# Validity Test of Hedging of Chinese Live Pigs Futures

## Analysis of Variance of Portfolio Based on Optimal Hedging Ratio

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**Abstract.** In January 2021, live pig futures will be officially listed on China's Dalian Commodity Exchange, aiming to reduce the price volatility risk of the pig industry and its related upstream and downstream enterprises. In order to examine the hog futures market since the extent of the transfer price risk function, the use of the live pig 2109 China dalian Commodity Exchange futures settlement price and wholesale price 20 provinces pigs data, using the mature of error correction model (ECM) to determine the pig the optimal hedging ratio of futures hedging transactions, Ederington's method was used to quantify the effectiveness of pig futures hedging by using the variance of unhedged transactions and the percentage of variance change after hedged transactions. The results show that the price risk transfer ability of Chinese pig futures market is weak, and the effectiveness of price discovery, the consistency of the combination of the future and the present, and the ability to avoid the pig cycle are still important factors affecting the hedging efficiency.

**Keywords:** Pig futures · Hedging · Transfer price risk · Optimal hedging ratio

## 1 Introduction

Transfer of spot price volatility risk is one of the important functions of futures market, and also the basis of the existence of futures market. The risk transfer function of futures contract is realized through futures hedging transaction. As the latest listed futures variety of Dalian Futures Commodity Exchange, live pig futures bear people's ardent expectation for transferring the risk of pork price and smoothing the pig cycle. After the pig futures listing, there are also a number of pork breeding giants including Makihara stock announced to transfer price risk through the pig futures market. So in the live pig futures listed six months later, its price discovery and risk transfer function has been effectively reflected? Can hedging of pigs effectively control the risk during this period? Based on the above problems, our research aims to test the effectiveness of pig futures hedging and provide theoretical support for upstream and downstream pig enterprises, investors and policy makers. Due to the impact of African Swine fever (ASF) and COVID-19, the current live pig spot price is highly volatile, and upstream and downstream enterprises of live pig products and financial institutions are facing significant investment and price risks. Our study provides valuable suggestions for related parties on the selection of pig varieties for controlling price risks.


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## 2 Literature Review

### 2.1 Hedging Ratio Theory

As one of the basic functions of futures market, transferring the price risk of spot market can be used by upstream and downstream companies to hedge the price risk that the future spot price will change in a direction that is not conducive to the company's operation. Therefore, futures hedging ratio has become an important embodiment of the effectiveness of futures market on the real economy. The research on the strategy of intertemporal hedging has always been the focus of the research on the intertemporal trading of futures market. Holbrook Working made a systematic exposition of the trading strategy of using futures for inter-period hedging, and discussed the significance of this strategy for the first time [1].

However, the time span of hedging, the choice of entry point and the pressure effect of hedging have always been difficult points in the theory of hedging. Ronald W. Anderson and Jean-Pierre Danthine provided a theoretical model for multi-period futures hedging, which provides a theoretical basis for the selection of hedging time span [2]. On the other hand, Roon, Jijman & Veld studied the hedging pressure effect of futures market, which provided a powerful development for the discovery and prediction of futures prices [3]. At the same time, as a supplement, Lapan & Moschini, under the assumption of CRRA utility function, for the first time took the enterprise as the first subject of futures cross-hedging transactions, and studied the decision and choice of an enterprise using futures for risk hedging from the first perspective of the enterprise subject [4]. It provides guidance for enterprise futures market's intertemporal trading decision.

### 2.2 Theory of Optimal Hedging Ratio

The main theoretical problem of futures optimal hedging ratio is to determine the optimal hedging ratio. Because of the widespread base risk in the futures market, there is great uncertainty in the proportion between the futures trading position and the spot trading position used for hedging in the actual hedging operation, and the optimal ratio should be determined according to the analysis and judgment of the correlation between the price changes of the two. That is, the optimal hedging ratio of futures is the key to realize the intertemporal trading of a company.

