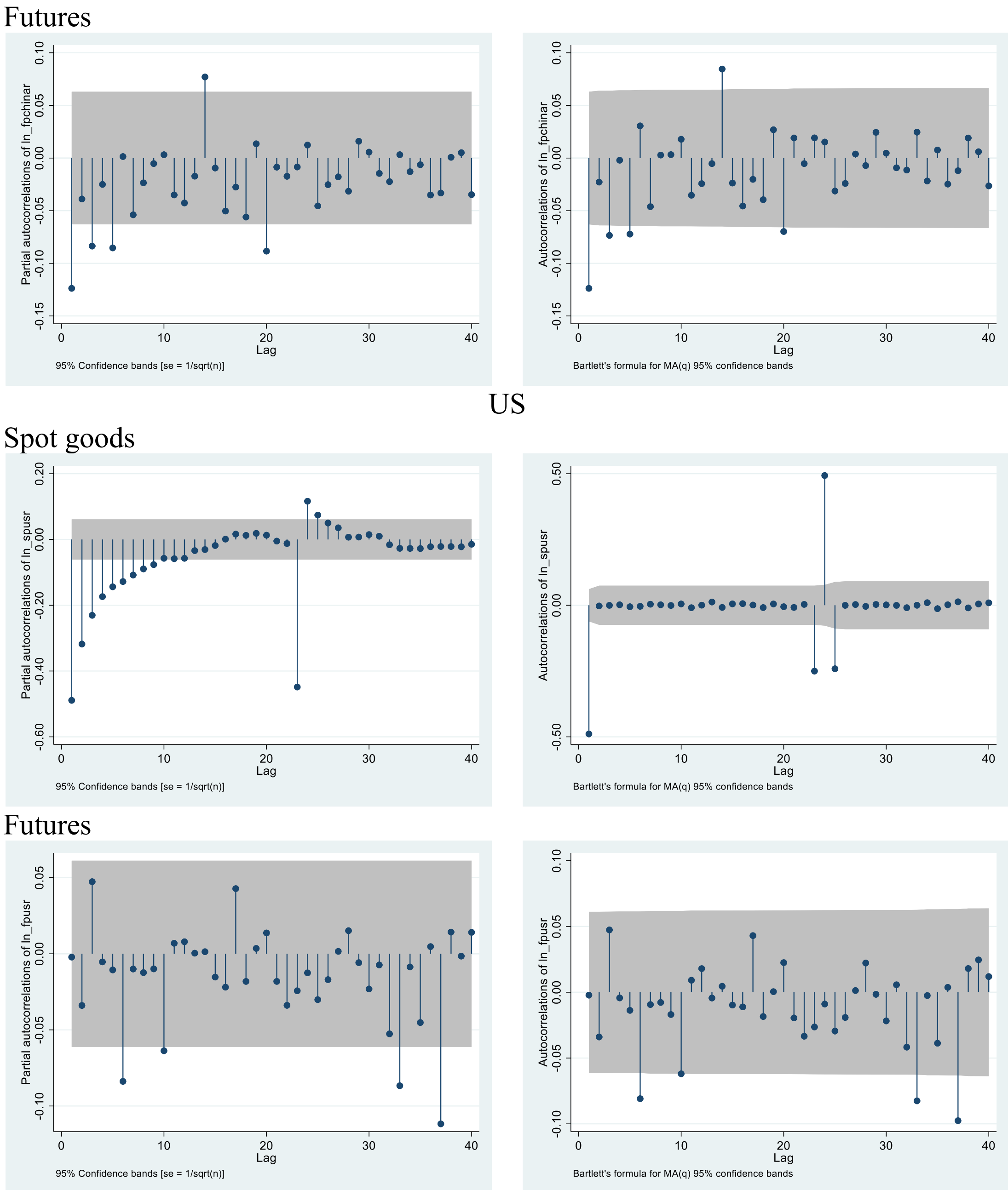

Figure 3: ARMA (p, q) identification.

