Journal of the Korea Academia-Industrial cooperation Society
Vol. 25, No. 5 pp. 54-66, 2024

https://doi.org/10.5762/KAIS.2024.25.5.54
ISSN 1975-4701 / eISSN 2288-4688

Research on the Fluctuation of Pork Prices in China under Major Sudden Public Safety Events

Shi-Yong Piao[1], Yuan-Ze Shi[1], Li-Ling Jin[1], Jong-In Lee[2*]
[1]College of Economics and Management, Yanbian University, China
[2]Department of Agricultural & Resource Economics, Kangwon National University

주요 급발적 공중보건 사건 하의 중국 돼지고기 가격 파동 연구

박세영[1], 사원택[1], 김려령[1], 이종인[2*]
[1]중국 연변대학교 경제관리학원, [2]강원대학교 농업자원경제학과

Abstract From early 2020 to the end of 2022, major sudden public health events, such as COVID-19, significantly influenced the agricultural market in China, with pork prices experiencing substantial volatility. This turbulence in pork prices had profound implications for national regulations and the dietary habits of the populace. Based on data concerning pork prices and COVID-19 infection rates in China from 2020 to 2022, this study employed the VECM error correction model to analyze factors impacting pork prices during these major public health events. Results revealed that in the initial stages of the significant public health events, there was a strong positive correlation between COVID-19 confirmed cases and pork prices, which weakened over time. Drawing on these findings, measures and recommendations were put forth to stabilize pork prices.

요 약 2020년 초부터 2022년 말까지의 주요 급발적 공중보건 사건(COVID-19 등)이 중국의 농산물 시장, 특히 돼지고기 가격에 큰 변동성을 가져왔다. 돼지고기 가격의 파동은 국가의 규제와 국민의 식생활에 큰 영향을 주었다. 본 연구는 2020~2022년 중국 돼지고기 가격, 코로나 확진자 등의 데이터를 바탕으로 VECM 오차 보정 모델을 사용하여 주요 급발적 공중보건 사건시기 돼지고기 가격에 영향을 주는 요인을 분석하였다. 결과적으로, 주요 급발적 공중보건 사건 초기에는 COVID-19 확진자와 돼지고기 가격이 강한 정의 상관관계를 보였으나, 시간이 흐름에 따라 약화되었다. 연구 결과 바탕으로, 돼지고기 가격의 안정화를 위한 조치와 이에 대한 제안을 제시하였다.

Keywords : Major Public Health Incident, Pork Price Fluctuations, VECM, Impulse Analysis, Error Correction Model, Regulatory Policies.

1. Introduction

It is widely known that pork, as a popular primary meat product, plays a vital role in people's daily lives. Therefore, the fluctuation in pork prices is not just an issue for the agricultural industry but also affects the living standards of the general populace. According to the National Bureau of Statistics of China, the country's pork production reached 55.41 million tons in 2022, ranking first globally. In China's meat production structure, pork accounts for about 40%, making it the top

*Corresponding Author : Jong-In Lee(Kangwon National Univ.)
email: leejongin@kangwon.ac.kr
Received February 19, 2024 Revised April 1, 2024
Accepted May 3, 2024 Published May 31, 2024

choice among animal proteins consumed[1]. Over the past 20 years, annual production has consistently exceeded 40 million tons, accounting for about 60% of meat production. The scale of China's pig farming market exceeds a trillion, making China a major producer and consumer of meat. The fluctuation in prices of meats like pork, chicken, and beef significantly affects the healthy development of the country's economy. Especially, pork, as the largest portion of domestic meat consumption, holds immense importance. In 2020, General Secretary Xi Jinping emphasized in his "Three Agriculture" work instructions the need to ensure the steady production and supply of agricultural products, particularly highlighting the promotion of pork production recovery and maintaining stable pork prices to safeguard the nation's food basket[2].

Price fluctuations not only impact people's quality of life, harming the interests of consumers and producers, but can also exacerbate social tensions, leading to risks of monetary inflation and deflation. In recent years, pork prices have shown intense volatility. For instance, from early 2020 to the end of 2022, the retail pork prices in local markets saw significant fluctuations, ranging from a high of 59.64 yuan to a low of 21.03 yuan[3]. Such sharp volatility in pork prices hindered the national regulatory work and impacted the dietary habits of the populace. Fluctuations in pork prices have negative implications for the agricultural industry, causing substantial changes in farming scales due to price variations, which in turn affects the supply of pork. Additionally, these price fluctuations can adversely impact consumer behavior, leading to market demand changes and even, in severe cases, panic hoarding, destabilizing societal conditions.

In early 2021, the COVID-19 outbreak hit China. During the pandemic, transportation blockades led to a halt in agricultural production and a break in the supply chain, severely impacting pork supply, curtailing consumer desire, and, accompanied by concurrent epidemics in livestock, causing significant losses for pork supply chain participants. Moreover, insufficient investment in agricultural production factors led to a decline in agricultural product supply capacity, causing rapid fluctuations in the pork supply-demand relationship, resulting in significant price changes.

Thus, to stabilize pork prices, reduce fluctuations, and protect the interests of producers and consumers, it is crucial to study the patterns and mechanisms of pork price fluctuations. Presently, domestic and international studies mainly focus on two aspects: the pattern of pork price fluctuations and the factors affecting these fluctuations.

