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An empirical analysis of pork price fluctuations in China with the autoregressive conditional heteroscedasticity model

Ting Jin [1,2] **Lei Li**[1*,3]

[1]Capital Circulation Research Base, Beijing Technology and Business University, 100048, Beijing, China. E-mail: lileicem@outlook.com. *Corresponding author.
[2]College of Economics and Management, China Agricultural University, Beijing, China.
[3]College of Economics and Management, Zhejiang A&F University, Hangzhou, China.

ABSTRACT: Pork price fluctuations are closely related to the national economy and people's livelihoods in China. Based on the monthly pork price fluctuations in China from January 2011 to August 2022, this study uses ARCH family models to assess the characteristics and laws of these fluctuations in China. The pork price fluctuations show obvious clustering, with external shock information from the previous month affecting the pork price in the following period; the pork market price is characterized by risk compensation, with the high risk of pork supply driving the pork price up. In addition, the pork price fluctuations are characterized by asymmetry, with a greater impact of good than of bad news on the pork price. Due to the pork industry' low entry threshold and the existence of sunk costs, positive information on the pork market has a stronger impact on price fluctuations than negative information. To guide pork supply, we recommend improving monitoring and early-warning mechanisms in the pork market to identify the pork price volatility threshold and measure the price volatility. In addition, price index insurance products should be constantly strengthened, with different types of insurance products being offered to meeting the insurance demand of various sectors in the pig meat supply chain.
Key words: pork price, price fluctuation, ARCH model, asymmetry.

Uma análise empírica da flutuação do preço da carne suína na China com o modelo autorregressivo de heterocedasticidade condicional

RESUMO: As flutuações do preço da carne suína estão intimamente relacionadas à economia nacional e à subsistência das pessoas. Com base na flutuação mensal do preço da carne suína na China de a janeiro de 2011 a agosto de 2022, este estudo usa os modelos da família ARCH para avaliar as características e as leis das flutuações do preço da carne suína na China. Nossos estudos mostraram que as flutuações do preço da carne suína apresentam agrupamento óbvio, e as informações de choque externo do mês anterior irão interferir no preço da carne suína no período seguinte. O preço de mercado da carne suína tem as características de "risco de recompensa", e o "alto risco" do preço da carne suína. Observa-se uma tendência de alta, mostrando que as oscilações do preço da carne suína são caracterizadas por assimetria. Devido ao baixo limiar de entrada da indústria de suínos e à existência de "sinking cost", as informações positivas sobre o mercado de suínos têm um impacto mais forte nas flutuações de preços do que as informações negativas. Recomenda-se melhorar o monitoramento do mercado de carne suína e o mecanismo de alerta precoce, esclarecer e identificar o limite de volatilidade do preço da carne suína e melhorar o sistema de seguro financeiro da indústria suína.
Palavras-chave: preço da carne suína, flutuação, modelo ARCH, assimetria.

INTRODUCTION

China is the world's largest producer and consumer of pork. Its number of live pigs in stock, slaughter and pork production ranks first in the world. Pork consumption accounts for more than 60% of Chinese residents' meat consumption. Rises in pork prices directly affect the national economy and people's livelihoods. In recent years, the impacts of outbreaks of animal diseases on the meat and poultry market have been continuously highlighted, especially the African swine fever outbreak in August 2018, which had a serious impact on China's meat and poultry market (ZHAO, 2022; HAN et al., 2022). African swine fever is an extremely contagious disease characterized by a rapid onset, an almost 100% mortality rate, absence of specific medicine, and lack of a vaccine. It can be controlled by only culling infected pigs. Therefore, the African swine fever outbreak led to a sharp drop in the stock of live pigs in China, causing drastic fluctuations in the price of live pigs. From 2019 to 2020, the prices of live pigs and pork jumped and remained high, reaching their highest levels in history in October 2019 and February 2020 at 41.96 yuan/kg and 58.89 yuan/kg, respectively. At the same time, due to the substitution

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effect, demand for chicken and beef increased sharply, which made their prices rise significantly in 2020. The African swine fever outbreak thus directly led to an imbalance between supply and demand in the meat and poultry markets, drastic price fluctuations and heavy agricultural economic losses. Moreover, as the COVID-19 pandemic continued in 2022, the next stage remained highly uncertain. In this context, it is of great practical significance to conduct a systematic study on pork price fluctuations and determine their characteristics.

