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The Effect of Hog Futures in Stabilizing Hog Production

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Abstract: China's large-scale hog farmers are playing an increasingly important role in promoting the stable development of the hog industry. Taking large-scale hog enterprises as samples, based on hog sales data from January 2019 to July 2022, this paper adopts a two-way fixed-effects model to test the impact, mechanism, and heterogeneity of hog futures on the production stability of large-scale hog farmers. The study found that hog futures help promote stable production of large-scale farmers. This finding still holds after a series of robustness tests. The mechanism analysis found that, first, hog futures help large-scale farmers expand their risk management factor inputs. Second, hog futures help reduce the impact of hog price risk on production. Finally, hog futures help stabilize farmers' production expectations. The moderating effects analysis found that the stabilizing effect of hog futures will enhance as farmers' share of hog farming operations increases. Heterogeneity analysis found that when hog prices fluctuate negatively, hog futures help promote the stable production of large-scale farmers. When hog prices fluctuate positively, the production stabilization effect of hog futures is not obvious. Therefore, hog enterprises should be encouraged to participate in hog futures hedging transactions to promote stable hog production.

Keywords: hog futures; stable production; expand production; risk hedging; stable expectations

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1. Introduction

Pork is the second-most-consumed meat globally, following poultry [1–3]. According to the Food and Agriculture Organization of the United Nations (FAO), the total world pork production reached 109.85 million tons in 2022. China is the world's largest producer and consumer of pork [4]. In 2022, China's pork production reached 55.41 million tons, accounting for 50.44% of the world's pork production. In China, pork is the staple animal protein for Chinese households [5], and pork prices are a critical component of China's Consumer Price Index [4]. Sustainable development of the hog industry is critical for China's economic growth.

However, China's hog industry has a long-term problem of cyclical fluctuations in the hog market [6]. Since the beginning of the new century, China's hog industry has experienced five major cyclical price fluctuations, especially after China acceded to the WTO in 2006. The fluctuation of pork prices intensified [7], and the hog cycle damaged the welfare of both supply and demand, leading to the imbalance of national economic development and the asymmetry of output–input [8].

From a theoretical perspective, the relationship between hog production and price conforms to the spider web model [9], where hog price and hog production interact with each other. Ensuring stable hog production is one of the important ways to promote stable hog prices. In terms of practicality, since pork consumption is relatively stable and less responsive to short-term price changes, the market price of hogs and pork mainly depends on the supply side [4]. Stabilizing the supply of hogs is crucial for maintaining stable market prices. The Central Document No. 1 of the last few years has also repeatedly emphasized the need to promote stable hog production. Therefore, answering the question of how to promote production stabilization among farmers is of theoretical and practical significance.

Scholars have discussed ways to stabilize hog production from several angles. First, stabilizing hog production using large-scale farming. The research found that hog industry chain operators are generally more aware of the “hog cycle”, while retail farmers may have difficulty accessing timely market information, leading to production volatility [10]. Limited market information has also been found to result in biased market expectations among small-scale breeders, which can trigger market supply fluctuations [11]. Therefore, in recent years, China’s industrial policies have focused on guiding large-scale hog farming. However, large-scale farming only improves the risk tolerance of farmers and does not fundamentally diversify the risk of hog prices. Second, hog production is stabilized through contract farming. Contracts shift the producer’s hog profitability risk to the contractor [12], reducing the negative impact of price fluctuations on production. For example, in Brazil, a cooperative relationship is formed through production contracts to transfer hog price risk to slaughtering enterprises [13]. In China, the main form of farming contract is the “company + farmer” model [14]. Large-scale hog farming companies sign farming contracts with small-scale farmers, and when the contract expires, the small-scale farmers sell their hogs to the cooperative farming company according to the agreed price. Thus, the impact of hog price risk on hog farming is reduced through cooperative farming. However, contract farming is exposed to the risk of default [15]. The incompleteness of the contract exposes both parties to the transaction risk of ex-post costs. For instance, when the price is fixed in the contract, the market price will increase the producer’s risk from selling the product in the market (outside the contract), and vice versa [16]. Higher market prices may lead to contractual breaches [17], which usually arise when unexpected external environmental changes occur [18]. Finally, as futures can play the role of hedging price risk [19], developed countries, such as the United States, provide farmers with hog price risk management tools by offering hog futures contracts.

The impacts of large-scale hog farming are manifold. Firstly, large-scale farming has a positive side. Due to advantages such as information and management [20], large-scale farming can alleviate hog production fluctuations [21,22] and promote hog price stability [23]. Large-scale farms are more likely to adopt capital-intensive and knowledge-intensive sustainable manure management technologies [24]. Secondly, there are also negative impacts from large-scale hog farming. Large-scale hog farming raises concerns about environmental pollution [25] and can negatively affect environmental efficiency [26]. In addition, large-scale hog enterprises are more vulnerable to hog epidemics [27]. Despite the limitations of large-scale hog farming, we need to recognize its positive effects and take advantage of the favorable aspects of large-scale farming. For example, we should focus on the role of large-scale farming in promoting the stability of hog production.

From the existing research, it is not yet known that futures can play a role in stabilizing production for hog enterprises. Since hog price and hog production are consistent with the cobweb model [7,9], and they affect each other, we can discuss the role of the future in stabilizing hog production from the perspective of the impact of futures prices on the spot price. Combining the existing research, we found that scholars hold three views on whether futures can reduce spot price volatility. First, scholars believe that futures help stabilize spot price volatility. Research has found that the futures market has the function of price discovery [28]. Futures trading helps in the better allocation of commodities, thereby reducing the magnitude and frequency of price fluctuations [29,30]. Research has found that futures markets reduce the long-run variance of spot prices and improve the stability of the spot market based on rational expectations models [31]. The research found that the futures market stabilizes spot price volatility in the short and long run when consumption perturbations dominate [32]. Second, some scholars hold the opposing view that futures cannot stabilize spot price volatility and even exacerbate spot price volatility. Scholars believe that future market speculation can destabilize the spot market [29]. Due to the low cost and fast speed of futures trading, changes in future prices will be transmitted from the future market to the spot market in a short period of time [30], exacerbating spot price volatility [33]. Finally, it has also been argued that futures may both exacerbate and mitigate spot price volatility. Scholars believe that in the short term, speculation in the futures market may lead to distortions of spot price pairs, but in the long term, future speculation does not distort spot market prices [34]. Research has found that the impact of futures on spot prices depends on the degree of self-sufficiency, and when the self-sufficiency rate is low, the spot market is more susceptible to the impact of future speculative trading, which exacerbates the price volatility of the spot market [35]. Based on the relationship between hog production and price, the lack of clarity in the relationship between futures and spot prices leads to the difficulty of knowing whether the hog future can stabilize hog production.

