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An Empirical Study on the Retail Price Threshold of Pork in the Chinese Market

Yu Wang[1] , Shiwei Xu[1] , Ganqiong LI[1,*], Yongen Zhang[1] , Xiaoyun Zhang[2] , Shengwei Wang[1] , Wen Yu[1,*], and Han Zhou[1]

[1] Agricultural Information Institute, Chinese Academy of Agricultural Sciences/ Research Center of Agricultural Monitoring and Early Warning Engineering Technologies of Beijing/ Key Open Laboratory of Intelligent Agricultural Early Warning Technologies and Systems, Chinese Academy of Agricultural Sciences/ Key Laboratory of Agricultural Monitoring and Early Warning Technology, Ministry of Agriculture and Rural Affairs, P.R. China, Beijing 100081
[2] Institute of Agricultural Economics & Information, Xinjiang Academy of Agricultural Sciences, Xinjiang, 100089

*Author for correspondence; Email: liganqiong@caas.cn (G.L.); yunwen@hotmail.com (X.Z.); Tel.: +86-10-8210-9762 (G.L.)

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This study aimed to identify warning thresholds that can guide sellers in achieving reasonable profits while reducing buyer payment costs. Monthly price data from January 2009 to June 2023 and the two-regime threshold regression model were used for an empirical analysis of the asymmetric effects of the changes in household consumption under different pork price fluctuation levels to verify that the changes in household consumption have significant pork price fluctuation thresholds and threshold effects. It was found that as the fluctuation of pork prices approached the threshold, the temporary price-intervention policy (e.g., reference price) effect of adjusting prices diminished. An empirical analysis was conducted from the perspective of asymmetric effects of the upstream (feed and piglets), midstream (live pigs), and downstream (pork) of price transmission. The impacts of the products in the upstream and midstream of the industry chain on pork prices declined gradually, and among the products, the impact of the prices of feeds for fattening pigs on pork prices was found to be the weakest. Thus, the price intervention policy (e.g., reference price) based on the pork price threshold suggests that strengthening the supervision of the price fluctuations of midstream products (e.g., controlling the profit margin) when the pork price fluctuation is near the threshold (8.24%) would have more significant effects on all sides.

Keywords: industry chain, policy regulation, price regulation, threshold regression

INTRODUCTION

Pork is the meat that is most consumed by Chinese urban and rural residents, and its price is the barometer of the price of meat in China, accounting for 9% of the weight in the country's consumer price index (CPI). This suggests that pork price fluctuation—in particular, the spurt or collapse in pork prices—has a significant impact on the CPI. Thus, research on the early-warning threshold of pork prices and the price transmission of the pig industry chain is of significance to the abnormal fluctuations in pork prices and stable consumption by residents.

The asymmetric price transmission of pork prices has been well-studied in previous literature (Wei and Chen 2010; Hwang et al. 2011; Dong 2015; Zhao and Wu 2015; Zhou and Koemle 2015; Mo and Wen 2019; Zhu et al. 2019; Chavas and Pan 2020; Shao et al. 2021; Wan and Li 2022; Acosta et al. 2023). Price transmission refers to the extent to which localized or exogenous shocks in one market tend to generate effects in other markets. Speed (how long it takes for a price response of a given magnitude to unfold) and especially symmetry (whether the magnitude or speed of a price response at one level depends on the direction of the shock that has occurred at another level) are two additional, dynamic dimensions of vertical price transmission (von Cramon-Taubadel and Goodwin 2021). The transmission of pork prices has a certain degree of asymmetry—for example, the one-way transmission of feed prices for fattening pigs to live pig prices and the two-way transmission of live pig prices to pork prices exhibit asymmetric price transmission characteristics. The response of pork prices to the increase in live pig prices is faster and more comprehensive than that to the decrease, while the response of live pig prices to the decrease in feed prices for fattening pigs is faster and more comprehensive than that to the increase. However, systematic research with respect to the early-warning threshold of pork prices is lacking. The threshold is broadly defined as a point at which the system's quality, attributes, and phenomena are changed dramatically or a critical point at which the system responds greatly even if changes in driving factors are minimal (Pan et al. 2022; Miao and Xu 2023).

In the evolution process of any system, there is a threshold rule. The critical threshold can be used for the system's quantitative management, restriction of bearing capacity in relevant fields, and risk monitoring and early warning (Li et al. 2022; Meng and Yan 2022). The quantitative search for thresholds is a difficult one, as it could be a point or an interval and may consist of multiple threshold points or threshold intervals (Gu 2022). Through setting a reasonable threshold or a threshold interval, a corresponding early warning is given. This is an important part of monitoring, early-warning work, and modern management.