The literature on pork prices can be divided into two categories. One stream analyzes the impact of pork price changes on consumer welfare. It is generally believed that the sharp rise in pork prices has had a negative impact on China's national economy and residents' welfare (ASSEFA et al., 2017; LI et al., 2019). The second stream analyzes the factors affecting the level and fluctuation of pork prices (LI & HE, 2007; ZHOU et al., 2014) and discusses discuss the transmission of pork prices (CECHURA & SOBROVA, 2008; ESPOSTI et al., 2013). These studies generally use the common multiple regression model, census X12 seasonal adjustment method and Hodrick-Prescott (H-P) filtering method. The pork price variable in most studies is usually the price level or the first-order price difference (GUO, 2017; ZHANG et al., 2018). However, these studies actually analyze price level changes rather than price fluctuations, where the latter refer to the process by which the price deviates from its trend, which generally needs to be measured by the coefficient of variation and variance. In addition, the analysis of pork price behavior cannot ignore the impact of inventory holder behavior. The theoretical research by BECK (1993) shows that due to the carry forward effect of inventory, the variance in the price of storable goods presents autocorrelation, or the price series display autoregressive conditional heteroskedasticity (ARCH). To analyze heteroskedastic time series, ENGLE (1982) proposed the ARCH model, which BOLLERSLEV (1986) modified into the generalized ARCH (GARCH) model. In contrast to the common regression model, the GARCH model further models the variance of the error. It is especially suitable for the analysis and prediction of volatility. Such analyses can play a very important guiding role in investor decision-making and their significance often extends beyond the usefulness of the prediction of the value itself. On the basis of existing research and national monthly pork price data from January 2011 to August 2022, this paper applies the models from the ARCH family (ARCH, GARCH, and so on) to measure the price fluctuations by price variance and considers the influence of inventory holder behavior.

The pork price functions as a weather vane with respect to the development of the pig industry and changes in the pork market, and pork price fluctuations of pork price have an important impact on the pig industry and pork market. The research question of this paper is as follows: what are the characteristics of pork price changes? Based on monthly pork price data for China from January 2011 to August 2022, this paper measures price fluctuations by the price variance and considers the existence of the ARCH effect. We empirically analyze the law governing the fluctuations in national pork prices by using models from the ARCH family, and propose corresponding control countermeasures to address future pork price fluctuations.

Theoretical analysis framework and data sources

Rational expectations, commodity inventories and price fluctuations

Inventories are an important factor affecting price changes. MUTH (1961) proposed a rational expectations model for the storable commodity market and found that the carry-over effect brought by inventories makes the price series present sequence correlation. BECK (1993) extended MUTH's model, arguing that inventory holders make inventory size decisions according to the current price and future price expectations. When the inventory enters the next period as new supply, the price fluctuation from the previous period is introduced into the next period. This means that the price in the next period is a function of the price in the previous period. At the same time, the price fluctuation in the next period is also a function of the price fluctuation in the previous period. That is, there exists heteroscedasticity in the price fluctuation conditional on that in the previous period. The variance of the prices of the two adjacent periods is sequence related; that is, there is an ARCH effect. Its basic logic can be expressed by a mathematical model as follows:

$$C_t = -\beta p_t + e_t^d \tag{1}$$

$$P_t = \gamma p_t^e + e_t^s \tag{2}$$

$$I_t = \alpha_{t+1}(p_{t+1}^e - p_t) \tag{3}$$

$$C_t + I_t = P_t + I_{t-1} \tag{4}$$

where, C_t is the consumption for period t, p_t is the market price for period t, P_t is the production for period t, I_t is the stock for period t, p_{t+1}^e the expected price for period t+1, and e_t^d and e_t^s are disturbances of supply and demand.