In this article, we explore the role of the hog future in promoting stable production for large-scale farmers. Compared with existing studies, the marginal contributions of this paper are reflected in the following aspects: (1) In terms of research, stable hog production through organizational modes such as contracting and large-scale farming essentially belongs to risk sharing and risk bearing. This paper expands the risk management approach from the perspective of hedging risk. (2) In terms of the research object, promoting stable hog production through contract farming or large-scale farming is essentially providing risk protection for small-scale farmers. Large-scale farmers still face the problem of a lack of hog price risk management tools. This paper expands the risk protection object to the group of large-scale hog farming entities. (3) In terms of research content, this paper establishes the theoretical framework of hog future to promote stable hog production and tests the role of hog future in stabilizing production and its mechanisms.

2. Materials and Methods

2.1. Introduction of Hog Futures

In January 2021, the Dalian Commodity Exchange (http://www.dce.com.cn/dalianshangpin/sspz/sz/hyygz30/6264142/index.html (accessed on 14 February 2024)) commenced trading hog futures, which are denominated in RMB and traded in lots of 16 tons with the code LH. The minimum trading margin required for hog futures is 5% of the value of the futures contract. The trading months for hog futures are January, March, May, July, September, and November. To manage systemic risk, the Dalian Commodity Exchange has established a stop limit for hog futures at 4% of the settlement price of the previous trading day. Trading for hog futures is conducted during regular business hours from Monday to Friday, with two sessions per day from 9:00–11:30 in the morning and 13:30–15:00. Physical delivery is required for hog futures, and the Dalian Commodity Exchange has designated spot delivery warehouses for this purpose. Upon expiration of the hog futures contract, the counterparty is obligated to make physical delivery following the hog delivery quality standards (F/DCE LH001-2021) set forth by the Dalian Commodity Exchange.

2.2. Theoretical Framework

The cobweb model is a theoretical tool for analyzing the production behavior of farmers. It is theorized that farmers' overreaction to changes in hog prices is responsible for cyclical fluctuations in hog prices due to the low price elasticity of pork demand and the relatively high price elasticity of hog supply [7,9]. In the theoretical context of the cobweb model, farmers' breeding behavior is influenced by hog price fluctuations and farmers' expectations about hog price. Further, farmers' expectations about hog prices also depend on their information acquisition capacity [11]. Therefore, we can analyze the role of hog futures on the stability of hog production from three aspects: hog price volatility, hog price expectation, and the ability to obtain information about hog prices. Firstly, hog enterprises engaged in hedging transactions can hedge the risk of hog prices and stabilize hog production. Secondly, for enterprises not participating in futures trading, since the futures price is an unbiased estimation of the spot price [28], hog enterprises can predict the upcoming spot price of hogs based on the hog futures price [36] to guide hog production and reduce production fluctuations. Farmers' rational production behavior will in turn reduce the level of hog price volatility, thus stabilizing hog production expectations [34]. Finally, based on the function of hedging price risk and stabilizing price expectations of hog futures, hog enterprises can expand the scale of hog farming, which in turn forces farmers to expand information inputs, improve management levels, and stabilize hog production. Based on this, this paper proposes research Hypothesis 1:

H1: *Hog futures promote the stable production of hog enterprises.*

Hog futures help farmers expand their production and play an implicit role in stable hog production. It is argued that because small-scale farmers have information disadvantages, they always form price expectations based on social networks [36], and their farming behavior is characterized by frequent exits and re-entries [11]. On the contrary, large-scale farmers have advantages such as information and management [20], and their profitability [37] and risk management are sustainable. Therefore, large-scale farming contributes to stable hog production [20,38]. After the listing of hog futures, farmers can utilize hog futures to hedge their risks and promote the expansion of production scale. The expansion of the production scale will force farmers to expand the factor input of risk management, which further contributes to the stability of hog production. Based on this, this paper proposes research Hypothesis 2:

H2: *Hog futures promote hog enterprises to expand the scale of production, forcing enterprises to expand the elemental input of risk management, and play an implicit role in stabilizing hog production.*

For hog enterprises involved in futures hedging, hog futures play a role in hedging price risk. Hog futures help farmers hedge against hog price risks and reduce the impact of hog price fluctuations on hog production volatility. Since hog breeding entities are affected by market prices [4,7], based on the risk-hedging function of hog future [39], hog enterprises utilize hog future to hedge the risk [40] and stabilize their production. As the hog fattening market is nearly perfectly competitive [7], hog enterprises are passive recipients of the market price. Due to frequent fluctuations in hog prices, enterprises face high market risks. In situations where hog prices are fluctuating, enterprises may decide to replenish their pens if they predict that hog prices will continue to rise. If the actual price of hogs at the time of slaughter is greater than the forecasted price, enterprises will profit; otherwise, they will face losses. Based on this, we propose research Hypothesis 3.

H3: *Hog futures reduce the impact of hog price volatility on hog production volatility.*

For hog enterprises not involved in future hedging, hog futures play a role in stabilizing production expectations. Hog futures reduce the level of hog price volatility and stabilize production expectations. Futures can hedge price risk [39], and developed countries take futures hedging to avoid price risk [41]. Participants in the hog future market form rational hog prices through bidding. For example, hog and pork demand enterprises can more accurately forecast future market demand based on their historical experience [42] and are the primary drivers of pricing. There are other participants in the futures market, such as professional investors [40], and speculators [43]. The price of the hog future is a rational outcome of a multi-party game [40]. With the combined forces of the participants, the hog future can reasonably reflect the level of hog supply and demand in the coming period. Farmers can make farming decisions based on rational hog futures prices, which can make hog supply adapt to hog demand as much as possible. Rational farming decisions will reduce the fluctuation level of hog prices, stabilize the expectation of hog production [44], and further promote the stability of hog production. Based on this, we propose research Hypothesis 4.

H4: *Hog futures reduce the level of hog price volatility and stable production expectations.*

2.3. Variables and Data Sources

The representativeness of the sample is an issue that needs to be carefully considered in empirical research. This paper analyzes the stabilizing effect of hog futures based on listed hog companies for two main reasons. First, according to the data released by the Ministry of Agriculture and Rural Affairs, the level of large-scale hog farming in China reached 53% in 2020, which indicates that large-scale farmers have become the main force of hog supply, so it is necessary to explore the role of hog futures in stabilizing the production of large-scale farmers. Second, there is a high capital and knowledge threshold in the hog future, and it is difficult for small-scale farmers to participate in hog future trading directly. Hog future is exactly the hedging tool for large-scale farmers. As the head enterprise of the hog industry, listed companies have certain human and capital strengths and can participate in hog future trading. Therefore, this paper selects listed hog companies as empirical samples.