Researchers use different methods to conduct monitoring and early-warning threshold research on agricultural product information, and among these are various studies on price thresholds. Some applied the Census X12 seasonal adjustment method, the Hodrick-Prescott Filter method, and the Value at Risk method (VaR method) to calculate the price risk thresholds of the animal by-products in Beijing (Wang et al. 2010; Wang and Zhao 2011; Zhao and Zhang 2014; Wang et al. 2015). Xia and He (2016) applied the Extreme Value Theory in building the price series of piglets, live pigs, and pork and calculating the market price index of live pigs. Fluctuation ratios were also classified into different stages through breakpoint inspection, and the price index thresholds of piglets, live pigs, and pork were identified. Ma et al. (2017) applied the smooth transition model and conducted an empirical analysis of the threshold effects of the impact of the prices of international agricultural products on the prices of domestic agricultural products. Gao and Xu (2021) simulated and predicted the degree of impact of extreme events on the market prices of 5 animal by-products (pork, beef, lamb, chicken, and eggs) on the basis of the Peak Over Threshold (POT) and Block Maxima Method (BMM). Xu et al. (2020) conducted a study on the thresholds of production information, consumption information, and price information. They applied statistical methods such as the quantile method and clustering method in researching and establishing annual, quarterly, monthly, weekly, and daily forms of monitoring and early-warning thresholds for China's agricultural products from two dimensions (increase and decrease), and analyzed the structure of the forms of thresholds.

In summary, previous studies have calculated the price risk threshold but have not answered the question of whether there is a threshold for price fluctuations or how many thresholds exist. This study aimed to analyze the uniqueness of the pork price fluctuation threshold value by focusing on the relationship between pork price fluctuations and CPI fluctuations using a threshold regression model. The direction of regulatory policies was also determined from the upstream, midstream, and downstream of the industrial chain. Based on the characteristics of asymmetric transmission of pork prices combined with the threshold of pork price fluctuations, effective policy recommendations for monitoring and early warning of pork price fluctuations were proposed.

MATERIALS AND METHODS

Data Source and Variable Description

The data in this study was retrieved from China Animal Husbandry and Veterinary Year Book (2023), China Animal Husbandry Association (CAAA 2003), China Yearbook of Agricultural Price Survey (2023), National Bureau of Statistics of China (n.d.), and the BRICS database (IBGE 2023). Monthly data from January 2009 to June 2023 was selected as the research index, including five variables, each with 175 observations. These indexes included CPI, market prices of compound feeds for fattening pigs, average market prices of 15–25kg piglets, live pigs (domestic Sanyuan [hybridization among three breeds of pigs]) ex-works prices (EXW) and pork-average retail market price of white pigs. CPI had no unit and the remaining units of other prices were CN¥/kg. January 2009 was selected as the base date, dividing the remaining data by the base period value to obtain the initial value of each variable. Among them, CPI represents household consumption, compound feed for fattening pigs and piglets as the representatives of upstream products of the live pig industry chain, and live pigs and pork, respectively referring to the midstream commodities and the downstream consumer goods in the live pig industry chain. Live pigs and pork are two forms of a commodity, with live pigs belonging to the field of production. The live pig price refers to the price at which the live pig fattened by a farm/farmer is purchased by a slaughterhouse (or a broker), and in a generic sense, represents the producer's price. Pork belongs to the field of consumption. The pork price refers to the price of pork (mainly of white pigs) in the retail market, and in a generic sense, represents the consumer's price. The volatility of the indicator was selected as the research variable for measuring the interrelationships between variables, and the specific formula was as follows:

$$\Delta V_i = \frac{V_{(t+1)i} - V_{ti}}{V_{ti}} \quad (1)$$

In the above formula, ΔV_i is the i-th variable, representing the fluctuation value of the i-th indicator, t≥1, i = 1, 2, 3, 4, 5.

The COVID-19 pandemic occurred in the time range selected by the sample, but the pork price did not change significantly because the supply of domestic pork and live pig industry chain in China remained stable.