Ederington argue that when the hedge portfolio variance minimized, then the portfolio of the interest rate is the optimal ratio, this theory is based on pure risk aversion perspective, it is completely don't care about the size of the portfolio expected return (mean), that the only goal of hedging is to reduce risk as soon as possible [5]. However, when futures prices do not belong to martingale process, such pure variance inference is not consistent with reality. Still, this calculation is one of the most widely used hedging strategies.

In order to improve the deficiency of Ederington's strategy, many researchers try to establish a "mean-variance" framework to obtain the objective function, but to make them consistent with the expected utility maximization principle, either the utility function is quadratic, or the return should be common normal. If neither of these assumptions is true, then the hedging ratio may not be the optimal expected utility maximization principle.

Some researchers, such as Cecchetti and Lence, have solved this problem by deriving the optimal hedging ratio based on expected utility maximization, but this method still needs to use a specific utility function and a specific income distribution [6].

Other researchers have attempted to eliminate these specific assumptions about utility functions and return distributions, such as Chen, Lee & Shrestha et al. [7]. Some of these involve minimization of the mean-spread Gini coefficient (MEG), which is also consistent with stochastic control theory.

Most of the studies mentioned above ignore transaction costs and other portfolio investments. Ditsch obtained the optimal hedging ratio when the transaction cost and investment in other securities were included in the model. He used CARA utility function to find that under certain circumstances, the optimal hedging ratio is zero, that is, the optimal hedging strategy is no hedging [8].

### 2.3 Research on the Dynamics of Optimal Hedging Ratio in Empirical Study

In addition to using different objective function theories to derive the optimal hedging ratio, previous studies also discussed the dynamics of hedging ratio. In the early research literature, it was generally assumed that the optimal hedging ratio was invariant over time. For example, Ederington estimated the static hedging ratio by using the unconditional probability distribution [5].

At present, many methods have been found to estimate the optimal hedging ratio in empirical studies. But most used ordinary least squares (OLS); However, Myers and Thompson found that simple regression of price level or return would lead to error in the estimation of optimal hedging ratio, but simple regression of price difference could provide reasonable and accurate estimation and eliminate the influence of autocorrelation of time series [9]. In order to further consider the influence of the co-integration relationship between the time series data of futures price and spot price on the determination of the optimal hedging ratio, Marvin proposed an error correction model (ECM) for estimating the optimal hedging ratio by considering the non-stationary and long-term equilibrium relationship between futures price and spot price [10].

### 2.4 Domestic Empirical Research on Optimal Hedging Ratio

With the development of reform and opening up, Zhengzhou Grain Wholesale Market was officially established in October 1990 with the approval of The State Council, marking the birth of China's commodity futures market. In recent years, the futures market has been increasingly used in the operation of Chinese companies, and the hedging ratio has become a key indicator to study the effectiveness of domestic companies' operation in the use of futures to achieve intertemporal trading.

In the past 30 years of continuous exploration and development, China's futures market has the traditional characteristics of the western futures market, but also with strong Chinese characteristics. In order to realize the Sinicization of hedging theory in futures market, Peng Hongfeng and Ye Yonggang developed a modified ECM-GARCH model based on the existing model by combining the characteristics of Chinese market [11]. Qu Xiaobo, Huo Xuexi and Cheng Jintao studied the determination of futures hedging ratio based on risk minimization and made an empirical supplement to this

model [12]. Hua Renhai and Zhong Junwei put forward a theoretical review on the hedging theory of futures market based on the characteristics and current situation of Chinese market [13].

China's academic circles generally hold a negative attitude towards the crude and simple application of the most international hedging theory in China's futures market. For different futures types of market segments, Chinese academic circles have distinguished different futures types by industry and cycle, and compared them with empirical studies on international futures markets. For example, Zhang Yishan, Fang Yi and Huang Kun conducted an empirical study on the functions and international influence of China's futures market, and found that China's futures market played a basic function in reality, but there were still great deficiencies in agricultural futures market [14]. The international futures market had a one-way influence on the price of the domestic futures market. Domestic futures markets have also long been less efficient than international futures markets. Yan Yunxian and Zhang Yuejie analyzed the hedging effectiveness of China's corn futures market [15], and Zhou Xizhi made an empirical analysis on the hedging performance of China's copper futures market, all of which provided reference and guidance for the analysis of live pig futures in the following paper [16]. This paper innovatively includes the latest listed futures variety pig futures into the empirical research category of China's futures hedging theory, which complements and improves the development of China's futures hedging theory in market segments.