This study utilizes monthly hog sales data from January 2019 to July 2022, which is publicly released by listed hog companies, to examine the impact of hog future listing on production fluctuations. The hog sales data is sourced from the JuchaoInformation Website (http://www.cninfo.com.cn/ (accessed on 14 February 2024)), while data for control variables are obtained from the National Bureau of Statistics (http://www.stats.gov.cn/ (accessed on 14 February 2024)) and the BRIC database (http://www.chinabric.com/ (accessed on 14 February 2024)). Based on the proposed hypotheses, this study sets the variables from the following aspects.

Dependent variable. Production fluctuations. Hog production fluctuations can be expressed in various ways, both changes in hog stock and changes in slaughter can measure hog production fluctuations [45]. In this paper, we use the HP filter method [46] to calculate hog slaughter fluctuations and take the absolute value of the obtained fluctuation term to measure hog production fluctuations. This is undertaken as follows.

The first is to obtain fluctuation data through the HP filter method. The HP filter method assumes that the time series consists of a trend term and a fluctuating term, and the output is as follows:

$$y_t = g_t + c_t \quad t = 1, \ldots, T \tag{1}$$

In Equation (1), y_t is the output in period t, g_t and c_t are the trend and volatility terms in period t, respectively. T is the end time.

According to Hodrick and Prescott, the condition for separating the trend term and fluctuation term is to minimize the following functions:

$$min = \sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=1}^{T} [(g_{t+1} - g_t) - (g_t - g_{t-1})]^2 \tag{2}$$

The second is about the determination of the smoothing parameter λ. According to Ravn and Uhlig [47], $\lambda = 1600p^4$, where p is the number of periods per quarter. Since this paper uses monthly data, p = 3, and the calculation yields $\lambda = 129600$.

The volatility of the time series can be obtained as

$$HP = \frac{c_t}{g_t} \tag{3}$$

The output fluctuations calculated by the HP-filter method refer to deviations of the actual values from the cycle value, and there is directionality. This paper does not consider the direction of fluctuations, but only the magnitude of fluctuations. Therefore, we take the absolute value of the hog production fluctuations calculated by the above method to obtain the corrected fluctuation indicator:

$$hf = |HP| \tag{4}$$

In Equation (4), hf is the fluctuation indicator.

Core independent variable. Future Listing. According to the research questions in this paper, referring to the previous studies, a dummy variable [48] for future listings is set. Specifically, in the time dimension, hog futures are assigned a value of 0 before listing and 1, and vice versa.

Moderating variables. Business weight. The sampled enterprises do not only have hog farming as a business. For example, the main business of the sample firm, WELLHOPE, is feedstuffs, and it has only started to be involved in hog farming in 2016. We set the variable "business weight" based on the number of hogs slaughtered and the size of enterprises to test the impact of hog futures on the stable hog production of different types of enterprises.

Control variables. From the perspective of hog production, factors such as corn price [5] and hog price [49] can affect hog production. We include corn price and hog price variables in our model. In terms of consumption, the price of pork substitutes [4] and consumption level [10] can also affect hog production. Therefore, we added chicken price, income level, and consumer price index (CPI) variables to the model. The occurrence of hog disease is a significant factor that impacts production [4]. This study controls for the impact of epidemic disease by utilizing the epidemic index published by the Bric database. According to existing research [50], the total enterprise assets are employed as a control variable to manage the characteristics of the enterprise. Given the seasonality of pork consumption [49], we include seasonal effects in our model. In addition, this paper controls for the effects of hog price fluctuations, corn price fluctuations, chicken price fluctuations, and CPI fluctuations. We have carried out logarithmization of the variables. The descriptive statistics of the main variables are shown in Table 1.

Table 1. Descriptive statistics of variables.

Variable Type	Variable	Mean	Std. Dev.	Min	Max
Explained variables	Production fluctuations	0.284	0.226	0.001	1.212
	Hog production	3.157	1.482	−1.833	6.449
explanatory variables	Future listing	0.440	0.497	0.000	1.000
Adjustment variables	Business weight	0.142	0.084	0.023	0.470
Control variables	Hog price	3.561	0.346	3.084	4.060
	Corn price	0.884	0.149	0.678	1.068
	Chicken price	3.047	0.048	2.975	3.193
	CPI	4.607	0.006	4.593	4.619
	Hog epidemic	−1.875	0.561	−2.526	−0.301
	Income	2.112	0.109	1.917	2.337
	Interest rate	2.825	0.368	1.684	3.527

2.4. Empirical Research Design

Fixed effects models mitigate endogeneity problems due to omitted variables and are commonly used to analyze panel data [51,52]. Considering that the production of hog enterprises may be affected by unobservable individual effects as well as time effects, referring to existing research, we use a two-way fixed-effects model to empirically analyze the impact of hog futures on the production stability of hog enterprises. The regression model established is as follows:

$$hf_{it} = \alpha + \beta f_t + \delta X_{it} + \gamma f X_{it} + \lambda_i + \upsilon_t + \varepsilon_{it} \quad (5)$$

In Equation (5), hf_{it} denotes hog production fluctuations in period t of the i enterprise, and f_t is the variable of future listing, X_{it} denotes the control variable, fX_{it} denotes the fluctuation of the control variable, which is calculated in a manner consistent with the fluctuation of hog slaughter. λ and υ denote unobservable individual and time effects, respectively. ε_{it} is the random disturbance term, and α, β, and γ are the parameters to be estimated.

3. Results and Discussion

3.1. Cointegration Test of Panel Data

In this paper, to avoid pseudo-regression, we perform panel cointegration tests on the panel data. Specifically, we use the Kao test, Pedroni test, and Westerlund test to conduct panel cointegration tests on the panel data, respectively. The results are shown in Table 2. According to Table 2, all three tests reject the original hypothesis that there is no long-run cointegration at the 1% significance level, suggesting that there is long-run cointegration in the panel data, which shows that we can directly use the original sequence for regression estimation.

Table 2. Results of cointegration test.

Method	Statistic	*p*-Value
Kao test	−6.257 ***	0.000
Pedroni test	−5.685 ***	0.000
Westerlund test	−3.341 ***	0.000

Note: *** denote 1% significance levels.

3.2. Analysis of Benchmark Regression Results

This paper uses stepwise regression to test the research hypotheses. The empirical results are shown in Table 3. In Table 3, Model 1 and Model 2 are the regression results without adding control variables and fixed effects and with adding control variables and fixed effects, respectively. According to Table 3, the core explanatory variable future listing is negative at least at the 5% significance level, and the significance level and goodness of fit increase after adding control variables and fixed effects, indicating that hog futures promote stable production by large-scale farmers. Hypothesis 1 is verified.