Regarding studies on pork price fluctuation patterns, Assefa T. T. et al. (2017) conducted an in-depth study using monthly pork price data, employing various models and linear programming methods. They concluded that pork price fluctuations can be categorized into four main phases: random fluctuation, seasonal fluctuation, cyclical fluctuation, and long-term trend fluctuation[5]. Eddy Bekkers et al. (2017) found that pork prices generally rise slowly over certain periods, with noticeable increases every two to three years, suggesting that cyclical changes are a crucial characteristic of pork price fluctuations[6]. Xiang Ling (2022) used data from January 2003 to August 2021 to study the price of live pigs in China and discovered evident seasonal fluctuation characteristics influenced by holiday effects and temperature changes[7].

Regarding the research on the influencing factors of pork price fluctuations, Hurt and Philip (1982) studied the supply of pigs in the United States using relevant data from 1967 to 1978 and found a significant negative correlation between pig prices and supply[8]. Shiva, Bessler, and Mccarl (2014) used the Vector Autoregression (VAR) model to model the connection between energy and agriculture and discovered that changes in energy prices indirectly affected pig prices through corn, an essential component of pig feed[9]. Zheng Jianzhuang, Wu Zhaoyan, and Shi Ailin (2022) conducted empirical research on the influencing factors of pork price fluctuations in China based on the VAR model. Using 168 sample data from January 2006 to December 2019, they concluded that the four major supply and demand factors affecting pork price fluctuations were the number of breeding pigs, per capita disposable income of rural residents, soybean meal prices, and chicken prices[10].

In terms of research on factors affecting pork price fluctuations, studies have shown influences from feed cost changes, changes in consumption structure, psychological changes in consumption, seasonal changes, and more. While many authors have studied these factors, there's a lack of consistent conclusions. There's also a shortage of empirical studies, especially systematic research at the micro and quantitative levels. Moreover, few studies directly investigate the impact of the COVID-19 pandemic on China's pork price changes.

Therefore, this paper establishes a theoretical study on the impact of confirmed COVID-19 cases and other relevant factors on China's pork price changes during the significant public health event. This research traces the fluctuations in pork prices under the backdrop of the major public health incident, capturing the inherent patterns of these fluctuations. The findings will provide guidance for China when facing similar situations in the future, aiding in the stable regulation of pork prices, increasing the value of the livestock industry in an orderly manner, and promoting the healthy development of agriculture and the national economy.

2. Current Situation of the Research Subject

2.1 Changes in Retail Prices in the Pork Commodity Market

An examination of the pork commodity market prices over the past decade (hereinafter referred to as "pork prices") provides insight into the overall changes in retail prices in recent years. As shown in Fig. 1, from 2012 to 2022, the pork commodity market prices reveal: From 2012 to 2018[3], the fluctuations in pork prices were relatively stable, with the largest price difference being less than 10 yuan/kg. Between 2019 and 2020, there was a sharp rise in pork prices, reaching a decade-high annual average of 69.51 yuan/kg in 2020. From 2020 to 2022, there was a moderate decline, but the prices remained significantly higher than those in 2021 and 2018.

Overall, the pork prices from 2012 to 2018 were relatively stable, showing a slight downward trend. From 2018 to 2020, there was a noticeable upward trend. From 2020 to 2022, there was a certain degree of decline, with the decline being less than the rise from 2018 to 2020. As shown in Fig. 1.

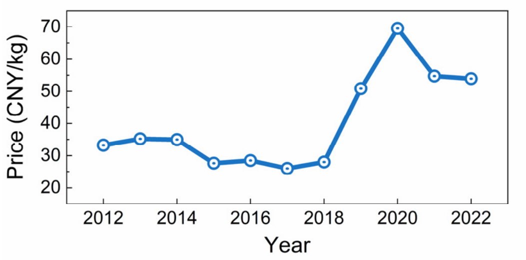

Fig. 1. Pork Commodity Market Prices from 2012 to 2022 [3]

This article focuses on the dramatic fluctuations in pork prices from 2020 to 2022 and further explores the phenomena behind these price changes. As evident from Fig. 2, the retail prices in the pork commodity market peaked around February 2020 and then began to decline until May 2020. From May 2020, prices started to rise again, peaking in August 2020, then falling until November 2020, and then increasing once more until January 2021. Overall, the pork prices in 2020 demonstrated a clear cyclical trend.

Beginning in January 2021, there was a notable overall decline in pork prices, dropping from 54 yuan/kg in January to a near low of 20 yuan in October 2021. Prices briefly rebounded from October to December 2021, only to decrease again until April 2022. From April to November 2022, there was a significant upward trend, though the increase was less pronounced than the decline observed from January to October 2021.

In general terms, pork prices were relatively high in 2020, while 2021 and 2022 saw lower prices. In 2020, the overall pork price hovered around an average of 52 yuan/kg, with evident fluctuations above and below this average. From the first to the second quarter of 2021, pork prices showed a significant downward trend. Between the second quarter of 2021 and the second quarter of 2022, prices displayed minor fluctuations. From the second quarter to the fourth quarter of 2022, there was a moderate upward trend. As shown in Fig. 2.

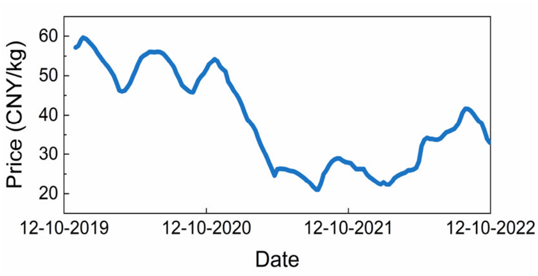

Fig. 2. Pork retail prices in the market from 2020 to 2022[3]

2.2 Changes in the Cumulative Number of Confirmed COVID-19 Cases

Through the cumulative number of confirmed COVID-19 cases, we can effectively reflect the severity of a major public health emergency. As can be seen from Fig. 3, the cumulative number of confirmed cases of COVID-19 reached a peak in the first quarter of 2020 with 31,433 cases. Between the first and second quarters of 2022, there was another peak with 19,485 cases, and in the fourth quarter of 2022, it reached yet another peak with 37,149 cases. From this, it can be observed that the cumulative number of confirmed COVID-19 cases responds rapidly, with peak values consistently occurring near the first quarter and having a short duration. As shown in Fig. 3.