### 2.5 Development of Hedging Theory of Hog Futures at Home and Abroad

In 1964, the Chicago Mercantile Exchange for the first time launched the live pig futures contract, opened the prelude to the development of live pig futures. Early research on pig futures focused on the dynamic response and transmission mechanism of pig futures prices and market changes. Steve Miller studied the reaction of the price of live pig futures to changes in market information [17]. Based on traditional theories, Coiling & Irwin found that live pig futures prices could effectively support efficient market hypothesis [18]. Schroeder & Goodwin studied the price discovery process of hog futures and the co-integration relationship of hog futures [19]. Ditsch & Leuthold evaluated the possibility of using live pig futures for intertemporal hedging and gave a positive estimate [8]. Hayenga & DiPietre proposed a series of strategies to use live pig futures for inter-period hedging, which provided reference for the development of domestic live pig futures hedging theory [20].

Since January 8, 2021, China's live pig futures will be listed and traded. Because the listing time is not long, the development of China's live pig futures is still in the initial stage. At present, there are few results of theoretical or empirical researches on live pig futures in China, and most of them focus on the impact of the listing of live pig futures on the live pig industry, and a few of them involve the relationship between the change of live pig futures price and the change of live pig spot price and the transmission mechanism. For example, Wang Yi studied how to use pig futures to avoid the risk of pig price fluctuations in the spot market and pointed out that the price discovery function of futures can be used to price the spot pig market [21]. Song Jue xia on the mode of our country "insurance + futures" hog price insurance research, found in this mode the expected price is based on the futures market, the actual price is based on the spot

market directly, which will be borne by the farmers themselves originally the basis of risk transfer to the insurance company, at the same time the insurance company has kept the corresponding more profitable opportunities [22]. Li Qiang introduced the application of hedging in the pig industry for the first time, pointing out that hedging by futures can effectively maintain the stability of the pig industry, providing guidance and reference for the localization of the optimal hedging theory of pig futures in China [23]. In contrast, this paper adopts the modified ECM model developed by Peng and Ye based on the existing model, combining the characteristics of The Chinese market, so as to more effectively enrich and develop the empirical research on the effectiveness of pig futures hedging in China [11].

In the futures market segment, the industry cycle and product cycle of different futures are the key factors affecting the effectiveness of the futures hedging. For example, The Yang's research on pig futures in China has paid much attention to the pig cycle, from the point of view of microeconomic analysis the hog futures market, futures will help ease the original theoretical analysis found that pigs pigs cycle caused by supply and demand, also let farming enterprises and farmers to hedging, reduce their economic pressure and reduce risk, stable their production yield, stability of the supply of live pigs, More consumers to provide a more stable hog price market [24]. Based on the "pig cycle" problem, Pang Jinbo et al. studied the characteristics and causes of China's pig price cycle fluctuations, and found that the "pig cycle" can be suppressed by using profit-sharing strategies [25]. And Zhu Huichun pointed out that the hog futures listed after the use of "insurance + futures" project of live pigs, pig futures "price discovery" and "risk off" two big functions gradually each main body, benefit the industry chain in promoting China's pig industry is protected for stabilizing price, and improve the mechanism of pig industry long-term steady development has played a positive role [26].

But at the same time, the industry research newspaper also pointed out that the current use of live pig futures to suppress the pig cycle of some difficulties, such as poor market atmosphere, lack of attractiveness to enterprises. As a key factor affecting the price of live pig futures, the pig cycle has an important impact on the effectiveness of hedging of live pig futures due to its own seasonal instability and the cyclic Lianlian al and seasonal uncertain changes of related industries in the upstream and downstream industry chain. This paper innovatively proposes to add the key factor, so as to develop the empirical research on the optimal hedging theory of hog futures in China.