Table 3. Benchmark regression results.

	Model 1	Model 2
Variable	**Production Fluctuations**	**Production Fluctuations**
Future listing	−0.061 **	−0.219 ***
	(0.027)	(0.076)
Hog price		−0.419 ***
		(0.156)
Corn price		1.278*
		(0.732)
Chicken price		4.344 ***
		(1.162)
CPI		6.155*
		(3.193)
Hog epidemic		0.057
		(0.080)
Income		−0.102
		(0.192)
Interest rate		−0.102
		(0.088)
Enterprise size		−0.125 *
		(0.074)
Constant	0.299 ***	−39.694 **
	(0.014)	(15.915)
Fluctuation term	No	Yes
Seasonal effect	No	Yes
Year effect	No	Yes
Individual effect	No	Yes
R-squared	0.014	0.371

Note: ***, **, and * denote 1%, 5%, and 10% significance levels, respectively; Standard errors are in parentheses.

Among the control variables, the coefficient of hog price is significantly negative, indicating that rising hog prices help mitigate hog production volatility. It also suggests that falling hog prices are an important factor affecting hog production. The coefficient on corn price is significantly positive, indicating that higher feed grain prices cause farmers to adjust hog slaughter. The coefficient of chicken price is significantly positive, indicating that changes in the price of pork substitutes also cause farmers to adjust their hog inventories. The coefficient of CPI is significantly positive, indicating that changes in consumption cause hog production to fluctuate. The coefficient of enterprise size is significantly negative, indicating that as the size of hog enterprises increases, enterprises will pay more attention to risk management, which helps to reduce hog production volatility.

3.3. Endogeneity Discussion and Robustness Testing

Bidirectional causality and omitted variables are important factors that contribute to the endogeneity problem, which reduce the reliability of the empirical results. Since hog future is an institutional arrangement that is relatively less affected by microfirms, the empirical model is less affected by bidirectional causality. Therefore, this paper centers on omitted variables. Even if this paper adopts a two-way fixed-effects model, it may still face the problem of omitted variables. In August 2018, China experienced the far-reaching African Swine Fever (ASF), which had a great impact on the supply of hogs in China. In December 2019, there was a COVID-19 outbreak in China. In January 2020, the Chinese government announced a series of measures against COVID-19, such as restricting the residents' movement, etc. The COVID-19 outbreak led to disruptions in the supply chain, affecting hog production. In addition, the Chinese government has also made frequent interventions in the hog industry, affecting hog production. Ignoring these factors may lead to unreliable estimates.

In this paper, we set dummy variables according to the time of the ASF to exclude the influence of the ASF epidemic on the estimation results. The empirical results are shown in Model 3 in Table 4. Based on the exclusion of the ASF, this paper sets dummy variables based on the time when the Chinese government announced the restriction of the movement of people to exclude the impact of the COVID-19 epidemic on hog production, and the empirical results are shown in Model 4 in Table 4. Based on the exclusion of ASF and COVID-19, we then set government intervention variables based on the central reserve meat policy to exclude the impact of the industrial policy on hog production, and the empirical results are shown in Model 5 in Table 4. According to the robustness test results in Table 4, hog futures still play a role in stabilizing hog production after excluding the interfering factors. This also indicates that the empirical result in the previous section is robust.

Table 4. Robustness test results.

	Model 3	**Model 4**	**Model 5**	**Model 6**
	Excluding the Impact of the ASF	**Excluding the Impact of the COVID-19**	**Excluding the Impact of Policy Interventions**	**Replacing the Core Explanatory Variable**
Variable	**Production Fluctuations**	**Production Fluctuations**	**Production Fluctuations**	**Production Fluctuations**
Future listing	−0.293 *** (0.112)	−0.290 ** (0.112)	−0.223 *** (0.079)	
Future trading				−0.143 *** (0.048)
Hog price	−0.479 *** (0.154)	−0.491 *** (0.155)	−0.318 * (0.166)	−0.542 *** (0.140)

Table 4. *Cont.*

Variable	Model 3	Model 4	Model 5	Model 6
	Excluding the Impact of the ASF	**Excluding the Impact of the COVID-19**	**Excluding the Impact of Policy Interventions**	**Replacing the Core Explanatory Variable**
	Production Fluctuations	**Production Fluctuations**	**Production Fluctuations**	**Production Fluctuations**
Corn price	0.862	0.663	1.210	0.856
	(0.760)	(0.788)	(0.779)	(0.656)
Chicken price	4.042 ***	3.990 ***	4.043 ***	3.173 ***
	(1.111)	(1.113)	(1.184)	(0.977)
CPI	10.033 ***	11.362 ***	6.311 *	8.376 ***
	(3.196)	(3.481)	(3.500)	(2.824)
Hog epidemic	0.138	0.116	0.033	0.10 1*
	(0.086)	(0.089)	(0.089)	(0.055)
Income	−0.158	−0.131	−0.084	−0.009
	(0.189)	(0.191)	(0.200)	(0.165)
Interest rate	−0.114	−0.086	−0.111	−0.033
	(0.089)	(0.094)	(0.096)	(0.078)
Enterprise size	−0.146 **	−0.147 **	−0.134 *	−0.152 **
	(0.071)	(0.071)	(0.074)	(0.059)
Constant	−55.569 ***	−61.559 ***	−39.772 **	−45.739 ***
	(15.935)	(17.107)	(17.089)	(13.975)
Fluctuation term	Yes	Yes	Yes	Yes
Seasonal effect	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes
Individual effect	Yes	Yes	Yes	Yes
R-squared	0.365	0.366	0.377	0.344

Note: ***, **, and * denote 1%, 5%, and 10% significance levels, respectively; standard errors are in parentheses.

In addition, we set up the future trading variable to replace the core explanatory variable through the trading data of hog future for the robustness test. Specifically, we set the core explanatory variables based on the holdings of hog futures, replace the future listing variable in the original model, and re-regress the model. The empirical results are shown in Model 6 in Table 4. According to the empirical results, the coefficient of variable future trading is negative at the 1% significance level, indicating that hog futures reduce production volatility. The empirical results of the previous section are once again confirmed.

3.4. Mechanism Analysis

Firstly, we test the expansion effect of hog futures. Expanding the scale of hog production helps to force farmers to expand the factor inputs related to risk management, thus reducing the volatility of hog production. We set the hog production variable according to hog slaughtering volume to test the expansion effect of hog future. The empirical results are shown in Model 7 in Table 5. According to Model 7, the coefficient of future listing is positive at the 5% significance level, indicating that hog futures help promote farmers to expand production. Hypothesis 2 is verified.