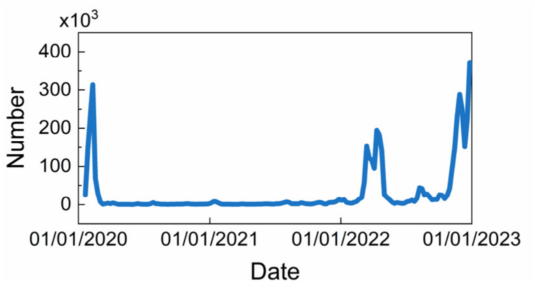

Fig. 3. Cumulative Number of Confirmed COVID-19 Cases[4]

2.3 Comprehensive Analysis of Pork Prices and the Fluctuations in Cumulative Confirmed Cases of COVID-19

By observing and comparing the aforementioned charts, it is evident that when the cumulative confirmed cases of COVID-19 rapidly rise and enter a decline phase, there's a downward trend in pork prices. This phenomenon is quite prominent over similar time frames. Therefore, this study proposes the hypothesis: the changes in the cumulative confirmed cases of COVID-19 might have a certain correlation with the

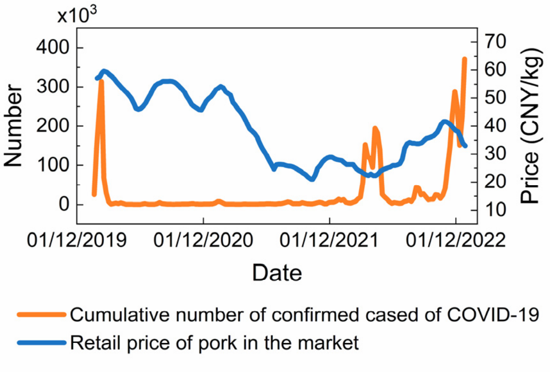

Fig. 4. pork prices and cumulative number of confirmed cases of covid-19[3,4]

fluctuations in pork prices. However, whether there exists a correlation and whether such correlation is significant still requires empirical analysis for further investigation. Thus, this study will carry out an empirical analysis to verify the validity of this hypothesis.

3. Model and Variable Selection

3.1 Theoretical Model

The VAR (Vector Autoregression) model can predict the dynamic relationships among mutually related time series data and analyze the impact of random disturbances on the variables. This model is constructed on the basis of the current and lag values of each variable, creating a VAR of lag order p. The structure of the VAR(p) model is as follows:

$$Yt = \alpha_1 Y_{t-1+}\alpha_2 Y_{t-2} + \ldots\ldots + \alpha_p Y_{t-P} + \mu_1$$

Where:

$$Y_t = \left[Y_{1t,}\, Y_{2t\ldots\ldots}\, Y_{kt} \right]^T,$$

$$\alpha_j = \begin{bmatrix} \alpha_{11.j} \cdots \alpha_{1k.j} \\ \vdots \quad \ddots \quad \vdots \\ \alpha_{k1.j} \cdots \alpha_{kk.j} \end{bmatrix},$$

Where:

$$j = 1,\ 2\cdots\cdots,\ p;\ \ \mu_{t=}\left[\mu_{1t}, \mu_{2t\ldots\ldots}\mu_{kt}\right]^T; \qquad (1)$$

For analyzing non-stationary time series that have a cointegration relationship, the Vector Error Correction Model VECM) must be used. After differentiating equation 1), the VECM equation can be written as:

$$\delta Y_t = \alpha ECM_{t-1} + \Sigma_{i=1}^{i=p-1}\beta_i \delta Y_{t-i} + \mu_i \qquad (2)$$

Where ECM_{t-1} is the error correction term that measures the long-term equilibrium relationship between variables. The coefficient vector α reflects the speed at which the error correction term adjusts its variables when they deviate from the long-term equilibrium state. The differentiated explanatory variables reflect the short-term fluctuations of each variable on the short-term changes of the explained variable[11].

3.2 Research Methods

This study uses Eviews10.0 software for the ADF unit root test of each variable, builds a VAR model, determines the lag order, tests the cointegration relationship, and performs Granger causality analysis. Eventually, this study establishes a VECM for impulse response analysis to study the dynamic characteristics between various factors and pork prices[12].

Specifically, the steps are as follows:

1. Test the stationarity of the time series based on the requirements of the VECM model. If the original series does not pass the stationarity test, use first or second order differences, ensuring all variables are stationary at the same order, and then determine the lag of the model.
2. Test for the presence of a cointegration relationship between independent and dependent variables.
3. Perform Granger causality analysis based on the VECM model.
4. Establish the VECM to reflect the dynamic relationships between the variables using the impulse response function. This can examine the long-term cointegration equilibrium relationship between variables and reflect the extent of short-term fluctuations between variables.