## 3 Data Sources and Research Methods

### 3.1 Data Sources and Sample Selection

Hog futures price data from the dalian Commodity Exchange, in order to get a continuous sequence of hog futures, this study selected the most recent hog futures contract settlement price, at the same time in order to avoid a significant reduction of price volatility and trading volume effect, after the delivery month, select the nearest delivery month hog futures contract price. The live pig spot price is derived from the average wholesale price of pigs in 20 provinces of China, and the pig baring price of Dalian port is selected. The trading object is the same as the trading object of the live pig futures contract. The

delivery warehouse of the live pig futures contract is basically located in Dalian and its surrounding areas, so the live pig spot price in Dalian is relatively representative. A total of 1 315 sample data were selected from January 15, 2021 to June 11, 2021. In order to compare the effectiveness of hedging transactions of live pigs futures, the sample data in this study were divided into two parts: the data from January 15, 2021 to June 11, 2021 were set as in-sample data and used for prior inspection, with a total of 915 data; Data from January 15, 2021 to June 11, 2021 were set as out-of-sample data for post-test, with a total of 400.

### 3.2 Determination of Optimal Hedging Ratio - Error Correction (ECM) Model

Hedging transactions in principle is the futures market trading positions and spot market of trading positions as a portfolio, the proportion of these two trading positions is hedging ratio to test the effectiveness of hog futures hedging effectiveness must first find the highest optimal hedge portfolio, also is to determine an optimal hedging ratio. Traditional methods to determine this ratio include vector autoregression (VAR) model and traditional simple regression (OLS) model, but these models do not consider the influence of the co-integration relationship between futures price and spot price time series data on the determination of the optimal hedging ratio. Therefore, the ECM model will be used in this paper to estimate the best hedging ratio of futures prices and spot prices with co-integration based on Granger and Engle's two-step method:

$$S_t = C + \beta F_t + \mu_t \tag{1}$$

Where C, $\beta$ are the coefficients to be estimated, $\mu_t$ is the disturbance term, which is a white noise sequence with zero mean and constant variance.

The second step is to estimate the error correction model, which is expressed as follows:

$$\Delta S_t = \alpha \Delta F_t + \sum\nolimits_{i=1}^{m} \lambda_i \Delta S_{t-i} + \sum\nolimits_{j=1}^{n} \theta_j \Delta S_{t-i} + \omega \mu_{t-1} + \varepsilon_t \tag{2}$$

$\alpha, \lambda, \theta, \omega$ are the parameters to be estimated, $\mu_{t-1}$ is the residual sequence estimated at the first step, $\varepsilon_t$ is the disturbance term sequence of white noise, $\alpha$ is the optimal hedging ratio to be estimated. Test.

### 3.3 Evaluation Model of Hedging Effectiveness

After obtaining the optimal hedging ratio, we will use Ederington to give the index value to measure the effectiveness of hedging, that is, compared with the return variance without participating in hedging, the reduction degree of the return variance after participating in hedging can be used to judge the strength of the effectiveness of hedging, and its expression is as follows:

$$H_e = \frac{Var(U) - Var(H)}{Var(U)} \tag{3}$$

**Table 1.** ADF test of pig cash and futures prices.

| Item | Futures price | Cash price | 10%Critical | Stationarity |
|---|---|---|---|---|
| Level data | 0.786 | -0.694 | -2.630 | NO |
| First difference | -2.869 | -6.340 | -2.630 | YES |

where, the variance of returns not involved in hedging is

$$Var(U) = Var(\Delta S_t) \tag{4}$$

The return variance of participating in hedging is:

$$Var(H) = Var(\Delta S_t) + h^2 Var(\Delta F_t) - 2hCov(\Delta S_t, \Delta F_t) \tag{5}$$

It reflects the degree of risk reduction after hedging.