Model Description

Under normal conditions, the relationship between the pork price fluctuation level and the CPI variation in a region can hardly be reflected with a simple linear model. Hansen (1996; 2000) put forward a threshold regression model which can be used to study the asymmetric relationship between variables. In this study, the pork price fluctuation level was taken as a single threshold variable, and a threshold regression model was established to validate the asymmetric relationship between the pork price fluctuation level and the CPI variation. The model is expressed as:

$$y_i = \theta_1' x_i + e_i, q_i \le \gamma \quad (2)$$
$$y_i = \theta_2' x_i + e_i, q_i > \gamma \quad (3)$$

In the equations above, the sample observation is $\{y_i, x_i, q_i\}_{i=1}^{n}$ .The explained variable γ_i that reflects the CPI variation and the threshold variable q_i that reflects the pork price fluctuation are real values, other explanatory variables x_i is m dimensional vector, and the threshold variable q_i that reflects the pork price fluctuation level can also be regarded as one of the explanatory variables x_i. It divides all sample observations into two regimes, which correspond to different regression models. The estimated parameter values depend on the value of q_i. Besides, x_i can be either an exogenous variable or the lagged variable of γ_i that reflects the hysteresis effects of the CPI variation. γ refers to the threshold value to be tested and estimated, i.e. the pork price fluctuation threshold. Dummy variables are defined as follows, $d_i(\gamma) = \{q_i \le \gamma\}$, among which, {·} refers to an indicative function, $x_i(\gamma) = x_i d_i(\gamma)$ supposing and converting the model to:

$$y_i = \theta' x_i + \delta_n' x_i(\gamma) + e_i \quad (4)$$

When $q_i \le \gamma, d_i(\gamma) = 1$; when $q_i > \gamma, d_i(\gamma) = 0$. In the equation (3) above, the parameters change as the regime changes. Convert the equation (3) to the matrix form below:

$$Y = X\theta + X_\gamma \delta_n + e \quad (5)$$

In the equation 5, Y and e are $n \times 1$ dimensional vectors composed of γ_i and e_i arranged in a certain way. X and Xγ are $n \times m$ dimensional matrices composed of x_i and $x_i(\gamma)$ arranged in a certain way. The regression parameter is (θ, δ_n, γ). The ordinary least square method (OLS) was adopted to estimate the residual sum of squares:

$$S_n\ (\theta, \delta_n, \gamma) = (Y - X\theta - X_\gamma \delta_n)'\ (Y - X\theta - X_\gamma \delta_n) \quad (6)$$

The residual sum of squares S_n (θ, δ_n, γ) was minimized and the values of the regression parameter θ, δ_n, γ, i.e. $(\hat{\theta}, \widehat{\delta_n}, \hat{\gamma})$ were estimated. To meet the requirements for minimizing the residual sum of squares, the value of γ was strictly limited to [γ, γ]= Γ, and when e_i is subject to N (0, σ^2), the ordinary least squares estimator was the same as the maximum likelihood method (MLE).

In Equation (4), the constraint γ and θ are linear with δ_n, and the function of the residual sum of squares of Y to the OLS estimates θ^(γ) and δ^n (γ) obtained from the regression of $X_\gamma^* = [X, X_\gamma]$ was as shown below:

$$S_n(\gamma) = S_n(\hat{\theta}(\gamma), \hat{\delta}_n(\gamma), \gamma) = Y'Y - Y'X_\gamma^*(X_\gamma^{*\prime} X_\gamma^*)^{-1} X_\gamma^{*\prime} Y$$

$\hat{\gamma}$ is the threshold value that minimizes $S_n(\gamma)$. The definition is $\hat{\gamma} = \underset{\gamma \in \Gamma n}{argmin}\, S_n(\gamma)$.

The threshold value $\hat{y}$ was also tested, first, whether the model has threshold effects which can be seen from Equation (1) and Equation (2). When $\theta'_1 = \theta'_2$, the model turns into a general linear model without a threshold value; that is to say, the model has no threshold effects. Thus, the null hypothesis of the test regarding the model's threshold effects is H_0: $\theta_1 = \theta_2$, and the alternative hypothesis is H_1: $\theta_1 \neq \theta_2$. The LR statistic of the test regarding the model's threshold effects is:

$$F(\gamma) = \frac{S_0 - S_1(\hat{\gamma})}{\hat{\sigma}^2} \quad (7)$$

In this equation, S_0 is the residual sum of squares under the condition of the null hypothesis that there is no threshold effect, and $\hat{\sigma}^2$ is the residual sum of squares estimated from Equation (3).

The second one is on testing whether the estimated threshold value $\hat{y}$ is consistent with the true value of γ. The null hypothesis is H_0: γ = ŷ; the alternative hypothesis is H_1: γ ≠ ŷ, and the LR statistic used by Hansen (1996; 2000) to test the consistency of ŷ is:

$$LR(\gamma) = \frac{S_1 - S_1(\hat{\gamma})}{\hat{\sigma}^2} \quad (8)$$

LR(γ) adopts a non-standard normal distribution. When $LR(\gamma) \le -2ln\,(1 - \sqrt{1-\alpha})$, the null hypothesis γ = ŷ cannot be rejected, and ŷ is considered to be consistent with the true value of γ.