At the same time, it is assumed that the disturbance terms of supply and demand are independent and identically distributed random variables, and that their variances are stationary random variables. Therefore, we can prove:

$$p_t = \alpha_0 + \alpha_1 p_{t-1} + \varepsilon_t \quad (5)$$

$$h_t = b_0 + b_1 \varepsilon_{t-1}^2 \quad (6)$$

Equations (5) and (6) together constitute the ARCH model. Equation (5) is the mean value equation. Equation (6) is the conditional variance equation, and $\varepsilon_t = e_t^d - e_t^s$ (MUTH, 1961; BECK, 1993; ENGLE, 1982).

MATERIALS AND METHODS

Since the introduction of the ARCH model by ENGLE in 1982, economists and econometricians have made continuous efforts to improve our ability to interpret and predict markets by enriching the models in the ARCH family (BOLLERSLEV, 1986; ENGLE, 1987; HAAS et al., 2004; BOETEL & LIU, 2010). Based on the above theoretical analysis, this paper used ARCH family models (ARCH, GARCH, and so on) to simulate the conditional variance of pork prices to analyze the characteristics of pork price fluctuations.

ARCH model

The ARCH model generally consists of the mean value equation and variance equation. The mean value equation of the ARCH model in this paper is the autoregressive model AR (i) of the pork price.

$$p_t = \sum_{i=1}^{n} \theta_i p_{t-i} + \varepsilon_t \quad (7)$$

where p_t is the pork price for period t, i is the lag order, n is the largest lag order, and ε_t is a random disturbance. When the disturbance term in equation (7) has a conditional heteroscedasticity effect, the variance equation corresponding to the ARCH model can be established as shown in equation (8):

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 \quad (8)$$

ARCH-M model

The ARCH-M model is widely used in financial analysis and measures the corresponding relationship between risk and return. When the predictable risk of assets is high, investors expect to obtain higher investment returns (ENGLE, 1987; HAAS et al., 2004). As pork market volatility intensifies and the risk increases, whether pork suppliers will increase the expected pork price to match the high risk—that is, whether pork price fluctuations are characterized by risk compensation—remains unknown.

To account for this relation, the conditional variance term h_t representing the forecast risk of the pork market is introduced into the explanatory variable of equation (8) to yield equation (9). Equation (9) combined with equation (8) constitutes the ARCH-M model. If the coefficient of the conditional variance term h_t is significantly positive, it indicates that the observable risk of the pork market leads market suppliers to require higher pork prices. In some studies, the conditional variance $\sqrt{h_t}$ in equation (10) is replaced by its conditional standard deviation or logarithmic form $\ln h_t$.

$$p_t = \theta_1 p_{t-1} + \lambda h_t + \varepsilon_t \quad (9)$$

GARCH model

If the variance equation of the GARCH model has many lag orders (that is, if the conditional variance h_t of the current disturbance term depends on the earlier disturbance term lag order q being larger), the parameters to be estimated will increase, and the actual estimation process will be difficult (BOLLERSLEV, 1986; GERVAIS, 2011). In such cases, the lag value of the conditional variance can be used to replace it to establish the GARCH model.

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} \quad (10)$$

Equations (7) and (10) constitute the GARCH (p, q) model. α_i and β_j are the parameter to be estimated. Here, the conditional variance of the pork price in the current period is determined by the variance of the previous forecast, which characterizes the external information in the previous period. The economic implications of the GARCH model are also more obvious if the sum of the coefficients $\left(\sum_{i=1}^{q} \alpha_i + \sum_{j=1}^{p} \beta_j\right)$ is close to 1, indicating that the impact of the shock gradually disappears (NELSON, 1991).

EGARCH model

This study focuses on whether the impacts of good news and bad news on price fluctuations in the pork market are the same, that is, whether the response of the pork market to good news is consistent with that to bad news and whether these responses are symmetrical, is the focus of this study. The EGARCH model is mostly used to verify the asymmetric characteristics of financial market time series data (BOETEL & LIU, 2010). Therefore, this study used the EGARCH models commonly used in financial markets to explore whether the pork market reflects asymmetric characteristics under the impact of good news and bad news.