## 4 Empirical Analysis Results

### 4.1 ECM model Regression Results

Table 1 is the result of unit root test on the original sequence and first-order difference sequence of the futures price and spot price of live pigs. The ADF values of the original sequence of the spot price and futures price are both greater than 10% critical value, so the null hypothesis of the existence of unit root cannot be rejected. Therefore, the original sequence of the futures price and the spot price are non-stationary. However, the ADF values of the first-order difference of the live pig spot and futures price series are both less than 10% critical value, and the null hypothesis with unit root is rejected, that is, the series after the first-order difference is a stationary time series. Therefore, the pig spot price sequence and futures price sequence conform to the first order integration process.

Table 2 shows the co-integration test of futures and spot prices of live pigs. As can be seen from Table 2, under the assumption that the number of co-integration vectors is 0, the trace statistics of pig futures and spot price data is 25.239 51, > 10% critical value 15.494 71, and the null hypothesis that there is no co-integration relationship between pig futures and spot price is rejected. Under the null hypothesis that the number of co-integration vectors is at least 1, the trace statistics of pig futures and spot price data is 0.014435, < 10% critical value 3.8441 466, which indicates that there is at least one co-integration relationship between pig futures and spot price, and there is a long-term equilibrium relationship between them.

Through the regression analysis of the first order difference series of spot price and futures price, it is found that the residual series has obvious fluctuation aggregation characteristics, indicating that the residual series may have heteroscedasticity. Under the null hypothesis without ARCH effect, the ARCH effect test statistics can diagnose whether volatility agglomeration exists or whether asymptotically follows F distribution. Lagrange multiplier test of ARCH effect on residual sequence shows that, at the

**Table 2.** Cointegration test of pig cash and futures

| Null hypothesis | Eigenvalue | Trace statistics | 10%Critical | P Value |
|---|---|---|---|---|
| $r \leq 0$ | 0.56089 | -0.694 | 15.41 | NO |
| $r \leq 1$ | 0.07689 | -6.340 | -2.630 | YES |

significance level of 10%, the assumption of homoscedasticity of residual sequence is rejected, and the existence of high-order ARCH effect, namely GARCH effect, is proved. According to the effectiveness calculation, the estimated value of the best hedging ratio in THE ECM model is 0.83.

## 5 Discussion and Analysis of Results

According to the above empirical analysis results, the optimal hedging ratio of pig futures and spot is about 0.83, which is close to the theoretical value of 1, reflecting that the overall trend of current pig prices is relatively consistent. Using the optimal hedging ratio to hog futures hedging transactions, the price of the asset portfolio risk is reduced, but the reduction of only 6%, and Europe and the United States about 80% of the mature market risk aversion rate is a far cry from, enough to reflect the current pig risk transfer function of the futures market in China has not yet been fully made use of. Below, we analyze the possible reasons for the low hedging effectiveness of the live pigs futures market.

### 5.1 The Initial Contract Activity is Low, and the Price Discovery Mechanism Needs to be Improved

When China's futures market was established, it was made clear that it was for the purpose of serving the spot market. Many traders involved in futures trading in the exchange are spot market producers, processors, consumers, importers and exporters and speculators, who are very familiar with the commodities related to the spot market. The trading price formed by these people through bidding in the futures exchange can reflect the relationship between supply and demand in the commodity market. In addition, there are many commodity traders in the futures market, who have professional trading teams and rich sources of information. These are the basis for the price discovery function of futures markets.

However, the inactivity of the live pig futures contract has hindered the accurate operation of the price discovery mechanism in the futures market. As shown in the figure below, in the first three months after the opening of the live pig market, most of the data of trading volume and position of the futures contract did not meet the standard of active contract, which reflected that the market was still in a wait-and-see process for the live pig futures, which resulted in a slight shortage of market liquidity, thus affecting the fair degree of the live pig futures price. Thus, the correlation between futures and spot prices of live pigs is insufficient. In addition, major commodity traders