RESULTS AND DISCUSSION

Pork Price Transmission Framework

The production of pigs consists of three stages: breeding sows, farrowing, and fattening, which make a cycle that takes at least 1.5 yr to be completed. Unlike fresh products, it is difficult to adjust the pork price through controlling the inventory of live pigs. The signal of short supply in the market cannot be immediately reflected in the pork output. Thus, it is very common for a round of overproduction to trigger the next round of underproduction, which leads to the constant price fluctuations of the whole market. The price fluctuations in the live pig industry chain are affected by many factors, among which the supply-demand relationship and the production cost are the most fundamental. Under the premise of a relatively stable supply-demand relationship, the production cost is a key factor for the price fluctuations in the pig industry chain. Based on this idea, this study is a research on the price transmission mechanism of the pig industry chain along with the idea of "the prices of upstream means of production - the prices of midstream commodities - the prices of downstream consumer goods" and concludes that the prices of upstream means of production determine the farmers' basic expectations for live pig prices and the midstream live pig prices determine the consumers' basic expectations for the downstream pork prices.

According to the data on the costs and benefits of agricultural products throughout the country over the years, among all costs of pig farming, the fluctuations on the costs of fodder concentrates and the costs of piglets have the most significant impact on the total cost of production. In 2022, in terms of pig farming by scattering raising-households, the cost of fodder concentrates, and the cost of piglets, respectively, accounted for 49.7% and 46.3% of the material and service cost. In terms of small-scale pig farming, the cost of fodder concentrates and the cost of piglets, respectively, accounted for 52.3% and 44.7% of the material and service cost. For medium-scale pig farming, the cost of fodder concentrates and the cost of piglets accounted for 52.4% and 44.6% of the material and service cost, respectively, while for large-scale pig farming, the cost of fodder concentrates and the cost of piglets, respectively, accounted for 52.5% and 43.9% of the material and service cost. Thus, regardless of scale of operation, the sum of the cost of fodder concentrates and the cost of piglets accounted for more than 96.0% of the material and service costs. This led to the research selecting compound feed for fattening pigs and piglets as the representative products of upstream means of production in the live pig industry chain and combining midstream commodities (i.e., live pigs), and downstream consumer goods (i.e. pork). The prices of the four kinds of products constitute the internal price system of the live pig industry chain. Based on the background of the determination of the pork price fluctuation threshold, this study puts forward monitoring and preventive intervention measures for pork price fluctuations from the perspectives of the upstream, midstream, and downstream of the live pig industry chain (Fig. 1).

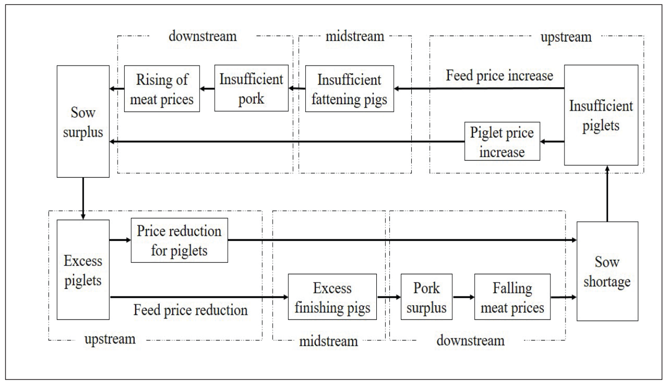

Fig. 1 Pork price transmission diagram.

The price transmission characteristics in the live pig industry chain are closely linked to the circulation characteristics, product characteristics, and market characteristics of the Chinese pork market. On one hand, pork is a commodity that is relatively inelastic in demand in China, so that the sellers in the downstream of the industry chain intrinsically intend to increase the positive fluctuations in pork prices and are more sensitive to the rise of live pig prices in the midstream of the industry chain. On the other hand, compared with pig breeding, the pig slaughtering, wholesalers, and retailers in the downstream of the industry chain are more influential in the pork market. In this imperfect competition market structure, the responses of the downstream sellers to the rise in live pig prices are more obvious than the responses to the fall in live pig prices (Dong 2015). The rise in live pig prices would reduce their profit margins while the fall in live pig prices would increase their profits. Besides, the constant big increase in the average wage of employees in wholesale and retail trade would also lead to asymmetric price transmission. Contrary to overseas scenarios, cost adjustment and governmental policies have little influence on the asymmetric price transmission of the Chinese pork market. At present, the retailing of pork in China is still dominated by market fairs, and small retailers have almost no menu cost in adjusting prices. Thus, menu cost is not the major cause that leads to the asymmetric price transmission in the Chinese pork market.

