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Research and analysis of beef price drivers in China

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Abstract: *This study employs beef price as its primary research object, with corn price, lamb price, pig price, chicken price and imported beef price selected as explanatory variables. The study then collates the monthly price change data for the aforementioned products over the period from 2019 to 2024. An OLS multiple linear regression model was constructed using Stata18 software to systematically analyse the factors affecting beef prices and to determine the strength of the influence of each factor on beef price changes. The findings of the study indicate that the volatility of beef prices is predominantly influenced by the prices of sheep meat, corn, chicken meat and imported beef. Conversely, the impact of pig prices and chicken meat prices on beef prices is comparatively limited. In light of these findings, recommendations are put forth with the aim of ensuring a stable supply of feed resources, such as corn and wheat, optimising the early warning and regulation mechanism of the beef market, its substitutes market and factor market, and enhancing the competitiveness of China's beef industry in the international market.*

Keywords: *Beef prices, OLS multiple regression, Influencing factors*

1. Introduction

Advancements in cattle breeding technology and optimizations in management practices have contributed to the continuous growth of beef production in China over the past few decades .At the inception of the reform and opening-up period in China, which began in 1978, the annual beef production amounted to less than 310,000 tonnes. However, by 2023, this figure had increased dramatically to 7.53 million tonnes, signifying a substantial rise and firmly establishing China as a significant contributor to global beef production[1].Concurrently, the enhancement of living standards among Chinese residents has led to a noticeable shift in meat consumption patterns and habits. With rising incomes and changing dietary preferences, beef has prominently emerged as a key component of the meat consumption structure in China[2].In 2022, the demand for beef reached 9,867,300 tonnes, marking a 6.1% increase compared to the previous year[3]. Despite this substantial progress, the development of China's beef industry faces several constraints that hinder its ability to fully meet the escalating market demand. One significant challenge is the prolonged cycle of domestic beef cattle breeding, which requires a considerable amount of time and resources[4].Additionally, high production costs, including feed, labor, and healthcare, further strain the industry's profitability. Limited environmental resources, such as land and water, also pose challenges as the industry expands. These factors, combined with the increasing demand, have created a significant production gap[5].In 2022, China's beef production fell short of meeting domestic demand by 2.684 million tonnes[6]. This production gap has led to a considerable reliance on imports, with China continuing to import large quantities of beef to supplement domestic supplies. The persistent discrepancy between beef production and demand underscores the need for further reforms and improvements within the industry.

The volatility of beef prices is influenced by an intricate interplay of various factors,these multifaceted influences encompass supply factors, demand dynamics, institutional policies, and other pertinent variables that collectively shape the market landscape for beef[7].In terms of supply factors, The cost of producing beef cattle is a significant consideration, encompassing expenses related to litter, feed, as well as the dual considerations for milk and beef production. The prolonged breeding cycle of beef cattle, coupled with the high risks and substantial costs associated with farming, have a major impact on producers' production decisions[8]. These costs and risks often dictate the volume of beef supply, which in turn influences market prices. Furthermore, a decline in milk prices can prompt dairy farmers to accelerate the culling of low-productivity cows. This practice augments the supply of beef in the market, as these cows are often processed for meat, thereby affecting beef prices. Fluctuations in

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maize prices, a crucial input in beef production, impact the beef market through the industrial chain transmission mechanism. An escalation in the cost of maize leads to increased farming costs, which are subsequently reflected in elevated beef prices[9].From a demand perspective, several factors contribute to beef price volatility. Income levels, consumption preferences of both urban and rural populations, and price changes of substitute products etc[10]. As income levels rise among urban and rural residents, there is a shift in the consumption structure of meat products. Consumers are increasingly inclined to purchase high-quality meats such as beef and mutton, which drives up demand and can lead to higher prices. Moreover, price fluctuations among different meat products induce substitution relationships, a phenomenon economically termed as the substitution effect. When beef prices rise, consumers tend to shift their purchases towards alternative meats like lamb, pork, and poultry, which are often perceived as more affordable[11]. This substitution not only influences the demand for beef but also affects its prices. Regarding institutional policy, China's reliance on beef imports introduces another layer of complexity to the market[12]. Policies related to trade, tariffs, and quotas can significantly impact the supply and prices of beef in the domestic market. Changes in international trade agreements, as well as political and economic relationships with beef-exporting countries, can all have far-reaching consequences for the beef industry in China. The paper aims to provide theoretical support for reforming the supply side of the country's beef industry and ensuring the stability of the beef market. By addressing the constraints and challenges faced by the industry, policymakers and stakeholders can work towards achieving a more sustainable and efficient beef production system that better meets the needs of Chinese consumers.