3.3 Variable Selection and Data Source

Many studies have explored the factors influencing pork prices. For instance, Rong and Zapata (2015) found that fluctuations in China's pork prices are primarily caused by pork prices themselves and previous prices[13]. In a 2021 study, Xiong Liang concluded that corn prices and piglet prices are the main factors affecting live pig prices[14]. Cui Yaxin and Zhang Jingxia (2021) researched the fluctuations in pork product prices during the COVID-19 epidemic in Zhengzhou and found that pork prices remained at a high level overall[15]. As shown in Table 1.

In summary, existing research suggests that the severity of the COVID-19 pandemic, fluctuations in the prices of major pig feeds, and price movements of pork substitutes such as other livestock and poultry meats may have a certain impact on pork prices. Therefore, this paper draws on the research elements of contemporary scholars and conducts modeling, data processing, and analysis to explore the correlation and impact of the COVID-19 pandemic on pork price changes. Specifically, the number of confirmed COVID-19 cases is established as the main independent variable (X1). The prices of corn and soybean meal, the main components of pig feed, are designated as X2 and X3, respectively. The prices of pork substitutes, including beef, mutton, and dressed chicken, serve as control variables X4, X5, and X6. Pork price is the dependent variable (Y) for analysis.

The data spans from January 2020 to December 2022. We collected monthly data on the number of confirmed cases of COVID-19 and pork prices, and other relevant variables from the National Bureau of Statistics and related articles, while the price of corn was sourced from the Ministry of Agriculture.

The data spans from January 2020 to December 2022. We collected monthly data on the number of confirmed cases of COVID-19 and pork prices, and other relevant variables from the National Bureau of Statistics and related articles, while the price of corn was sourced from the Ministry of Agriculture.

Table 1. Variable Selection

Researcher	Independent Variables	Dependent Variable
Rong , Zapata (2015)	Pork's own price	Fluctuation in live pig prices
Xiong Liang (2021)	Corn price, piglet price, soybean meal price, beef price, inflation rate, disposable income	Change in live pig prices
Cui Yaxin, Zhang Jingxia (2021)	Interruption of production due to African swine fever and COVID-19	Fluctuation in pork product prices
Herein (2023)	Accumulated confirmed cases of COVID-19, pork's own price, corn price, soybean meal price, beef price, mutton price, and broiler chicken price	Change in live pig prices

4. Analysis Results

4.1 Stationarity Test and Determination of Lag Order

4.1.1 Stationarity Test of Variables

For the establishment of a VAR model, all variables must be stationary series. Therefore, the Augmented Dickey-Fuller (ADF) test is used to check for unit roots in all variables. The results are referred to in Table 2.

At the 5% significance level, the ADF critical values for X1, X2, X3, X4, X5, X6, and Y are all above the threshold, indicating non-stationary sequences for each. Therefore, a first-order difference is applied to the variables X1, X2, X3, X4, X5, X6, and Y, resulting in the series △X1, △X2, △X3, △X4, △X5, △X6, and △Y. The ADF statistics for these differenced series are all below the critical values at both the 1% and 5% significance levels.

From these results, we can conclude that the null hypothesis of a unit root is rejected for each series. Hence, after the first-order differencing, all variables are stationary time series, meaning that the series △X1, △X2, △X3, △X4, △X5, △X6, and △Y are all first-order integrated series (I(1)). This satisfies the prerequisites for establishing a VAR model, paving the way for subsequent analysis.

Table 2. ADF Unit Root Test Results for Each Variable

Variable	ADF	1% Level Critical Value	5% Level Critical Value	10% Level Critical Value	Prob.*	Conclusion
Y	-1.1797210	-3.473672	-2.880463	-2.576939	0.3808	Non-stationary
X1	0.215946	-3.474567	-2.880853	-2.577147	0.9728	Non-stationary
X2	-2.140606	-3.473672	-2.880463	-2.576939	0.2293	Non-stationary
X3	-1.486554	-3.473967	-2.880591	-2.577008	0.5379	Non-stationary
X4	-1.556672	-3.473967	-2.880591	-2.577008	0.5022	Non-stationary
X5	-2.344300	-3.473967	-2.880591	-2.577008	0.1596	Non-stationary
X6	-0.828154	-3.473382	-2.880336	-2.576871	0.8079	Non-stationary
△Y	-4.398035	-3.473672	-2.880463	-2.576939	0.0004	Stationary
△X1	-5.421894	-3.474567	-2.880853	-2.577147	0.0000	Stationary
△X2	-5.109320	-3.473672	-2.880463	-2.576939	0.0000	Stationary
△X3	-4.048506	-3.473967	-2.880591	-2.577008	0.0016	Stationary
△X4	-5.329742	-3.474567	-2.880591	-2.577008	0.0000	Stationary
△X5	-3.861160	-3.473967	-2.880591	-2.577008	0.0021	Stationary
△X6	-13.05685	-3.473672	-2.880463	-2.576939	0.0000	Stationary

Y: Pork price is the dependent variable X1:the number of confirmed COVID-19 cases is established as the main independent variable X2:The prices of corn and soybean meal, X3:the main components of pig feed X4: beef X5: mutton X6: dressed chicken

4.1.2 Determination of Lag Order

To ensure that the VAR model is in a globally stable state, it is necessary to determine a reasonable model lag period. Thus, a determination of the optimal model lag period is performed. By constructing a vector autoregression model VAR for △X1, △X2, △X3, △X4, △X5, △X6, △Y, and referring to the LR, FPE, AIC, SC, HQ criteria, the lag order is determined. Refer to Table 3. for results. The optimal lag order is determined to be 2, thus a second-order VAR model is established.