Descriptive Statistics of Variables

Table 1 shows the descriptive statistics of the model's variables. The maximum value of the negative fluctuation of the explained variable CPI was - 0.018 and the maximum value of the positive fluctuation was 0.065. The variation coefficient was the lowest, indicating that consumer prices are basically stable. The maximum value of the negative fluctuation of the threshold variable pork price was - 0.202 and the maximum value of the positive fluctuation was 1.127. The variation was at a medium level. In 2023, the pork price was reduced to 22 CN¥/kg and was below the historical average. This indicates that China's ability to ensure a stable price and supply of pork is constantly improving. The maximum value of the negative fluctuation of the explanatory variable piglet price was - 0.447, the maximum value of the positive fluctuation was 1.367, and the maximum value of the variation coefficient was 0.139. This suggests that the price fluctuation range is large. The maximum value of the negative fluctuation of the explanatory variable live pig price was - 0.279, the maximum value of the positive fluctuation was 1.257, and the variation coefficient was between the pork price and the piglet price. The maximum value of the negative fluctuation of the explanatory variable price of feed for fattening pigs was - 0.157, the maximum value of the positive fluctuation was 0.058, and the variation coefficient was less than 0.1. This implies that the price is relatively stable.

A correlation test was conducted to verify whether there is an association between upstream products and downstream products and between midstream products and downstream products in the live pig industry chain (i.e., whether there is a correlation between fluctuations in prices of feed for fattening pigs and piglet prices and fluctuations in pork prices, and between fluctuations in live pig prices and fluctuations in pork prices) and whether there is a correlation between fluctuations in product prices and changes in household consumption. Table 2 shows the results of the correlation tests performed. The correlation coefficient of piglet prices and pork prices was up to 0.8302 and the correlation coefficient of live pig prices and pork prices was up to 0.9536, indicative of the strong correlation between the prices of upstream commodities in the live pig industry chain (piglets) and the prices of downstream consumer goods (pork); and a strong correlation between the prices of midstream commodities (live pigs) and the prices of downstream consumer goods (pork). Also, the correlation between the fluctuations in pork prices, piglet prices, and live pig prices and the CPI variation was apparently higher than the impact of the fluctuations in the prices of feed for fattening pigs. Thus, it is necessary to conduct further research to test the transmission mechanism among their prices.

Test for Stationarity of Series

In performing a test for stationarity of series, the Augmented Dickey-Fuller test was adopted for unit root test (Table 3). The result of the sequence of variables ΔCPI, ΔPIGLET, ΔLIVEPIG, ΔPOCK, and ΔFEED was below the significance level of 5%, thus the unit root hypothesis was rejected. This indicates that the sequence of variables ΔCPI, ΔPIGLET, ΔLIVEPIG, ΔPOCK, and ΔFEED is stationary.

Threshold Effect Test

Whether the threshold regression model has non-linear threshold effects was tested, and the method of Hansen (1996; 2000) of using the Lagrange Multiplier (LM) test statistic to conduct the threshold effect test was performed. Since the LM test statistic adopts a non-standard distribution, the Bootstrap Method was adopted to calculate the *P* value, selecting 15%

Table 1. Descriptive statistics of model variables (Unit: yuan/kilogram).

Variable	Abbreviation	Type	Observations	Mean	CV	Min	Max
ΔConsumer Price Index of Residents	ΔCPI	Explanatory Variable	175	0.021	0.015	-0.018	0.065
ΔFeed price for fattening pigs	ΔFEED	Explanatory variable	175	0.002	0.016	-0.157	0.058
ΔPiglet price	ΔPIGLET	Explanatory variable	175	0.008	0.139	-0.447	1.367
ΔLive pig prices	ΔLIVEPIG	Explanatory variable	175	0.006	0.128	-0.279	1.257
Δpork price	ΔPORK	Explained / Threshold variable	175	0.005	0.111	-0.202	1.127

Note: Δ Indicates the price volatility of the corresponding product.

Table 2. Correlation test of fluctuation of CPI, piglet prices, live pig prices, pork price and feed prices in fattening pigs.