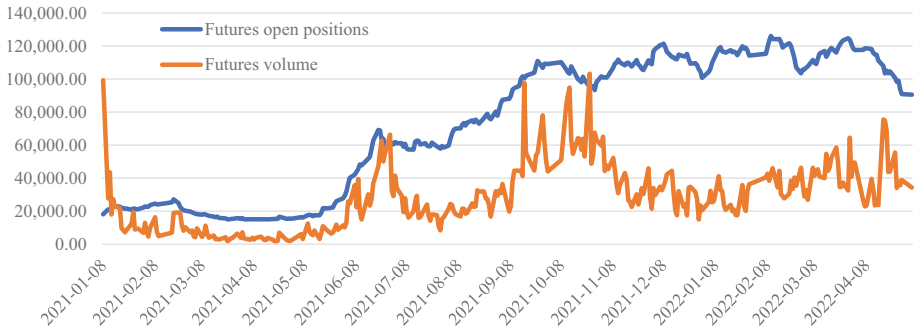


**Fig. 1.** Change chart of Trading Volume and Open Position of live pig futures (Unit: hands)

in the market generally showed a wait-and-see attitude in the initial stage of listing, leading to the relative fragmentation of the current market. In recent months, as the time of listing continues, the pig contract has attracted more and more attention, and the price discovery function of futures will be further strengthened, which is conducive to the pig futures to further play its role of risk transfer.

### 5.2 The Market Duration is Short and the Current Regression is not Significant

At present, it is less than half a year since the launch of the pig futures, and the nearest contract, Pig 2109, will not be delivered until September, making the current observable price only part of the normal hedging operation cycle. Can see from Fig. 1, the hog futures contracts since listing, the basis has experienced from the significant positive to the negative significantly, at the same time in recent months, affected by swine fever period price linkage down now, disk continue to premium logic, which not only further confirms hog futures market since the listing of fair value is still in a precarious situation, It also directly leads to the poor correlation between futures and spot price data, which is not conducive to the embodiment of the effectiveness of hedging. However, with the gradual entry of institutions and commodity enterprises, the live pig futures market will gradually move on the right track. If the market operates normally, the futures contract will return to the current price before delivery, which will enhance the negative correlation of the current price and thus improve the effectiveness of hedging. Therefore, if the hedging cycle is long enough to include at least one current regression, the resulting hedging effectiveness should be significantly improved.

### 5.3 The Existence of the "Pig Cycle" Makes Investors have Rational Expectations

Pork prices in China have long experienced cyclical fluctuations, known in the industry as the "pig cycle". The internal economic logic of the pig cycle is the price development track of "meat price rising -- pig supply increasing -- meat price falling -- pig supply decreasing -- meat price rising". A complete pig cycle usually lasts for 3 to 4 years, and each year will experience "small cycle". In the context of a significant "pig cycle", investors' expectations of the current futures price do not only depend on the spot price

of pigs, they are more concerned about the spot price of pigs in previous years in the months when the futures contract expires, because the latter can better reflect the cyclical relationship. Theoretically, the price sequence of live pigs spot is not Markovian, so the information contained in spot price cannot completely determine the future price trend, leading to rational expectations of investors, thus reducing the correlation of spot price. From the point of view of data analysis, the current pig market capacity continues to recover, supply amplification, coupled with the law of cyclical changes in pork, the market still maintains a near high and far low pattern, resulting in a great negative basis, so although this week's pig spot disk fell, but futures still maintain a high upside pattern.

## 6 Conclusion

In general, the conclusion of this study does reflect the lack of hedging effectiveness of the live pig futures market to some extent, and the limited ability of the futures to transfer price risks. On the one hand, this paper believes that the main factors affecting the effectiveness of pork futures hedging are short-term and easily adjusted factors. In terms of hedging demand with a long period, the reference significance of this study still needs further market observation. On the other hand, some regular and persistent factors, such as "pig cycle", may still limit the improvement of the overall effectiveness of pig futures hedging, which should be closely watched by the hijackers to guard against secondary risks. In the Chinese market, due to the above limitations of pig futures and the lack of hedging effectiveness, we will pay more attention to the hedging effect of soybean meal futures, the alternative of pig futures, in order to realize the risk hedging of pig spot varieties in the future.

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