2. Data source and indicator selection.

In this study, the monthly price of beef from November 2019 to October 2024 and the data of corn price, imported beef price, chicken price, pork price and lamb price for a total of 58 months in the same period are selected as the sample data for analysis. The price data for imported beef are derived from the price information for imported frozen beef published by the General Administration of Customs. These figures are calculated based on the total amount and quantity of imported frozen beef per month. (Wu Duck Zhu, 2024) The data on the prices of beef, pork, chicken and corn were derived from the HBN Global Agriculture Database. This involved converting the weekly data into monthly data by calculating the arithmetic mean and standardising all units into Yuan/kg. In this study, the beef price is employed as the explanatory variable, with five explanatory variables selected for analysis: pork price, lamb price, chicken price, corn price and imported beef price, as shown in Table 1.

Table 1: Explanatory variables and abbreviations.

Explanatory variables	Pig price	Lamb price	Chicken price	Corn price	Imported beef price
Acronyms	X1	X2	X3	X4	X5

3. Model building and data analysis

In this study, the sample data were analysed using State18 for descriptive statistics, Pearson correlation analysis, variance inflation factor (VIF) test, and ordinary least squares (OLS) regression analysis. The OLS regression analysis was employed to ascertain the linear impact of one or more independent variables on the dependent variable, under the assumption that the observed values are independent of each other. The present study considers the influence of multiple factors on beef prices and constructs an OLS multiple linear regression model to determine the effect of the respective variables on the dependent variable.

$$Y = \beta 0 + \beta 1 * X1 + \beta 2 * X2 + \beta 3 * X3 + \beta 4 * X4 + \beta 5 * X5 + \varepsilon$$

Where, β 0 is the intercept term, β 1 – β 5 is the regression coefficient, and ε is the error term.

3.1 Descriptive analysis

Descriptive statistical analysis is a method of exploring the fundamental characteristics of variables, with a particular focus on the trend of concentration and dispersion of continuous variables. In order to gain a comprehensive understanding of the characteristics of the sample, this study initially conducted a descriptive statistical analysis of the variables within the sample. The results of this analysis are presented in Table 2 below.

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Table 2: Descriptive analyses

Variable	Mean value	Standard deviation	Minimum value	Maximum value	Observed value
Y	44.45	2.07	38.27	47.01	58
X1	20.84	6.32	14.8	34.27	58
X2	41.39	1.77	37.09	44.17	58
X3	12.89	0.49	12.35	14.8	58
X4	1.28	1.63	0.92	1.47	58
X5	38.99	5.61	30.77	51.95	58

As demonstrated in Table 1, the mean price of beef is 44.45 yuan, with a standard deviation of price fluctuation of 2.07 yuan. The highest recorded price is 47.01 yuan, and the lowest is 38.27 yuan. This observation is indicative of the high concentration of beef prices between 2019 and 2024, which have generally remained relatively stable despite occasional price fluctuations. In contrast, the price of pig meat demonstrates greater volatility, with a price range of 14.8 yuan to 34.27 yuan per kilogram, and an average price of 20.84 yuan per kilogram. This indicates a significant degree of instability in the pig meat price over an extended period. The average price of chicken is 12.89 yuan/kg, with a standard deviation of 0.49 yuan/kg, indicating a relatively concentrated data distribution around the mean value. The mean price of mutton is 41.39 yuan / kg, the standard deviation is 1.77, and the highest recorded price is 44.17 yuan / kg; the lowest recorded price of corn is 1.7 yuan / kg, the highest recorded value is 2.76 yuan / kg, and the mean price is 2.08 yuan / kg. It is evident that the prices of lamb and corn tend to be higher overall, yet they remain relatively stable. The mean price of imported beef is 38.99 yuan, with a price range between 30.77 yuan and 51.95 yuan, indicating significant price variation. Furthermore, the standard deviation of the price of imported beef is significant, indicating that the overall price level of imported beef is low and the price volatility is substantial.

3.2 Pearson correlation analysis

Pearson correlation analysis is a statistical method used to reflect the closeness of the linear relationship between two continuous variables, and the correlation coefficient (r) is a measure of the interdependence between two variables. If $r > 0$, it means that there is a positive correlation between the two variables, i.e. the two variables become larger or smaller at the same time, if $r = 0$, it means that there is no linear correlation between the two variables, and $r < 0$, it means that there is a negative correlation between the two variables, and that an increase in one variable leads to a decrease in the other variable. Usually, if $|r|$ is greater than 0.8, it indicates a strong linear relationship between the variables; if $|r|$ is less than 0.3, it indicates a weak correlation between the variables. In this paper, the Pearson correlation coefficient analysis was used to analyse the degree of interaction between the beef price and the pig, chicken and lamb prices, as well as the maize price and the imported beef price, in order to visually reflect the correlation between the variables.