	ΔPIGLET	ΔLIVEPIG	ΔFEED	ΔPORK	ΔCPI
ΔPIGLET	1				
ΔLIVEPIG	0.847	1			
ΔFEED	0.188	0.198	1		
ΔPORK	0.830	0.954	0.209	1	
ΔCPI	0.254	0.239	0.042	0.264	1

Table 3. Dickey Fuller unit root test.

Test sequence	Observa-tions	Statistics	P-value	Critical Value		
				1%	5%	10%
ΔCPI		-2.107	0.024			
ΔFEED		-1.723	0.044			
ΔPIGLET	174	-1.819	0.035	-2.348	-1.654	-1.287
ΔLIVEPIG		-2.237	0.013			
ΔPOCK		-2.131	0.022			

at the end and adopting 5 000 as the frequency in sampling (Table 4). The model had a high LM test value. The F (Gamma) lines in Fig. 2 are above the confidence level of 95% and below the significance level of 5%, such that the null hypothesis of no threshold effects was rejected, indicating that there are threshold effects.

Analysis of Threshold Regression Results

According to the theoretical framework and variable selection above, a two-regime threshold regression model was established with regard to the CPI fluctuation:

$$\Delta POCK_i = \theta_1 \Delta FEED_i + \theta_2 \Delta PIGLET_i + \theta_3 \Delta LIVEPIG_i + \theta_4 CPI_i + (\delta_1 \Delta FEED_i + \delta_2 \Delta PIGLET_i + \delta_3 \Delta LIVEPIG_i + \delta_4 CPI_i)(q_i \leq \gamma) + e_i \quad (9)$$

Equation (9) is a two-regime threshold regression model that adopted the threshold regression analysis put forward by Hansen (1996; 2000) in estimating the model's parameters. The computed threshold value of γ was 8.237, suggesting that the threshold value of the pork price was 8.24% (Table 5).

Since the model was found homoscedastic (Table 3), regression analysis was performed, results of which are shown in Table 6, while the threshold estimate is shown in Fig. 3. The model applies linear OLS regression and non-linear threshold regression to empirical analysis and parameter estimation, respectively. OLS estimates the whole sample and ΔPIGLET, ΔLIVEPIG, and ΔCPI and were found to be below the significance levels of 5%, 1%, and 10%, respectively. This implies that the fluctuations in the CPI, the fluctuations in piglet prices, and the fluctuations in live pig prices will have a significant positive impact on the variations in pork prices. The non-linear threshold regression model divided samples into two groups by the threshold value, and the samples above the threshold value and the samples below the threshold value were estimated separately. This was done to determine the asymmetric effects under different regimes. A total of 63 and 112 observations were separately contained in Regime 1 and Regime 2. Compared with Regime 1, the goodness-of-fit of Regime 2 was improved (Table 4). The variables ΔCPI, ΔPIGLET, and ΔLIVEPIG passed the significance test, suggestive of the positive impact on ΔPORK. This means that if the fluctuations in piglet prices, live pig prices, or CPI are above the threshold value of the fluctuations in pork prices, regulating the variations in pork prices will have positive impacts. The fact that the ΔFEED coefficient was not significant indicates that the increase in breeding costs has little influence on the asymmetric price transmission in China's pork market (Dong 2015) in the long term. When the pork price fluctuation level is reduced to 8.24% or below (in Regime 1), the ΔCPI variables

Table 4. Threshold effect test of the model.

Sampling Frequency	Truncation Ratio	Threshold Estimation	LM Test Value Without Threshold Value	Bootstrap *P*-value
5 000	0.150	8.271	102.742	0.000

Table 5. Threshold estimation of the model.

Threshold Estimation	95% Confidence Interval	Total Variance	Residual Variance	Joint R-Squared	Heteroscedasticity Test (*p*-value)
8.238	[8.2269, 8.4486]	2 300.64	10.668	0.534	0.028