Table 3. Determination of Optimal Lag Order

Lag	LogL	LR	FPE	AIC	SC	HQ
1	-576.11	NA	1.31e-05	8.62	-9.63*	9.03*
2	-523.51	95.04	1.25e-05*	8.57*	10.58	9.39
3	-479.52	75.24*	1.36e-05	8.64	11.66	9.86
4	-439.08	65.26	1.56e-05	8.76	12.78	10.39
5	-408.89	45.80	2.09e-05	9.02	14.05	11.06

* indicates lag order selected by the criterion

4.2 Cointegration Test

This study uses the Johansen multivariate cointegration test method to test the long-term equilibrium relationship between the cumulative confirmed cases of the COVID-19 epidemic, pork, corn, soybean meal, beef, mutton, and broiler chicken retail prices in the wholesale market. Based on the information in Table 4, we determine whether all the above variables have a cointegration relationship under a lag of 2.

According to the Eigenvalue and TraceStatistic values, at the 5% significance level, the null hypothesis is rejected. This indicates that there exists a long-term cointegration relationship among X1, X2, X3, X4, X5, X6, and Y. Specific results can be referred to Table 4. 4.3 Vector Error Correction Model.

Table 4. Cointegration Test Results

Hypothesized No. of CE(s)	Eigenvalue	Un restricted Cointegration Rank Test (Trace)		
		Trace Statistic	0.05 Critical Value	Prob.**
None *	0.318453	171.6987	150.5585	0.0018
At most 1	0.257926	114.5737	117.7082	0.0776
At most 2	0.143606	70.12610	88.80380	0.5021
At most 3	0.130261	47.02747	63.87610	0.5516
At most 4	0.075189	26.23266	42.81525	0.7246

Table 5. Error Correction Results

Cointegrating Eq:		Y (-1)	X1 (-1)	X2 (-1)	X3 (-1)	X4 (-1)	X5 (-1)	X6 (-1)
Cointegration term	CointEq1	1	-0.000427	-37.69472	2.569970	-4.442676	3.476769	-13.02184
	C	447.3756						
Error Correction:		D(Y)	D(X1)	D(X2)	D(X3)	D(X4)	D(X5)	D(X6)
CointEq1		-0.008544	233.8760	0.000685	0.001295	0.015688	0.025871	0.009510
Independent Variable	D(Y(-1))	0.814530	-645.7441	0.000864	0.005738	0.049842	0.043561	0.017470
	D(X1(-1))	3.21E-05	0.259518	7.60E-07	2.20E-06	1.44E-05	1.92E-05	-4.14E-06
	D(X2(-1))	-1.981518	-23295.09	0.625843	-0.347003	-0.189823	-0.014494	-1.492570
	D(X3(-1))	0.036586	2900.471	0.007752	0.600638	-0.210299	-0.250291	-0.162462
	D(X4(-1))	-0.065747	-4235.693	-0.003481	-0.09270	-0.025292	-0.026197	0.082398
	D(X5(-1))	-0.117951	1354.648	3.69E-05	0.033947	0.272335	0.356766	-0.062387
	D(X6(-1))	0.039684	7884.387	0.001520	0.020029	-0.018245	0.043624	-0.073993
C		-0.024863	173.5245	0.0 02297	0.008329	0.028014	0.011028	0.018777

Based on the given data, we construct the Vector Error Correction Model. The specific results are shown in Table 5.

From the above table, we can derive the equation for the Vector Error Correction Model as:

Y=0.000427*X1+37.69472*X2+2.569970*X3+4.442676*X4+3.476769*X5+13.02184*X6+447.3756

$\triangle Y$ =-0.008544(0.000427*X1+37.69472*X2+2.569970*X3+4.442676*X4+3.476769*X5+13.02184*X6+447.3756)+0.814530 $\triangle Y_{t-1}$+3.21E-05 $\triangle X1_{t-1}$ - 1.981518 $\triangle X2_{t-1}$+0.036586 $\triangle X3_{t-1}$ - 0.065747 $\triangle X4_{t-1}$ - 0.117951 $\triangle X5_{t-1}$+0.039684 $\triangle X6_{t-1}$ - 0.024863

Based on Table 8, the error correction coefficients for the retail market prices of pork, cumulative confirmed cases of COVID-19, corn, soybean meal, beef, mutton, and broiler chickens are -0.008544, +233.8760, 0.000685, 0.001295, -0.00015688, 0.025871, and 0.009510, respectively. This suggests that in the short term, when the prices of these commodities deviate from the long-term equilibrium state, they will be adjusted at rates of -0.008544, +233.8760, 0.000685, 0.001295, -0.00015688, 0.025871, and 0.009510, respectively. The adjustments are primarily driven by short-term fluctuations. From the above error correction model, we can deduce that the error correction coefficient is negative, conforming to the negative correction principle. When short-term fluctuations in pork prices deviate from the long-term equilibrium state, they will be subject to a very small positive correction intensity to adjust them back to equilibrium. In terms of short-term fluctuations, when pork prices rise in the previous period, prices rise in the previous period, the drop in current pork prices is significant; when soybean meal prices rise in the previous period, the current pork prices will rise slightly; when beef prices rise in the previous period, the current pork prices will decline slightly; the same goes for mutton prices; when broiler chicken prices rise in the previous period, the current pork prices will rise slightly. current pork prices will rise in almost the same magnitude; when the number of confirmed COVID-19 cases rises in the previous period, the rise in current pork prices is minimal; when corn

4.3 Impulse Response Analysis

The impulse response function measures the impact of a one standard error shock to the residual term on the current and future values of endogenous variables. In this study, a one standard deviation shock was applied to several endogenous variables, resulting in impulse response functions for the relationships among the retail market prices of pork, cumulative confirmed cases of COVID-19, corn, soybean meal, beef, mutton, and broiler chickens. The detailed analysis results are provided in Fig. 5.