Secondly, we test the risk-hedging effect of the hog future. China's hog market is almost fully competitive, and each hog farmer is a recipient of the market price. Therefore, to avoid the price risk, hog farmers can only decide the breeding quantity according to the market price. After the listing of hog futures, hog enterprises can use the hedging function of futures to hedge the hog price risk, and reduce the impact of the hog price on hog farming. We introduce an interaction term between future listing and hog price fluctuations in our empirical model to test the risk-hedging function of hog futures. If the coefficient of the hog price fluctuations is significantly positive and the coefficient of the interaction term between futures listing and hog price fluctuations is significantly negative, hog futures are considered to play a role in reducing the risk of hog price. Model 8 in

Table 5 reports the empirical results of the risk hedging mechanism. According to Model 8, the coefficient of hog price fluctuations is significantly positive, which indicates that farmers' hog farming behavior depends on hog price. The coefficient of the interaction term between future listing and hog price fluctuations is significantly negative, indicating that hog future plays a role in reducing the risk of hog price. Hypothesis 3 is verified.

Table 5. Empirical results of expansion effects and risk hedging mechanisms.

	Model 7	Model 8
Variable	**Hog Production**	**Production Fluctuations**
Future listing	0.291 **	−0.242 ***
	(0.115)	(0.076)
Future Listing × Hog price fluctuations		−0.642 **
		(0.288)
Hog price fluctuations		0.370 *
		(0.190)
Hog price	0.111	−0.413 ***
	(0.181)	(0.155)
Corn price	1.670 *	0.960
	(0.986)	(0.741)
Chicken price	−4.050 ***	3.643 ***
	(1.147)	(1.197)
CPI	4.381	5.373 *
	(4.124)	(3.192)
Hog epidemic	−0.002	0.044
	(0.092)	(0.080)
Income	0.503*	−0.058
	(0.285)	(0.191)
Interest rate	0.084	−0.060
	(0.108)	(0.090)
Enterprise size	0.660 ***	−0.117
	(0.107)	(0.073)
Constant	−11.446	−34.011 **
	(19.662)	(16.020)
Fluctuation term	No	Yes
Seasonal effect	Yes	Yes
Year effect	Yes	Yes
Individual effect	Yes	Yes
R-squared	0.951	0.380

Note: ***, **, and * denote 1%, 5%, and 10% significance levels, respectively; standard errors are in parentheses.

Thirdly, we examine the stable expectation mechanism of hog futures. In the production decision-making process, farmers take into account their expectations of future prices. The more volatile the spot price is, the more volatile the farmers' expectations become. This study aims to verify whether the listing of hog futures can stabilize spot price volatility and, therefore, stabilize expectations.

We test whether hog futures reduce the level of hog price volatility based on time series data, and the empirical results are shown in Table 6. In Table 6, Model 9 and Model 10 are the empirical results without adding control variables and fixed effects and with adding control variables and fixed effects, respectively. According to the empirical results, the variables of future listing are all negative at the 1% significance level, indicating that hog futures can reduce the level of hog price volatility and thus play a role in stabilizing farmers' production expectations. Hypothesis 4 is verified.

Table 6. Empirical results of the stable expectation mechanism.

	Model 9	**Model 10**
Variable	**Hog Price Fluctuations**	**Hog Price Fluctuations**
Future listing	−0.170 ***	−0.290 ***
	(0.059)	(0.046)
Corn price		−0.055
		(0.420)
Chicken price		−0.713
		(0.568)
Hog epidemic		0.249 **
		(0.120)
CPI		−2.294
		(2.476)
Constant	0.260 ***	12.953
	(0.017)	(11.097)
Fluctuation term	No	Yes
Seasonal effect	No	Yes
Year effect	No	Yes
R-squared	0.051	0.734

Note: *** and ** denote 1% and 5% significance levels, respectively; standard errors are in parentheses.

3.5. Moderating Effects and Heterogeneity Analysis

The stabilizing effect of the hog future can be affected by the percentage of a farmer's hog business. When the proportion of hog breeding businesses increases for hog farmers, they tend to invest more in related business information search, talents, and capital, thereby increasing the profitability of the hog business. Therefore, the implicit and explicit stabilization effects of the hog future increase when the revenue share of the hog business increases. Model 5 in Table 5 shows the empirical results of the moderating effect of hog business weight. The interaction term between future listing and business weight is significantly positive, indicating that the effect on production fluctuations of hog future becomes more evident as the share of enterprises' hog business increases. Model 11 in Table 7 shows the empirical results of the moderating effect of hog business weight. The interaction term between future listing and business weight is significantly negative, indicating that the stabilizing production effect of hog future becomes increasingly evident as the proportion of enterprises' hog business increases.

Differences in the direction of hog price fluctuations can cause differences in the stabilization effects of hog futures. When hog prices fluctuate negatively, based on the risk hedging function, hog futures can reduce the impact of hog price risk on production, thus stabilizing hog production. When hog prices fluctuate positively, pork supply fails to meet demand. Since pork supply is affected by the growth cycle of hogs, it is difficult to return to the normal supply level in the short term. For a while, hog prices will continue to rise. Thus, farmers tend to reduce slaughtering to gain excess profit. At this time, the stabilizing effect of hog futures is not obvious. We divide the sample into two groups according to the direction of hog price fluctuations to test the heterogeneity mentioned above. The empirical results are shown in Model 12 and Model 13 in Table 7. The empirical results show that when hog prices fluctuate negatively, the coefficient of future listing is negative at the 5% significance level, indicating that hog futures can stabilize hog production. When the hog price fluctuates positively, the coefficient of future listing is not significant, which means that the stabilizing effect of hog futures is not obvious.

Table 7. Empirical results of moderating effects and heterogeneity.

Variable	Model 11 The Moderating Effect of Business Weight Production Fluctuations	Model 12 Negative Hog Price Fluctuations Production Fluctuations	Model 13 Positive Hog Price Fluctuations Production Fluctuations
Future listing	−0.327 *** (0.115)	−0.416 ** (0.183)	−0.581 (0.445)
Future Listing × Business weight	−1.182 *** (0.430)		
Business weight	1.373 *** (0.277)		
Hog price	−0.403 *** (0.152)	−2.420 *** (0.800)	−0.002 (0.481)
Corn price	0.228 (0.782)	2.647 ** (1.148)	−1.560 * (0.807)
Chicken price	4.361 *** (1.082)	8.660 *** (3.314)	1.550 (1.408)
CPI	7.701 ** (3.238)	8.470 (7.230)	5.511 (4.419)
Hog epidemic	0.123 (0.084)	0.429 *** (0.145)	−0.071 (0.099)
Income	−0.117 (0.186)	−0.695 ** (0.309)	0.600 (0.438)
Interest rate	−0.105 (0.085)	−0.469 * (0.254)	0.062 (0.126)
Enterprise size	−0.117 (0.072)	−0.067 (0.078)	−0.266 ** (0.113)
Constant	−45.970 *** (16.020)	400.557 (326.009)	−1112.185 *** (407.781)
Fluctuation term	Yes	Yes	Yes
Seasonal effect	Yes	Yes	Yes
Year effect	Yes	Yes	Yes
Individual effect	Yes	Yes	Yes
R-squared	0.365	0.367	0.375

Note: ***, **, and * denote 1%, 5%, and 10% significance levels, respectively; standard errors are in parentheses.