The correlation coefficient (r) is a statistical tool to assess the closeness of the relationship between two variables. When $r> 0$, it means that two variables will become larger or decrease at the same time, when $r =0$, there is no linear correlation between two variables, and $r <0$, indicating that an increase of one variable triggers a decrease in the other variable. Generally speaking, if $| r |$ is greater than 0.8, the linear relationship between variables is strong; if $| r |$ is less than 0.3, the correlation between variables is weak. This paper uses correlation coefficient analysis to analyze the interaction between beef and pig, chicken and mutton, corn and imported beef.

Table 3: Results of correlation test

	Lny	lnx1	Lnx2	Lnx3	Lnx4	Lnx5
lny	1.000					
lnx1	0.098	1.000				
lnx2	0.836***	0.200	1.000			
lnx3	0.156	0.618**	-0.005	1.000		
Lnx4	0.448***	-0.604***	0.371***	-0.578***	1.000	
Lnx5	0.542***	-0.304**	0.367***	0.139	0.365***	1.000

(Note: *, **, *** are significant at the 10%, 5% and 1% levels respectively)

The results of the correlation test demonstrate in Table 3 that the correlation coefficients of beef price with pig price, lamb price, chicken price, corn price and imported beef price are 0.098, 0.836, 0.156 and 0. The correlation coefficients of beef price with lamb price, corn price, and imported beef

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price are statistically significant at the 0.01 level, indicating a positive correlation relationship. The correlation coefficients of beef price with lamb price, corn price, and imported beef price are 0.448 and 0.542, respectively. In particular, the correlation coefficient r for the price of mutton is greater than 0.8, indicating a strong linear relationship between beef and mutton. In contrast, the correlation coefficients for the price of hogs and chicken are not statistically significant. It can thus be concluded that there is a significant positive correlation between the price of beef and the price of mutton, as well as between the price of corn and the price of imported beef. In contrast, the correlation with the remaining variables is relatively weak.

3.3 Multicollinearity test

In order to circumvent the potential interference of subsequent regression analysis, the variance inflation factor (VIF) was subjected to rigorous testing.

Table 4: Multicollinearity test

Variant	VIF	1/VIF
x1	4.03	0.248306
x2	3.06	0.326910
x3	2.66	0.376334
x4	2.28	0.438718
X5	2.06	0.484337
Mean VIF	2.82	

The findings of the study are presented in Table 4. In the event of the variance inflation factor (VIF) value exceeding 10, it can be concluded that a severe multicollinearity issue is present. Conversely, if the VIF value is less than 10, it signifies that the multicollinearity between each independent variable and the dependent variable is negligible, and it will not compromise the stability of the model or the accuracy of prediction. In this study, the average VIF value is 2.82, which is less than 10, and it can be concluded that no severe multicollinearity problem exists in the model.

3.4 Results of the OLS regression analysis

OLS regression is a fundamental linear regression technique employed to ascertain the parameters of a linear regression model and to examine the influence of one or more independent variables on the dependent variable.

Table 5: OLS regression coefficients

Number of obs	F(5, 52)	Prob > F	MS	R-squared	Adj R-squared	Root MSE
58	50.05	0.0000	40.4632484	0.8280	0.8114	0.89915
Variant	Coefficient	Standard error	t-value(t)	P>|t|	95%CI	
x1	0.0289814	0.0378194	0.77	0.447	-0.0469087~0.1048715	
x2	0.6904629	0.1018532	6.78	0.000	0.4860794~0.8948463	
x3	1.229782	0.3931012	3.13	0.003	0.440967~2.018598	
x4	5.097905	1.28129	3.98	0.000	2.526808~7.669001	
x5	0.0635771	0.0305029	2.08	0.042	0.0023686~0.1247856	
Constant	-9.606778	6.055963	-1.59	0.119	-21.75896~2.5454	

The results presented in Table 5 demonstrate that F(5, 52) = 50.05, indicating that the model has passed the F-test and is statistically significant. This finding supports the appropriateness of utilising ordinary least squares (OLS) for regression analysis. The P-values of variables X2, X3, X4 are less than 0.01, and the P-values of variables X1, X5 are less than 0.05, indicating that the regression equations have a high goodness of fit and satisfy the criterion of a 95% confidence interval.

The impact of beef price changes on lamb prices, chicken prices, corn prices and imported beef prices is significantly positive. The coefficient of lamb prices is positively significant at the 1% level. If the control variables remain unchanged, the price of lamb will prompt a 0.69-unit increase or decrease in the price of beef for every unit of enhancement. It can thus be demonstrated that the price of mutton exerts a positive influence on the price of beef. An increase of one unit in the price of maize is associated with a 0.69-unit increase in the price of beef. The coefficient has a p-value of 0.000, indicating that the price of maize has a significant positive impact on the price of beef. This result demonstrates that maize, as a basic cost of production in beef cattle breeding, influences the price of

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beef. The price of imported beef exerts a discernible influence on the price of beef, albeit one that is comparatively modest in comparison to the impact of lamb prices. The price of pork does not exert a statistically significant impact on the price of beef.