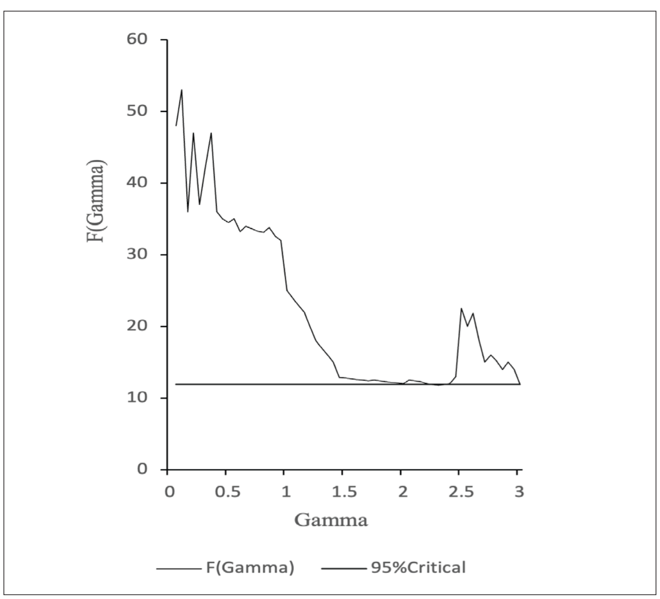

Fig. 2. F Test for threshold reject linearity if F sequence exceeds critical value.

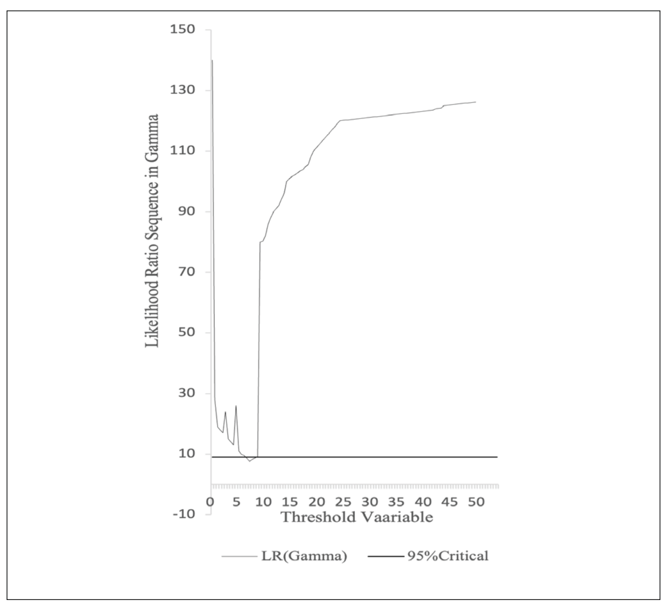

Fig. 3. Confidence interval construction for threshold.

Table 6. Empirical analysis results of a two zone Threshold Regression Model for pork price fluctuation.

Parameter Estimation	OLS Regression			Zone 1 (q<=8.2378)			Zone 2 (q>8.2378)		
Explanatory Variable	Estimated Value	Standard Error	t-Statistics	Estimated Value	Standard error	t-Statistics	Estimated Value	Standard Error	t-Statistics
Intercept	-2.019	0.193	-1.046	4.029	1.251	3.221	-1.176	2.371	-0.496**
ΔPIGLET	0.235	0.411	0.572**	3.124	1.089	0.625*	0.318	0.039	8.154**
ΔLIVEPIG	0.411	0.900	0.457***	0.672	0.421	2.869**	0.268	0.811	0.330***
ΔFEED	1.053	1.731	0.608	3.192	2.153	1.483	1.213	1.681	0.722
ΔCPI	0.618	0.971	0.636*	0.094	0.992	0.095	3.709	0.491	7.554**
Observations		175.000			63.000			112.000	
Degrees of freedom		170.000			58.000			107.000	
R-squared		0.208			0.401			0.572	

Note: *, * *, and * * *respectively indicate that the estimated values of the variables pass the t-test at the significance levels of 10%, 5%, and 1%.

are no longer significant, which means that the variations in CPI can hardly have any influence on the variations in pork prices. In addition, the significance of ΔPIGLET and ΔLIVEPIG also decreased in Regime 1, indicating that fluctuations in CPI are often caused by other factors, so the impact on pork price fluctuations is not significant. Pork prices account for 9% of the weight of China's CPI. Pork price fluctuations, especially the sharp rise and fall in prices, will have a greater impact on the CPI index. The goal of China's pork market policy is to stabilize prices; that is, to avoid sharp price rises and falls and promote the stable operation of the CPI. To achieve this, the Chinese government often takes measures such as increasing the supply of live pigs and supplying frozen pork together with the imposition of macroeconomic regulation and control.

Estimation and Test of the Second Threshold Value

The threshold value of the fluctuations in pork prices were obtained through empirical analysis. Whether the model has the second threshold value was also tested. The process entailed deleting the samples above the threshold value and the threshold effect test was repeated with the remainder of the samples. Results revealed that the Bootstrap *P*-Value of the model was greater than 0.10, the LM test value was small, and the F (Gamma) lines in Fig. 4 were below the confidence level of 95% (Table 7). Thus, the null hypothesis of no second threshold values cannot be rejected indicating that there is no second threshold value.