The mean equation of the EGARCH model is equation (7), and the variance equation of the EGARCH model is shown in equation (11). In equation (11), when the pork market is hit by good news, the influence of external information in the previous period is $\sum_{i=1}^{q}(\alpha_i+\varphi)$; and when the pork market is hit by bad news, the influence of external information in the previous period is $\sum_{i=1}^{q}(\alpha_i-\varphi)$.

$$\log(h_t)=\alpha_0+\sum_{i=1}^{q}\left(\alpha_i\left|\frac{\varepsilon_{t-i}}{\sqrt{h_{t-i}}}\right|+\varphi_i\frac{\varepsilon_{t-i}}{\sqrt{h_{t-i}}}\right)+\sum_{j=1}^{p}\beta_j\log(h_{t-j}) \quad (11)$$

Data sources and descriptive analysis

In this paper, we used monthly data to analyze pork price fluctuations. The research period is from January 2011 to August 2022, with a total of 140 time series observations. The data over the years were collected from the China Animal Husbandry Information Network and China Animal Husbandry Statistics over the years. The price of "pork" refers to the price of pork without a bone belt (unit: yuan/kg). The change trend and growth rate of China's pork price from January 2011 to August 2022 is shown in figure 1.

Figure 1 illustrates that the pork fluctuated between 20 yuan/kg and 30 yuan/kg from January 2011 to July 2019, with the quarterly fluctuation

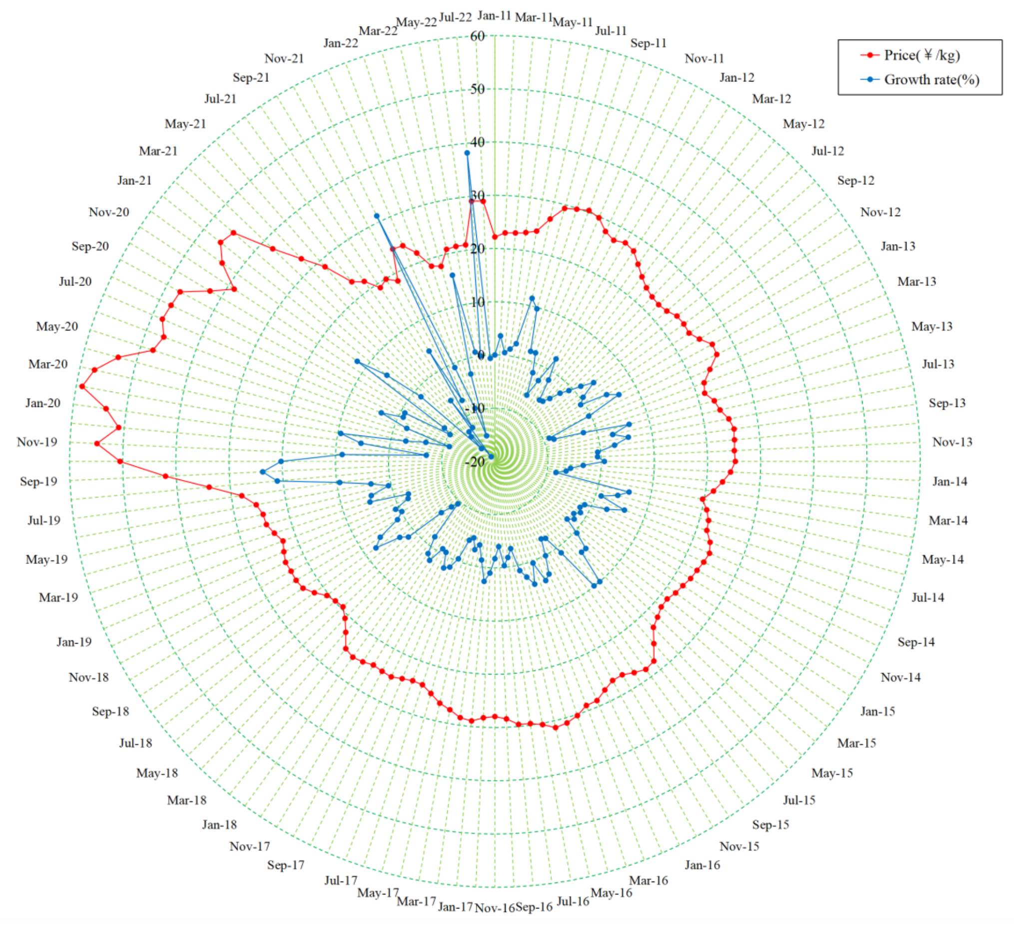

Figure 1 - Change trend and growth rate of pork price from January 2011 to August 2022.