Based on the analysis results, we can draw the following conclusions:

1. Dynamic Impact of the Severity of the COVID-19 Pandemic on Pork Prices:

The severity of the COVID-19 pandemic has a conconsiderable short-term response to pork prices, indicating that pork prices are highly sensitive to the severity of the pandemic. The impact peaks in the sixteenth period, then gradually stabilizes. This shows that the effect of the pandemic's severity on the decline (or increase) in pork prices is most pronounced in the sixteenth period. Afterward, the effect levels off. This proves that in the early stages of the pandemic, pork prices would rise rapidly with an increase in COVID-19 cases. However, in the later stages, due to government regulations, there's a substantial effect in stabilizing pork price fluctuations. As time progresses, the influence of the pandemic on pork prices diminishes and eventually becomes almost negligible.

2. Dynamic Impact of Corn Prices on Pork Prices:

When subjected to a shock in corn prices, pork prices decline continuously from the first period, reaching their lowest in the twelfth period. This indicates a negative correlation between corn prices and pork prices. The current corn feed prices significantly affect the pork prices of the same period, indicating a strong negative correlation.

3. Dynamic Impact of Soybean Meal Prices on Pork Prices:

When subjected to multiple periods of shock in soybean meal prices, the impact on pork prices is minimal, suggesting that the influence of soybean meal prices on pork prices is not significant.

4. Dynamic Impact of Beef Prices on Pork Prices:

When subjected to a shock in beef prices, pork prices decline continuously from the first period, reaching their lowest in the sixth period. This confirms that beef and pork might be substitutes, showing a negative price correlation. From the sixth to the tenth period, the prices remain stable, and from the tenth period, they rise slowly, stabilizing by the twentieth period. This demonstrates that the influence of beef prices on pork prices weakens after the tenth period.

5. Dynamic Impact of Lamb Prices on Pork Prices:

After a shock in lamb prices, pork prices decline steadily, reaching their lowest in the fourteenth period. This suggests a prolonged negative correlation between lamb and pork prices, indicating their potential substitution relationship.

6. Dynamic Impact of Broiler Chicken Prices on Pork Prices:

When subjected to a shock in lamb prices, pork prices rise consistently, peaking in the twentieth period. This indicates a strong positive correlation between broiler chicken and pork prices. It proves that when broiler chicken prices rise, consumers tend to prefer pork, leading to a synchronous increase in pork prices.

In summary, the initial stages of the COVID-19 pandemic had a strong influence on the fluctuation of pork prices. However, as time progressed, the influence waned, almost becoming negligible. This underscores the effectiveness and swift response of China's pandemic control policies in stabilizing pork prices and ensuring the stability of the pork market in China.