CONCLUSION AND RECOMMENDATIONS

Under different pork price fluctuation levels, the variations in the consumer price index (CPI) have asymmetric effects. Through establishing a two-regime threshold regression model to estimate the pork price fluctuation threshold, it can be concluded that the rate of change in CPI has significant pork price fluctuation threshold effects and has a unique threshold

Table 7. Testing the second threshold value of the model.

Sampling Frequency	Truncation Ratio	Threshold Estimation	LM Test Value Without Threshold-Value	Bootstrap P-value
5000	0.15	9.216	71.635	0.179

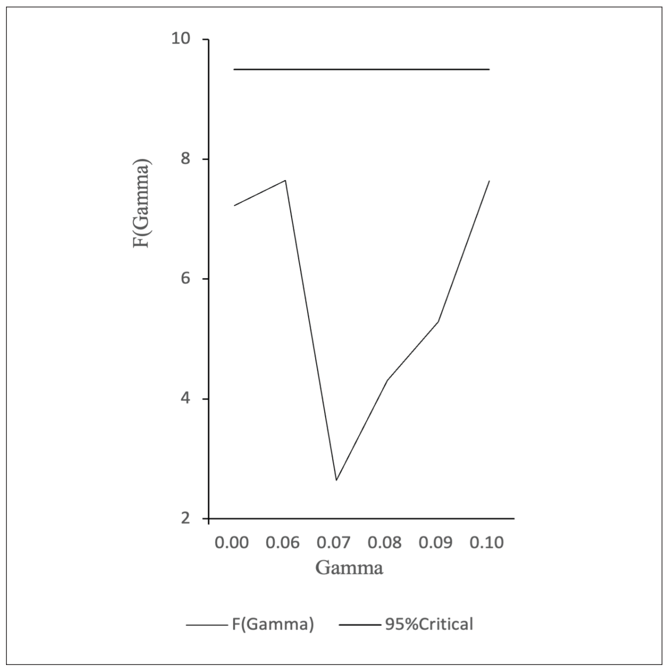

Fig. 4. F Test for threshold reject linearity if F sequence exceeds critical value.

value. China's national pork price fluctuation threshold value was found to be 8.24% which is significantly higher than the threshold level of pork price fluctuations in previous studies. This is mainly the threshold generated by the impact of pork price fluctuations on CPI fluctuations, rather than simply considering the results from the agricultural product market. The current pork price of CN¥ 21.38/kg, with a fluctuation range of 1.92%, is very stable and insufficient to lead to significant fluctuations in CPI.

At present, the domestic regulation policy is to stabilize price fluctuations through temporary pork collection and storage policies when there are sharp rises or falls in the live pig price or the pork price. Therefore, the profits of retailers selling pork will be easier to control. Besides, government policies are more likely to lead to negative asymmetric price transmission and have little influence on positive asymmetric price transmission. Thus, when the pork price fluctuation range exceeds the threshold value of 8.24%, the government can adjust the pork price fluctuations significantly through pork collection and storage policies; however, when the pork price fluctuation range is small, the effects of government policies are not obvious. It is recommended for the government to conduct temporary monitoring measures rather than intervening in the market supply. Furthermore, it is only when the price of pork rises by more than 8.24% that the government should embark on its policy of limiting the profits of midstream products (live pigs), increasing the supply of pork in the market or implementing policies that reduce the increase in pork prices to a reasonable range. On the contrary, if the increase of pork price becomes lower than 8.24%, the policy could be to increase purchase and storage to reduce the supply of pork in the market, and reduce the decline range in pork prices to a reasonable range.

With the increase in the live pig and pork supply capacity, the optimization and adjustment of meat consumption structure, and the continuous improvement on risk management tools such as live hogs and pig insurance, the influence of the "pork period" will wane and the pork price fluctuation range is expected to shrink. This study suggests the need to further strengthen the monitoring and early warning of pork prices and live pig prices and enhance the capacity to ensure the supply of live pigs and pork. In addition, although modeling based on existing variables and data showed that there was only a unique threshold for pork price fluctuations, if this issue is considered from different perspectives, different classification criteria could be set to transform the current unique threshold into multiple thresholds. In the future, the influencing factors of pork price fluctuations from other angles can be measured and the early warning thresholds of pork price fluctuations from more aspects can be explored. This may improve the ability to monitor and give early warnings on pork price fluctuations and establish the significant role of scientific research in the implementation of government policies.

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