range of pork prices mostly remaining within 10%. However, the trend of rising pork prices accelerated in August 2019, with the price peaking at 58.89 yuan/kg in February 2020. Affected by COVID-19, the growth rate of pork prices remained in the double digits, even going as high as 60%. By May 2021, the pork price had dropped to less than 30 yuan/kg.

Empirical analysis results

Stability test of the pork price series

Before we use the ARCH model, it is necessary to test the stationarity of the pork price series. If the mean value or covariance function of the series changes with time, it means that the random laws of the mean value and covariance of the series differ at different time points. If the model is then directly estimated, the parameter estimation or hypothesis test may be biased. Table 1 shows the stationarity test results of the augmented Dickey–Fuller (ADF) test for the pork price. “c” and “t” in (c, t, 1) indicate that the ADF test regression model contains an exogenous variable constant term and time trend term respectively, and “1” indicates the lag order of the test model based on the Schwarz Information Criterion (SIC). The results showed that the t-statistic value corresponding to the ADF test is -7.0079, significant at 0.01, indicating that the null hypothesis of the existence of a unit root in pork prices is rejected-that is, that the pork price data are a stable time series.

ARCH model results of the pork price

Before we construct the pork price ARCH model, the pork price mean equation is used to determine whether the residual term has an ARCH effect. The variance equation corresponding to the mean value equation is then formulated. Table 2 shows the results of the first-, second-, third- and fourth-order lags of equation (7). Comparing the four autoregressive models, the lag order of the autoregressive model of the pork price is 3, *i*=3. This demonstrates that the t statistics corresponding to the coefficients of the four models are all significant at the level of 0.01, thus the original hypothesis of a coefficient value of 0 is rejected. Therefore, the lag order corresponding to the autoregressive model of the pork price is determined to be order 3, as shown in equation (12).

$$p_t = \theta_1 p_{t-1} + \varepsilon_t \qquad (12)$$

It is necessary to check whether the disturbance term has a significant ARCH effect before we use the ARCH model. First, the auxiliary regression equation (8) is established for the conditional variance h_t of the disturbance term in equation (13). If at least one coefficient α_i in equation (8) is significantly different from 0, it shows that the pork price has an ARCH effect—that is, that the conditional variance h_t in the period t is disturbed by the external information from the previous period, and the disturbance term of the autoregressive equation of the pork price has significant ARCH effect. Table 3 shows that the F statistics and LM test nR^2 of lag orders 1 to 5 are significant, which indicates that the disturbance term of the autoregressive equation of the pork price has an ARCH effect.

The validation of the ARCH effect of the pork price shows that pork price volatility has obvious volatility clustering, that is, that pork price volatility appears in groups, with large fluctuations appearing next to large fluctuations and small fluctuations also appearing together. The conditional variance of volatility does not appear to be random. The clustering characteristic of pork price fluctuation means that when violent pork price fluctuations occur violently, they may last for an extended period of time. This means that when there are signs of drastic fluctuations in pork prices (such as a cyclical decrease in supply), it is necessary for government departments to take measures to shorten the duration of the violent fluctuations as much as possible.

In this paper, the lag order of the variance equation in the ARCH model of the pork price is determined to be 3. Table 4 shows the estimation results of the mean and variance equations of the ARCH model when equation (8) uses lags from order

Table 1 - Augmented Dickey–Fuller (ADF) stability test results of the pork price series.

Test factors	Form inspection	Test model	Judgment criteria	T value
Pork price	(*c*,*t*,1)	ADF	SIC	-7.0079^{***}

Note: *** indicates significance at the level of 1%; SIC means Schwarz information criterion.