3.6. Discussion

Since the relationship between futures and spot prices is not yet clear, the answer to the question of whether the hog future can contribute to the stabilization of hog production is unknown. Our research found that even if there is speculative trading in the futures market that exacerbates spot price volatility, the hog future can still play a role in stabilizing production. The possible reasons are as follows:

Firstly, before hog companies engage in hedging. The effect of speculative trading on prices is usually short-term. In the short term, speculative trading can cause future prices to deviate from rational prices. The hog firm's decision to hedge is long-term. If speculative trading causes future prices to fall rapidly in the short term, pork demanders will buy to hedge, allowing future prices to gradually return to normal levels. On the contrary, when the future price rises rapidly in the short term, hog companies will sell hedges. Under the correction of the hedging entities (e.g., hog enterprises and pork demand enterprises, etc.), the future price can quickly return to the normal level. Therefore, irrational future prices will not last for a long time. In other words, since the production decisions of hog enterprises are characterized by long-term (this long-term is relative to speculative trading), when speculative trading leads to a rapid increase in futures prices, hog enterprises will hedge, thus promoting stable production. When speculative trading leads to a rapid decline in the future price, hog production enterprises do not decide to produce based on short-term price trends, but wait for the future price to return to rationality. Therefore, the impact of speculative trading on the hedging effect of hog enterprises is relatively limited.

Secondly, after hog companies engage in hedging. The short-term fluctuation of future prices will not affect hog production after hedging. It is undeniable that the short-term sharp fluctuations in future prices will bring the risk of forced position closure, which has a high demand for the enterprise to control future trade risk. As large hog enterprises have advantages such as talents, controlling trading risks happens to be an advantage of large hog enterprises. After avoiding the risk of forced position closure, hog enterprises only need to choose hedging or physical delivery after future expiration. At this time, the short-term drastic changes in futures prices caused by speculative trading have a relatively limited impact on the production of enterprises.

4. Limitations, Conclusions and Implications

4.1. Limitations of the Study

Our research has certain limitations. In terms of the empirical sample, this paper discusses the stabilizing effect of the hog future with the sample of large hog enterprises, and the sample has certain limitations. A large number of large-scale hog farmers exist in China, while the number of large hog enterprises is relatively small. Although the hog production of large-scale hog enterprises has reached a high proportion, and large-scale hog enterprises and large-scale farmers have similar characteristics, we should also pay more attention to the large-scale farmers. In the future, we can obtain the production and operation data of large-scale farmers through field research to test the role of hog futures on large-scale farmers' production stabilization and its heterogeneity.

4.2. Conclusions

This paper aims to broaden the governance perspective of hog supply volatility by analyzing the impact of hog futures on production stability. We utilized monthly hog sales volume data from hog-listed companies and employed a two-way fixed effects model to investigate the impact and mechanism of hog futures on hog production stability. Our findings suggest that the hog future has a positive impact on hog enterprises' production stability. This finding remains robust after excluding several confounding factors, such as the ASF epidemic, COVID-19, and government intervention. The mechanism analysis finds that hog futures help encourage farmers to expand their risk management factor inputs. Hog futures help reduce the impact of hog price volatility on farmers' production fluctuations. Hog futures help stabilize farmers' production expectations. The analysis of the moderating effect finds that the stabilizing effect of the hog future increases as the proportion of farmers' hog business increases. There is heterogeneity in the stabilizing effect of hog futures; when hog prices fluctuate negatively, the hog future helps promote stable production for large-scale farmers. When the hog price fluctuates positively, the production stabilization effect of the hog future is not obvious.

4.3. Implications

The implications of our findings are as follows.

First, the government should establish a market monitoring and early warning mechanism based on hog future prices. Price expectations play a crucial role in influencing hog production. The hog future price reflects the expectations of future market participants regarding the future supply and demand in the pork market. By establishing a monitoring and early warning mechanism for hog future prices, the government can regulate the spot market with the help of hog futures' price discovery function, thus reducing the possibility of large fluctuations in hog prices.

Second, the government should consider stabilizing hog forward price expectations by actively participating in hog future trading. The current hog price intervention policy mainly consists of the central reserve meat policy. The Development and Reform Commission intervenes in short-term market prices by assessing the range of rising hog prices and deciding to put in or store frozen pork. However, government intervention may disturb short-term market price signals and not affect hog price expectations. This may trigger a game between market subjects and the government, leading to more violent price fluctuations, and causing a reduction in the guiding effect of price signals on farming subjects, further aggravating the imbalance between supply and demand. Therefore, while intervening in market prices in the short term, the government should also consider participating in hog future trading to influence forward price expectations. Moreover, with the advantage of the economic system, state-owned farms can simultaneously decide to increase or decrease production capacity while intervening in the forward price, thus ensuring the stability of the hog supply.

Third, the capital market should play a multi-level role in supporting the development of the hog farming industry. The government should promote financial innovations that serve large-scale hog breeding subjects and encourage them to participate in hog futures trading. The large-scale hog breeding subject is the dominant player in hog futures pricing. Its deep participation helps form rational hog futures prices that accurately reflect the future hog market supply and demand.

Fourth, the government should actively promote financial innovation and services that cater to small and medium-sized hog farming subjects. The high capital and trading thresholds associated with hog futures present significant obstacles for these small farmers. To address this issue, the market should offer financial products with low capital and operation thresholds for small and medium-sized farmers by promoting financial innovation based on hog futures. This approach not only enhances the trading depth of the hog future but also contributes to the formation of a rational hog future price. Additionally, professional investors can participate in hog future trading by absorbing risk-averse funds from small and medium-sized farmers. This protective function shields small and medium-sized farmers from price risks and, based on the information advantage of professional investors, helps to achieve rational pricing of hog futures.