4. Conclusions and recommendations

The article presents an empirical analysis of the factors influencing the fluctuation of beef prices in China. The analysis is based on monthly data from the HBN Global Agricultural Database and the General Administration of Customs for the period from November 2019 to October 2024. An OLS regression model is constructed to investigate the relationship between the variables. The results of the correlation test indicate that fluctuations in the price of beef are influenced by those of lamb, corn, chicken and imported beef. The influence of chicken and pig prices on beef prices is less pronounced. The OLS regression results indicate that the effect of beef price is more pronounced when influenced by fluctuations in corn and lamb prices. Conversely, the price of chicken and imported beef have a more significant impact on the volatility of beef prices. The influence of pork prices on beef prices in China is relatively limited. An increase in corn prices will result in higher costs of beef cattle breeding, which will in turn lead to an increase in beef prices. The market price of lamb has a positive impact on the market price of beef. When the majority of consumers tend to purchase mutton, demand for mutton increases, thereby exerting upward pressure on the price of mutton. The price of imported beef exerts a direct influence on the domestic price of beef to a certain extent. However, the overall volume of beef imports remains constrained, rendering it challenging to promptly address the prevailing shortage of beef supply and the sustained high price situation in the near term.

The maintenance of beef price stability can serve to safeguard consumer demand for beef, stimulate production and consumption within China's beef industry, and facilitate a more rationalised market. This, in turn, can contribute to the sustainable development of the beef cattle industry. The following recommendations are put forth with regard to the principal factors influencing fluctuations in the price of beef.

(1) It is imperative to guarantee a consistent and reliable supply of feed resources, including corn and wheat. It is recommended that scientific feed management strategies, advanced feed processing technology and breeding management methods, and standardised, large-scale breeding be implemented in order to improve the conversion efficiency of feed. Furthermore, the combination of planting and farming should be encouraged, the timely expansion of feed reserves should be facilitated, and the safety of the feed supply should be ensured in order to prevent drastic fluctuations in feed prices, reduce the production costs of beef cattle farmers, enhance the enthusiasm of farming, and effectively ease the fluctuations in beef prices.

(2) The early warning and control system for the beef market, the substitutes market and the factor markets must be optimised.The pig and lamb substitute market must be effectively connected with the early warning and control system for corn, wheat and other factor markets. A comprehensive price information monitoring system must be established with the help of big data, the Internet and other modern information technologies, and price adjustments must be released. This will ensure the provision of clear and accurate market information for farmers, processors and consumers, thereby improving the incomplete and asymmetric nature of market information.Great importance should be attached to market fluctuations triggered by external factors such as sudden epidemics and public health and safety. It is vital to establish a modern three-tier disease prevention and control system consisting of the state, provinces and municipalities, and issue early warning information on abnormal price fluctuations in a timely manner to guide market participants to adjust their production and management strategies in accordance with changes in the market, and take appropriate interventions, such as the provision of financial subsidies, tax reductions and exemptions, and financial support, as necessary, to ensure that the stable operation of the livestock industry and the price system is maintained.

(3) Enhance the competitive advantage of China's beef industry in the global market. The present study finds that the competitiveness of Chinese beef products in the international market is inadequate, and the market share is comparatively negligible. The primary source countries of beef imports are Brazil, Argentina, Uruguay, the United States and Australia, among others. The high concentration of import source countries gives rise to the high potential risks of China's beef imports. In order to enhance the competitiveness of China's beef industry in the global market, it is recommended that the country enter into a free trade agreement (FTA) with Australia and New Zealand, as well as other

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countries. Such an FTA would facilitate the expansion of beef import sources, beef cattle production resources and beef products that conform to the Chinese import quality standards of the national trade agreement. Furthermore, it would allow China to take advantage of the competitive advantage of different source countries, improve the beef import preferential conditions and promote the development of the Chinese beef industry on an international level. A comparison of the scientific and technological level of China's beef market with other international animal husbandry markets reveals a disparity, placing China at a disadvantage when compared with similar international products. Consequently, in the context of beef cattle industry development in our country, it is imperative to draw lessons from international advanced experience, cultivate the capacity of beef trade enterprises to engage in international business development, increase investment in breeding, and concurrently increase investment in beef cattle breeding technology. This will ensure the enhancement of beef product quality standards, the strengthening of beef product quality certification and testing, and the enhancement of our country's beef competitiveness in the international market.

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