Table 2 - Determination of the lag order of the autoregressive model for the pork price.

Parameter	Lag order 1	Lag order 2	Lag order 3	Lag order 4
θ_1	-0.9992***	-1.5897***	1.7903***	1.7832***
θ_2	-	-0.5895***	-1.1196***	-1.0795***
θ_3	-	-	0.3297***	0.2608
θ_4	-	-	-	-0.0359
R^2	0.9394	0.9404	0.9428	0.9404
D.W.	1.1765	-2.2326	2.5918	2.5679
AIC	-2.7086	-3.0432	-3.1067	-3.0861

Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

1 to order 5. Among the five models, the first-order autoregressive coefficients θ_1 in the mean equation are highly significant, and the difference is not significant; in the variance equation, the coefficients of the first-order lag are significant, the second- and third-order models are not significant, and the third-order lag is not significant. Therefore, the lag order of the variance equation of the ARCH model is determined to be order 1. The economic meaning of this is that the fluctuation of pork prices in the current month is impacted by external factors in the previous period. For example, the impact of external factors such as an epidemic disease on fluctuations in the pork market has a time lag, generally into the next month.

Results of the ARCH-M model for the pork price

When the price of pork fluctuates violently and risk is high, do farmers, pork dealers and retailers increase the expected market price? To answer this question, this section uses the ARCH-M model for analysis.

Based on the ARCH model of the pork price, the ARCH-M model is established. The estimated results are shown in table 5. The λ value is 0.9743, and the original hypothesis of no significant difference from 0 is rejected at the level of 0.01, which indicates that suppliers in the pork market demand a correspondingly higher average income with an increase in forecast risk, that is, that the pork market has risk compensation characteristics.

Results of the GARCH model for the pork price

Table 4 shows that when equation (8) includes a lag of order 3, the former ε_{t-5}^2 coefficient is highly significant, which indicates that there may be a high-order conditional heteroscedasticity effect in the pork price fluctuations. Therefore, a GARCH model of the pork price is constructed. Generally, GARCH (1, 1) can simulate most time series data. In this paper, we determine that the value of P and Q in the GARCH model of the pork price is 1. The estimated results of the model are shown in table 6. In the variance equation, the coefficients corresponding to the disturbance term and the previous prediction variance are 0.2771 and 0.7327, respectively. The P value indicates that the two coefficients are highly significant, which indicates that the fluctuation of the pork price in the current period is impacted not only by the external information of the previous period but also by the prediction variance of the previous period, that is, that the fluctuation information of the pork

Table 3 - ARCH effect test of the autoregressive equation of the pork price.

	Lag order 1	Lag order 2	Lag order 3	Lag order 4	Lag order 5
F	1.3362*	1.6103*	2.1326*	7.0371**	12.0437***
nR^2	1.354*	2.0621*	6.5612*	18.6201**	30.2092**

Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

Table 4 - Construction of the variance equation of the ARCH model for the pork price.

Parameter	Lag order 1	Lag order 2	Lag order 3
θ_1	2.0045^{***}	1.8687^{***}	1.7864^{***}
θ_2	-1.5286^{***}	-1.2654^{***}	-1.1378^{***}
θ_3	0.5226^{***}	0.3973^{**}	0.3508^{**}
α_0	0.0016^{***}	0.0007^{***}	0.0004^{*}
α_1	1.0431^{***}	0.4441^{*}	0.1326^{**}
α_2	-	0.7183	0.6625
α_3	-	-	0.5187

Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

price in the previous period is also transmitted to the current period.