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4.4. ARMA-GARCHX Estimates

As described in Section 3.4.2, implementing GARCH (1,1) is adequate to capture volatility clustering in time series, hence the ARMA-GARCH model was built. In the ARMA(p,q)-GARCH model: the ARMA-mean equation controls the autocorrelation of returns and the effect of past perturbations on yields, and the GARCH-X variance equation further indicates the effect of external explanatory variables on volatility.

Table 4 contains the model estimation findings as well as the variance equation. The ARCH and GARCH terms in the variance equation both have p-values less than 0.05, showing that they are significant. The presence of conditional heteroskedasticity fulfils the principal requirement of GARCH model building, implying that both futures and spot price return have significant conditional heteroskedasticity. At the same time, in the Chinese and American market, the value of FP, sigma-sq is over 0 with the high significance level, indicating that the change of futures price will have a significant positive impact on the volatility of spot logarithmic yield. At the same time, it is also found that the Chinese SP, sigma-sq coefficient is less than 0, while in the United States this value is not significant, indicating that spot price volatility will not have a significant positive effect on the volatility of the futures price logarithmic yield. The results show that the price transmission of the futures market contains the volatility conduction, so the price information can be fully reflected on the spot price.

Table 4: Regression results.

Variables	China		US	
	(1)	(2)	(3)	(4)
	SP	FP	SP	FP
FP, sigma-sq	2.913152		667.5152	
	0.000		0.000	
SP, sigma-sq		-7587.844		0.0023391
		0.000		0.969
ARCH (-1)	0.2789915	0.3011363	3.874973	0.0757797
	0.000	0.000	0.000	0.000
GARCH (-1)	0.7654306	0.7252605	.2506132	0.8566458
	0.000	0.000	0.000	0.000

5. Discussion

Beyond the wheat market and even the commodity market, there is a similar price transmission relationship in the stock market and the foreign exchange market [10]. Even individual commodities, different types of assets have a linkage and transmission relationship, such as the international gold market and the crude oil market, as people often say that the price of crude oil is a barometer of gold prices [11].It is beneficial to our understanding of the price transmission model in the entire financial market and also important for market investors to select portfolios and design hedging strategies to achieve the purpose of risk hedging and risk reduction to comprehensively consider these factors when making investment decisions.

The study is limited to wheat spot and futures market in two countries. As wheat is an important crop traded across the world, any unexpected changes in the global demand and supply position may affect the price. Any change in import and export policies and commodities trading may bring changes to the market environment and thereby affect the results, but do not separate the effects of these factors.

Further studies may be conducted to examine the price discovery functions and volatility transmission between the domestic and foreign market. The price transmission of wheat is interpreted by using statistical and econometric models. Further studies can be done using sophisticated analytical models to improve the accuracy.

6. Conclusion

This paper explores the difference between the price conduction of the wheat spot and futures market in China and the U.S., using VAR to conduct qualitative research on the price guiding relationship between the spot and futures market of China and the United States, and ARMA-GARCH to study the volatility transmission between market prices. The results show that the prices of the futures market and the spot market guide each other both in China and the United States, and the price transmission capacity and efficiency of the American spot and futures market are better than Chinese, and the performance of the futures market of two countries for volatility transmission is better than that of the spot market through the GARCH model, meaning that the price transmission and price discovery function of the futures market are better.

The results found in this paper show that China's futures market has certain price transmission capabilities, but not mature, and there is still a certain gap with developed countries. So, it is necessary to continually deepen the reform of the futures market and improve its price discovery ability. To improve the efficiency of resource allocation and better integrate with the international futures market, investors must continue to optimize the domestic futures trading rules, strive to resolve the obstacles in the system and mechanism, attract more domestic and foreign financial and industrial traders to participate in the Chinese futures market, and enhance the price discovery capability and international influence of Chinese futures market. When excessive speculation in the futures market affects the function of price discovery, relevant departments should strengthen research, fully understand the root cause of the problem, implement precise policies, and try to adopt indirect means to affect market expectations and curb speculative bubbles.

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