Fifth, to foster financial talent concentration in the hog industry, the government should provide incentives through measures such as personal tax benefits. The hog industry is characterized by high risk and low profitability, resulting in low compensation for industrial employment personnel, and making it difficult to attract highly skilled professionals. Offering preferential policies such as personal tax deductions for employed personnel would improve the industry's appeal and encourage the concentration of talented resources within the hog industry. This, in turn, would promote financial and service innovation in the industry, and support the participation of large hog enterprises in hedging. Furthermore, such incentives would facilitate financial innovation that caters to small and medium-sized farmers, ensuring the industry's stable development.

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References

1. Zira, S.; Rydhmer, L.; Ivarsson, E.; Hoffmann, R.; Röös, E. A Life Cycle Sustainability Assessment of Organic and Conventional Pork Supply Chains in Sweden. *Sustain. Prod. Consum.* **2021**, *28*, 21–38. [CrossRef]
2. Ndue, K.; Pál, G. Life Cycle Assessment Perspective for Sectoral Adaptation to Climate Change: Environmental Impact Assessment of Pig Production. *Land* **2022**, *11*, 827. [CrossRef]
3. OECD. *Food and Agriculture Organization of the United Nations OECD-FAO Agricultural Outlook 2021–2030*; OECD-FAO Agricultural Outlook; OECD: Paris, France, 2021; ISBN 978-92-64-43607-7.
4. Ma, M.; Wang, H.H.; Hua, Y.; Qin, F.; Yang, J. African Swine Fever in China: Impacts, Responses, and Policy Implications. *Food Policy* **2021**, *102*, 102065. [CrossRef]
5. Wang, Y.; Wang, J.; Wang, X. COVID-19, Supply Chain Disruption and China's Hog Market: A Dynamic Analysis. *China Agric. Econ. Rev.* **2020**, *12*, 427–443. [CrossRef]
6. Wang, J.; Wang, X.; Yu, X. Shocks, Cycles and Adjustments: The Case of China's Hog Market under External Shocks. *Agribusiness* **2022**, *39*, 703–726. [CrossRef]
7. Tan, Y.; Zeng, H. Price Transmission, Reserve Regulation and Price Volatility. *China Agric. Econ. Rev.* **2019**, *11*, 355–372. [CrossRef]
8. Jia, Y.; Sun, W.; Su, G.; Hua, J.; He, Z. The Threshold Effect of Swine Epidemics on the Pig Supply in China. *Animals* **2022**, *12*, 2595. [CrossRef] [PubMed]
9. Harlow, A.A. The Hog Cycle and the Cobweb Theorem. *Am. J. Agric. Econ.* **1960**, *42*, 842–853. [CrossRef]
10. Qiao, F.; Huang, J.; Wang, D.; Liu, H.; Lohmar, B. China's Hog Production: From Backyard to Large-Scale. *China Econ. Rev.* **2016**, *38*, 199–208. [CrossRef]
11. Cai, J.; Hong, Y.; Zhou, M.; Hu, R.; Ding, F. Farmer Field School Participation and Exit Decisions in Hog Production: A Case Study from Beijing. *Agribusiness* **2023**, *39*, 549–563. [CrossRef]
12. Roe, B.; Sporleder, T.L.; Belleville, B. Hog Producer Preferences for Marketing Contract Attributes. *Am. J. Agric. Econ.* **2004**, *86*, 115–123. [CrossRef]
13. Miele, M. Contracts in Brazilian Pork and Poultry Meat Chains: Implications for Measuring Agricultural Statistics. In Proceedings of the Sixth International Conference on Agricultural Statistics, Rio de Janeiro, Brazil, 23–25 October 2013.
14. Liang, Q.; Wang, X. Cooperatives as Competitive Yardstick in the Hog Industry?—Evidence from China. *Agribusiness* **2020**, *36*, 127–145. [CrossRef]
15. Ikeda, S.; Natawidjaja, R.S. The Sustainability of Contract Farming with Specialized Suppliers to Modern Retailers: Insights from Vegetable Marketing in Indonesia. *Agriculture* **2022**, *12*, 380. [CrossRef]
16. Cungu, A.; Gow, H.; Swinnen, J.F.M.; Vranken, L. Investment with Weak Contract Enforcement: Evidence from Hungary during Transition. *Eur. Rev. Agric. Econ.* **2008**, *35*, 75–91. [CrossRef]
17. Guo, H.; Jolly, R.W. Contractual Arrangements and Enforcement in Transition Agriculture: Theory and Evidence from China. *Food Policy* **2008**, *33*, 570–575. [CrossRef]
18. Klein, B. Why hold-ups occur: The self-enforcing range of contractual relationships. *Econ. Inq.* **1996**, *34*, 444–463. [CrossRef]
19. Dutkiewicz, J. Uncertain Hog Futures: Life, Death, and Arbitrage on the Factory Farm. *J. Cult. Econ.* **2020**, *13*, 278–289. [CrossRef]
20. Hu, Y.; Yu, Y. Scale Difference from the Impact of Disease Control on Pig Production Efficiency. *Animals* **2022**, *12*, 2647. [CrossRef]
21. Zhou, J.; Zhang, K.J.; Ding, S.J. A Study of the Stabilizing Effect of Large-Scale Breeding on Pig Production Fluctuation in China: An Empirical Analysis Based on Provincial Panel Data. *J. Jiangxi Univ. Financ. Econ.* **2015**, *1*, 84–94. [CrossRef]
22. Yang, S.H.; Wang, K. Study on Stabilization Effect of Scale Management on Fluctuation of Hog Production in China: Double Test Based on Moderating Effect and Threshold Effect Models. *Issues Agric. Econ.* **2022**, *7*, 81–96. [CrossRef]
23. Wang, G.Y.; Wang, X.H.; Li, C.X. The Stabilization Effect of Farming Capitalization on Hog Price Fluctuation: An Empirical Analysis Based on China Panel Data. *Chin. Rural Econ.* **2018**, *6*, 55–66.
24. Pan, D.; Tang, J.; Zhang, L.; He, M.; Kung, C.-C. The Impact of Farm Scale and Technology Characteristics on the Adoption of Sustainable Manure Management Technologies: Evidence from Hog Production in China. *J. Clean. Prod.* **2021**, *280*, 124340. [CrossRef]
25. Kuhn, L.; Balezentis, T.; Hou, L.; Wang, D. Technical and Environmental Efficiency of Livestock Farms in China: A Slacks-Based DEA Approach. *China Econ. Rev.* **2020**, *62*, 101213. [CrossRef]
26. Wu, Q.; Xu, L.; Geng, X. Ecological Efficiency of Hog Scale Production under Environmental Regulation in China: Based on an Optimal Super Efficiency SBM-Malmquist–Tobit Model. *Environ. Sci. Pollut. Res.* **2022**, *29*, 53088–53106. [CrossRef]
27. Wallace, R.; Bergmann, L.; Hogerwerf, L.; Kock, R.; Wallace, R.G. Ebola in the Hog Sector: Modeling Pandemic Emergence in Commodity Livestock. In *Neoliberal Ebola*; Springer: Cham, Switzerland, 2016; pp. 13–53, ISBN 978-3-319-40940-5.
28. Carter, C.A.; Mohapatra, S. How Reliable Are Hog Futures as Forecasts? *Am. J. Agric. Econ.* **2008**, *90*, 367–378. [CrossRef]
29. Kawai, M. Price Volatility of Storable Commodities under Rational Expectations in Spot and Futures Markets. *Int. Econ. Rev.* **1983**, *24*, 435–459. [CrossRef]
30. Irwin, S.H.; Sanders, D.R.; Merrin, R.P. Devil or Angel? The Role of Speculation in the Recent Commodity Price Boom (and Bust). *J. Agric. Appl. Econ.* **2009**, *41*, 377–391. [CrossRef]