Result of the EGARCH model for the pork price

As mentioned above, the GARCH (1, 1) model can simulate a large amount of time series data. Therefore, when analyzing the characteristics of pork price fluctuations, we set the P and Q values in equation (11) to 1. The results of the EGARCH model estimation are shown in table 7. According to the estimation of the EGARCH model, the corresponding φ value is 4.8914, and the original hypothesis of a zero value is rejected at the significance level of 1%, which also implies that the impact of good news on the pork market is stronger than that of bad news. Therefore, price fluctuations in the pork market show significant asymmetry. The reason for this finding is that the entry threshold in the breeding industry is low and suppliers in the pork market are more sensitive to price increases than to decreases. When good news appears in the pork market, a large number of market entities are attracted to flood the pork breeding industry. This sudden increase in supply is likely to exacerbate market fluctuations; in contrast, when bad news appears, reducing supply is complicated by the presence of sunk costs, as it is impossible for farmers to reduce the number of pigs in the short term due to the initial investment required for pig breeding. Therefore, the impact of bad news on pork supply in the short term is limited.

Other studies using data before 2019 have also reached similar conclusions. These studies have constructed the GARCH-M, TARCH and ARCH models, analyzing the fluctuation aggregation characteristics and asymmetries in the pork price at different stages (GUO, 2017; WANG & ZHOU, 2020). However, these studies did not take into account the changing characteristics of pork price fluctuations since the outbreak of COVID-19 in 2019.

CONCLUSION

Based on our analysis of monthly pork prices in China with ARCH family models, a number

Table 5 - Estimation results of the ARCH-M model for the pork price.

Parameter	Estimated value	Standard error	P value
θ_1	1.2671	0.2982	0.0000
λ	0.9743	0.0053	0.0000
α_0	0.0029	0.0012	0.0000
α_1	0.4964	0.0053	0.0081

Table 6 - Estimated results of the GARCH model for the pork price.

Parameter	Estimated value	Standard error	P value
θ_1	0.9992	0.0016	0.0000
α_0	0.0002	0.0005	0.0364
α_1	0.2771	0.0884	0.0017
β_1	0.7327	0.0609	0.0000

of tentative conclusions regarding the characteristics of pork price changes can be drawn.

(1) Pork price fluctuations shows obvious clustering—that is, large fluctuations appear continuously, and small fluctuations also appear in groups. Information on external factors in the previous month leads to fluctuations in the pork price in the following period.

(2) Based on the ARCH-M model, it is shown that pork price fluctuations reflect risk compensation. Specifically, pork farmers, wholesalers, retailers and other market supply entities demand a higher market price due to the increased risk from pork market price fluctuations.

(3) The analysis by the ARCH model and EGARCH models shows that the fluctuations in the pork price are asymmetric, with the impact of good news in the pork market being greater than that of bad news. Good news is likely to increase the expected pork supply, and demand tends to be relatively stable. Increased supply, in turn, is likely to increase the range of the pork market price fluctuations. However, it is difficult for bad news to change the operating behaviors of pork producers in the short term and thus it has no obvious impact on pork supply.

Based on our research, the following measures are recommended to maintain the stable development of the pig industry and pork market price:

(1) We should enhance market monitoring and early-warning mechanisms and clarify the threshold of pork price fluctuations.

The clustering and asymmetry of pork price fluctuations are rooted in the impact of uncertain external emergencies. To stabilize the pig industry and pork market and maintain a relatively stable pork price, it is necessary to establish and improve market monitoring and early warning mechanisms to address possible emergencies in advance. At the same time, it is necessary to determine the reasonable dynamic range and threshold of pork price fluctuations, and market regulations should consider this fluctuation range accordingly.

(2) Fluctuations in pork prices should be identified and pig industry price index insurance products should be constantly strengthened.

The emergence of uncertain external events causes an imbalance between pork supply and demand, which eventually leads to market price fluctuations. Therefore, it is necessary to build a new mechanism for pig industry price index insurance based on the timely identification of the degree of pork price fluctuations. It is suggested that the government improve the policy support system for the pig industry by promoting legalization and institutionalization, and that insurance companies should actively advance the financial and insurance system for the pig industry.

Table 7 - Estimation results of the EGARCH model for the pork price.

Parameter	Estimated value	Standard error	P value
θ_1	0.8987	0.0269	0.0000
α_0	-5.3888	0.0774	0.0000
α_1	0.0255	0.0330	0.4403
β_1	0.1543	0.0382	0.0001
φ	4.8914	1.4018	0.0005

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DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

AUTHORS' CONTRIBUTIONS

The authors contributed equally to the manuscript.

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