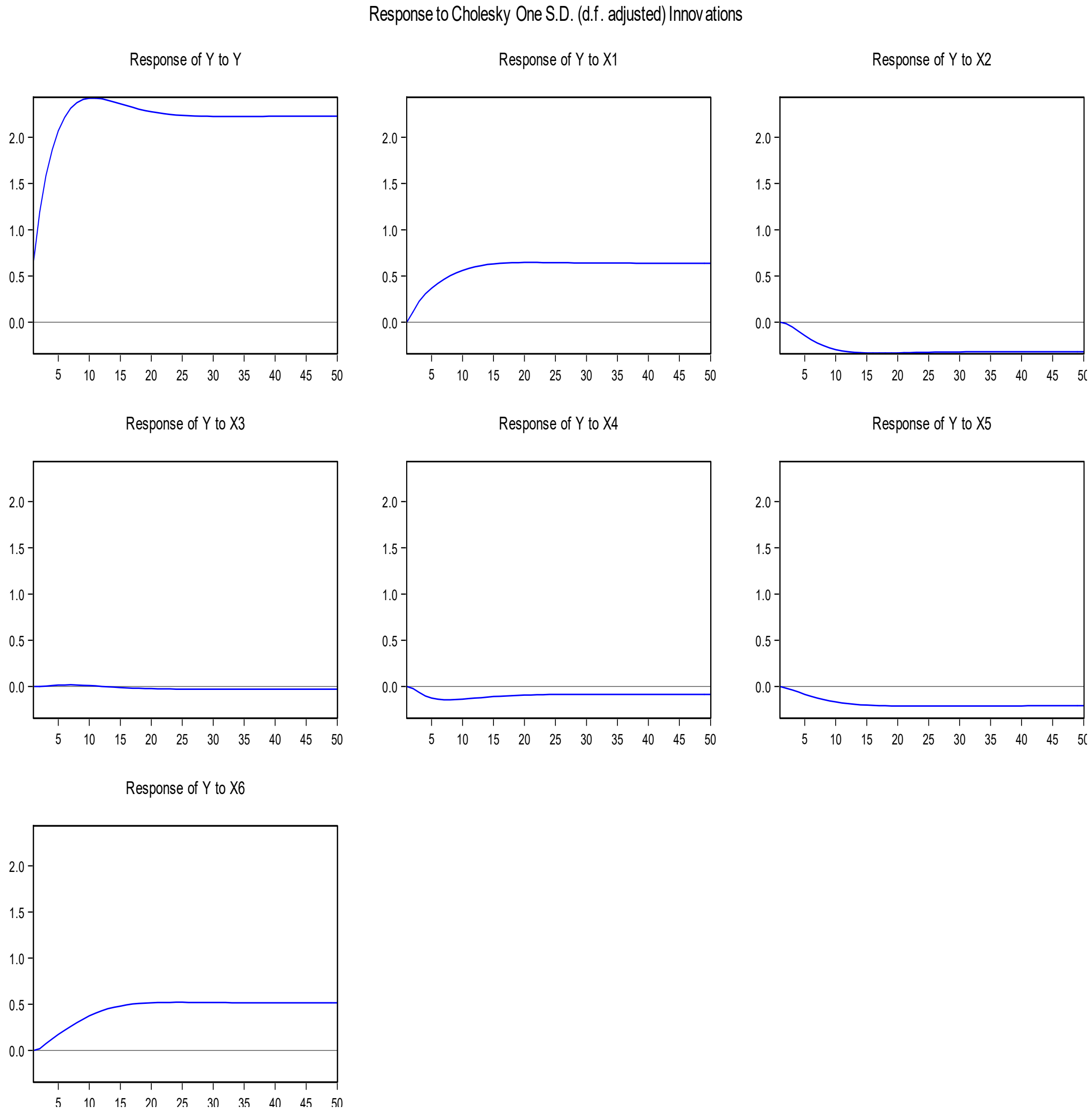

Fig. 5. Results of Impulse Response Analysis

5. Conclusion

This study, based on weekly data related to the confirmed COVID-19 cases and pork and pork substitute prices from 2020 to 2022, established a VECM error correction model to empirically examine the impact and characteristics of pork prices following a major public health emergency. Generally speaking, the major public health event had a significant effect on pork prices. In the initial stages of the public health crisis, the number of confirmed COVID-19 cases had a strong positive correlation with pork prices. This correlation weakened over time, and in the later stages, the effect was virtually zero.

Based on the above conclusions, this paper proposes the following recommendations:

Firstly, establish a graded supervision and prevention mechanism for agricultural products during major events. The government should set up a pork supervisory and preventive mechanism in anticipation of significant sudden incidents. During such incidents, proactive measures should be implemented. The government should monitor pork price fluctuations and establish a product supply-demand balance early warning system. During major intervention events, the primary principle is to ensure pork supply, followed by increasing the availability of pork substitutes to reduce demand for pork[16]. If the event has a significant impact on pork prices, the government should provide financial subsidies to pork industry participants to stabilize prices quickly.

Secondly, form a comprehensive guidance system involving the government, pork production and processing enterprises, and pork retail or wholesale markets. Pork production and sales usually come with unpredictable risks, just like major public health emergencies. To ensure economic stability, it is recommended to form an integrated agricultural relief system led by the government, in collaboration with production and sales entities[17]. The government should set up an agricultural disaster relief fund to assess and assist businesses or individual traders affected by the epidemic, ensuring the regular operation of the pork market after major incidents.

Thirdly, increase economic support for agricultural products. The public health emergency has affected the pork industry. To ensure the orderly operation of the pork market after the outbreak, the government should incentivize the financial sector to delve deeper into the pork-related industry[18]. The government should integrate the market value laws of agricultural products with the leverage of the financial sector, adjusting loan limits and financing guarantees based on local pork production and sales situations. Financial subsidies or interest rate cuts should be given to heavily affected pork industry businesses.

Fourthly, ensure an effective supply of agricultural products. The government and agricultural sectors need to plan sustainable pork production models, send qualified professionals to guide farmers, and establish a feedback system that includes the government, enterprises, and the public. This ensures the balance of pork supply and demand and the effective supply of pork[19]. The government should manage each area in a grid-like fashion, fostering cooperation between pork production companies and farmers. The local government should reasonably increase pork storage, so when emergencies arise, they can promptly release reserves to stabilize supply and ensure smooth operation of the pork industry after unexpected events.

Fifthly, in order to enhance the risk resistance and market competitiveness of farmers, they should be encouraged to join agricultural cooperatives and purchase insurance related to agriculture. The joining of cooperatives not only helps to integrate resources, but also provides opportunities to obtain financial support, policy subsidies, and tax exemption policies. At the same time, purchasing agricultural insurance can effectively reduce the losses caused to farmers by disasters, stabilize their income, and help them quickly restore agricultural production and living order, eliminating the adverse effects of disasters[20]. Therefore, village collectives and government departments should actively advocate for farmers to join cooperatives and purchase agricultural insurance, jointly safeguarding the stable development of agriculture.

References

[1] Statistical Bulletin on National Economic and Social Development of the People's Republic of China in 2022 [Internet]. National Bureau of Statistics[cited 2022], Available From: https://www.stats.gov.cn/xxgk/sjfb/tjgb2020/202302/t20230228_1919001.html(accessed May 02, 2023)

[2] L. L. Fu, L. M. Yu, J. X. Zhao, "VAR model analysis of the impact of the epidemic on pig prices". *Journal of Henan Agricultural University,* No.002, pp.056, 2022.

[3] Retail Price Statistics of Pork from the Ministry of Agriculture and Rural Affairs of the People's Republic

of China [Internet]. Ministry of Agriculture and Rural Affairs of the People's Republic of China, Available From: http://zdscxx.moa.gov.cn:8080/nyb/pc/search.jsp

[4] Epidemic Notification from the National Health Commission of the People's Republic of China [internet] National Health Commission of the People's Republic of China, Available From: http://www.nhc.gov.cn/xcs/yqtb/list_gzbd.shtml (accessed May 02, 2023)

[5] T. T.Assefa, M. P. M. Meuwissen, C.Gardebroek, et al. "Price and Volatility Transmission and Market Power in the German Fresh Pork Supply Chain" *Journal of Agricultural Economics,* Vol.68, No.1, 2017. DOI: https://doi.org/10.1111/1477-9552.12220

[6] E.Bekkers, M.Brockmeier, J.Francois, et al."Local Food Prices and International Price Transmission". *World Development,* Issue.96, pp.96, 2017.