31. Turnovsky, S.J.; Campbell, R.B. The Stabilizing and Welfare Properties of Futures Markets: A Simulation Approach. *Int. Econ. Rev.* **1985**, *26*, 277. [CrossRef]
32. Miljkovic, D.; Goetz, C. Destabilizing Role of Futures Markets on North American Hard Red Spring Wheat Spot Prices. *Agric. Econ.* **2020**, *51*, 887–897. [CrossRef]
33. Yan, Y.; Guiyu, Z. The Empirical Study on Price Discovery of Cornstarch Futures Market in China. *Appl. Econ. Lett.* **2019**, *26*, 1100–1103. [CrossRef]
34. Dimpfl, T.; Flad, M.; Jung, R.C. Price Discovery in Agricultural Commodity Markets in the Presence of Futures Speculation. *J. Commod. Mark.* **2017**, *5*, 50–62. [CrossRef]
35. Mao, Q.; Ren, Y.; Loy, J.-P. Price Bubbles in Agricultural Commodity Markets and Contributing Factors: Evidence for Corn and Soybeans in China. *China Agric. Econ. Rev.* **2021**, *13*, 91–122. [CrossRef]
36. Xiong, T.; Li, M.; Cao, J. Do Futures Prices Help Forecast Spot Prices? Evidence from China's New Live Hog Futures. *Agriculture* **2023**, *13*, 1663. [CrossRef]
37. Malak-Rawlikowska, A.; Gebska, M.; Hoste, R.; Leeb, C.; Montanari, C.; Wallace, M.; de Roest, K. Developing a Methodology for Aggregated Assessment of the Economic Sustainability of Pig Farms. *Energies* **2021**, *14*, 1760. [CrossRef]
38. Zhong, S.; Li, J.; Guo, X. Analysis on the Green Total Factor Productivity of Pig Breeding in China: Evidence from a Meta-Frontier Approach. *PLoS ONE* **2022**, *17*, e0270549. [CrossRef]
39. Bina, J.D.; Schroeder, T.C.; Tonsor, G.T. Conditional Feeder Cattle Hedge Ratios: Cross Hedging with Fluctuating Corn Prices. *J. Commod. Mark.* **2022**, *26*, 100193. [CrossRef]
40. Pang, J.; Deng, L.; Wang, G. An Evolutionarily Stable Strategy and the Critical Point of Hog Futures Trading Entities Based on Replicator Dynamic Theory: 2006–2015 Data for China's 22 Provinces. *PLoS ONE* **2017**, *12*, e0172009. [CrossRef]
41. Velandia, M.; Rejesus, R.M.; Knight, T.O.; Sherrick, B.J. Factors Affecting Farmers' Utilization of Agricultural Risk Management Tools: The Case of Crop Insurance, Forward Contracting, and Spreading Sales. *J. Agric. Appl. Econ.* **2009**, *41*, 107–123. [CrossRef]
42. Chen, R.; Wei, B.; Jin, C.; Liu, J. Returns and Volatilities of Energy Futures Markets: Roles of Speculative and Hedging Sentiments. *Int. Rev. Financ. Anal.* **2021**, *76*, 101748. [CrossRef]
43. Acharya, V.V.; Lochstoer, L.A.; Ramadorai, T. Limits to Arbitrage and Hedging: Evidence from Commodity Markets. *J. Financ. Econ.* **2013**, *109*, 441–465. [CrossRef]
44. Huang, J.; Serra, T.; Garcia, P. Are Futures Prices Good Price Forecasts? Underestimation of Price Reversion in the Soybean Complex. *Eur. Rev. Agric. Econ.* **2020**, *47*, 178–199. [CrossRef]
45. Hao, M.; Chen, R.; Fu, X. Effect of Pig Price Volatility on Sichuan Pig Farmers' Behavioral Response in China. *J. Agric. Sci.* **2014**, *6*, 55. [CrossRef]
46. Hodrick, R.J.; Prescott, E.C.; Ravn, M.O.; Zimmermann, C. Postwar U.S. Business Cycles: An Empirical Investigation. *J. Money Credit. Bank.* **1997**, *29*, 1–16. [CrossRef]
47. Ravn, M.O.; Uhlig, H. On Adjusting the Hodrick-Prescott Filter for the Frequency of Observations. *Rev. Econ. Stat.* **2002**, *84*, 371–376. [CrossRef]
48. Yu, Q.; Wu, Y.; Chen, X.; Zhang, L.; Liang, Y. Do China's National Agricultural Science and Technology Parks Promote County Economic Development? An Empirical Examination Based on Multi-Period DID Methods. *Agriculture* **2023**, *13*, 213. [CrossRef]
49. Wang, J.; Wang, G.; Cui, Y.; Zhang, J. How Does Imported Pork Regulate the Supply and Demand of China's Pig Market during the Epidemic?-Based on the Analysis of African Swine Fever and COVID-19. *Front. Vet. Sci.* **2022**, *9*, 1028460. [CrossRef]
50. Gao, G.Y.; Pan, Y.; Lu, J.; Tao, Z. Performance of Multinational Firms' Subsidiaries: Influences of Cumulative Experience. *Manag. Int. Rev.* **2008**, *48*, 749–767. [CrossRef]
51. Liu, G.; Zhang, C. Economic Policy Uncertainty and Firms' Investment and Financing Decisions in China. *China Econ. Rev.* **2020**, *63*, 101279. [CrossRef]
52. Zhang, Y.; Zhuo, C.; Deng, F. Policy Uncertainty, Financialization and Enterprise Technological Innovation: A Way Forward towards Economic Development. *Front. Environ. Sci.* **2022**, *10*, 905505. [CrossRef]