[7] L.Xiang, *Research on the Fluctuation Characteristics and Influencing Factors of Chinese Pig Prices,* Master's thesis, Xihua University, Sichuan, China, pp. 21-41, 2022.

[8] H. P. Garcia, "The Impact of Price Risk on So Farrowings, 1967 – 78", *American Journal of Agricultural Economics,* Vol.64, No.3, pp.565-568, 1982. DOI: https://doi.org/10.2307/1240651

[9] L.Shiva, D. A.Bessler, B. A.McCarl, (2014) "On the Dynamics of Price Discovery:Energy and Agricultural Markets with and without the Renewable Fuels Mandate", *Agricultural and Applied Economics Association (AAEA) Conferences. 2014 Annual Meeting,* AAEA, Minneapolis, Minnesota, USA, July, 2014, DOI: https://doi.org/10.22004/AG.ECON.169780

[10] J. Z. Zheng, C. Y. Wu, A. L. Shi, "Empirical study on the influencing factors of pork price fluctuations in China based on VAR model", *Chinese Journal of Animal Husbandry,* Vol.58, No.2, pp.259-265, 2022. DOI: https://doi.org/10.19556/j.0258-7033.20210520-01

[11] X. Y. Deng, *Endogenous Volatility of Agricultural Product Prices and Interaction with Future Prices,* Master's thesis, Southwest University of Finance and Economics, Sichuan, China, pp. 41-47, 2019. DOI: https://doi.org/10.27412/d.cnki.gxncu.2019.000670

[12] R. B. Zhang, "Empirical Analysis of the Relationship between Futures Prices and Spot Prices of Agricultural Products in China", *Business Economics Research,* No.31, pp.100-102, 2015. DOI: https://doi.org/10.3969/j.issn.1002-5863.2015.31.038

[13] C.Rong, H. O.Zapata, "Dynamics of Price Volatility in the China US Hot Industries", *Southern Agricultural Economics Association,* 2015.

[14] L. Xiong, "A Study on the Factors of Changes in Chinese Pork Prices and Stability Strategies", *Price Monthly,* Issue..3, pp.36-41, 2021. DOI: https://doi.org/10.14076/j.issn.1006-2025.2021.03.06

[15] Y. X. Cui, J. X. Zhang, "Impact and countermeasures of pork product price fluctuation under the COVID-19", *Agriculture and Technology,* Vol.41, No.11, pp.161-164, 2021. DOI: https://doi.org/10.19754/j.nyyjs.20210615044

[16] Z. P. Zhou, H. X. Liang, "The impact of the COVID-19 on the price of agricultural products in China", *Price Monthly,* Issue 11, pp.6-11, 2020. DOI: https://doi.org/10.14076/j.issn.1006-2025.2020.11.02

[17] L. Liu, S. Chen, X. J. Fei, "The transmission effect of investor sentiment and monetary policy on China's agricultural product prices under major public emergencies -- take the COVID-19 as an example", *Contemporary Economic Sciences,* Vol.45, No.1, pp.89-102, 2023. DOI: https://doi.org/10.20069/j.cnki.DJKX.202301007

[18] M. Y. Wang, Y. Deng, "The impact of the COVID-19 on agricultural product prices and countermeasures", *Chinese Business Review,* Issue..3, pp.5-7, 2021. DOI: https://doi.org/10.19699/j.cnki.issn2096-0298.2021.03.005

[19] F. Liu, M. M. Pan, "Research on the impact of novel coronavirus pneumonia epidemic on agricultural product prices and coping strategies", *Journal of Anhui University of Engineering,* Vol.35, No.4, pp.80-87,2022. DOI: https://doi.org/10.3969/j.issn.2095-0977.2020.04.010

[20] Li Yingchao, *Study on the livelihood resilience of farmers on the Loess Plateau under the dual exposure of meteorological disasters and COVID-1,* Master's thesis, Northwest A&F University, Shaanxi, China, pp. 68, 2023

Shi-Yong Piao [Regular member]

• Jun. 2018 : Kangwon Univ., Dept. of Agricultural and Resource Economics, MS
• Aug. 2021 : Kangwon Univ., Dept. of Agricultural and Resource Economics, PhD
• Sept. 2021 : Yanbian Univ., Agricultural and Forestry Economics and Management, Assistant Professor

〈Research Interests〉
Livestock Economy, Food Economy

Li-Ling Jin [Regular member]

• Sept. 2020 ~ current : Yanbian Univ., Agricultural and Forestry Economics and Management, Graduate student

〈Research Interests〉
Livestock Economy, Food Economy

Yuan-Ze Shi [Regular member]

• Sept. 2020 ~ current : Yanbian Univ., Agricultural and Forestry Economics and Management, Graduate student

〈Research Interests〉
Livestock Economy, Food Economy

Jong-In Lee [Life member]

• Feb. 1987 : Kangwon Univ., Animal Science, BSC(Agr)
• Feb. 1993 : Kangwon Univ., Livestock Management, MM
• Aug. 1997 : Missouri Univ., Agricultural Economics, MSAE
• Dec. 2000 : Oklahoma Univ., Agricultural Economics, PhD
• Feb. 2006 ~ current : Kangwon Univ., Dept. of Agricultural and Resource Economics, Professor

〈Research Interests〉
Livestock Management, Livestock Economy, Food Consumption