# Research on the Correlation Between China's Meat Non-staple Food Prices Based on Univariate Regression

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**Abstract—**In recent years, the price of non-staple foods for meat in China has fluctuated frequently, which has brought a greater impact on the daily consumption of residents. The author of this article selected the monthly prices of pork, beef, mutton and chicken in China in the past 20 years, and used a linear regression model and a quantile regression model to empirically analyze the price correlation between pork and other meats. The linear regression results show that all meat prices are significantly correlated with pork prices in the same direction; quantile regression results show that the parameter values of the median regression model are closer to the correlation when the pork market is running smoothly; in the lower quartile, only chicken prices and pork prices have a significant correlation, while beef and mutton prices have a weak correlation with pork prices; at the upper quartiles, all meat prices are closely related to pork prices. The results show that using the quantile regression model can dig deeper into the relationship between meat prices.

**Keywords-**relevance; meat prices; pork market; quantile regression

## 1 INTRODUCTION

Non-staple meat food is an important part of the food consumption of Chinese residents. With the increase of income level, the demand of Chinese residents for meat consumption is becoming stronger. In 2020, China's total meat output was 76.39 million tons, of which pork output was 41.13 million tons. Pork accounted for the largest proportion of China's meat consumption market. In addition, meat non-staple food is an important part of CPI, and its price affects changes in domestic CPI and affects inflation expectations. The price volatility of China's meat market has increased in recent years. And unexpected volatility of meat prices will affect the decisions of consumers and investors, and further affect the smooth operation of the domestic economy. Meat products are all high-nutritional and high-protein foods, and they have a certain degree of substitution. The substitution part is manifested in the synergy of price changes, and the synergy of high price fluctuations has seriously affected the meat consumption

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demand of my country's urban and rural residents. In addition, the meat market is always in a state of imbalance between supply and demand and cyclical changes in meat prices. It is also more difficult for the relevant departments to control the meat market. Therefore, the analysis of the correlation between meat prices is helpful to grasp the operation law of the meat market, and then provide a certain reference for the formulation of related policies.

There is a lot of literature on the correlation between residents' meat prices. The first is to use the AIDS model and the ELES model to study the relationship between the proportions of consumption expenditures of each meat from the perspective of price and volume, and construct and calculate the cross-price elasticity of meat to reflect the correlation [1-3]. The second is to study from the perspective of time series, part of which studies the influence of upstream industries and raw material prices on meat prices from the perspective of vertical industrial chains [4], and the other part starts from the relationship between horizontal meat product prices and studies the correlation between the transmission mechanism of meat price fluctuations and meat prices [5-8].

From the above two research perspectives, the former combines production and price. However, due to the limitation of the source of monthly meat production data, annual data on production and price are often used to study price elasticity, which weakens the sensitivity of the horizontal correlation of meat price fluctuations. The latter studies mostly use models based on linear assumptions to study meat price fluctuations and the impact of other meat prices, which may ignore the outliers and nonlinear relationships that occur when the price of the research object fluctuates at a high level. Some domestic scholars have noticed this situation. In order to avoid the frequent false regression of multiple regressions, this article uses univariate linear regression and univariate quantile regression methods to explore the correlation between pork and beef, mutton and chicken prices at different levels of pork price fluctuations.

## 2 DATA DESCRIPTION.

The data for this study comes from the China Animal Husbandry Information Network. The monthly prices of boneless pork, boneless beef, bone-in mutton and white striped chicken are selected as the corresponding indicators for the prices of pork, beef, mutton and chicken. The sample interval is from January 2001 to October 2020, and there are 238 samples for each price series. In order to eliminate the price factor, the price series was adjusted for CPI based on January 2001. In addition, in order to eliminate the influence of seasonal factor fluctuations, the CPI adjusted price series was adjusted for the X-12 season. Remember PP, BP, MP, and CP for the processed pork, beef, mutton, and chicken price variables, respectively.

This article uses the price growth rate to replace the price. Because the mutual influence between prices has a certain lag, the price period in this article is selected at an interval of 3 months. Formula (1) is as follows:

$$R_{i,t} = \left[P_{i,\mathrm{t}} - P_{i,\mathrm{t}-3}/P_{i,\mathrm{t}-3}\right] \times 100\% \quad (1)$$

In the above formula, $\mathrm{P}_{\mathrm{i,t}}$ represents the price of the i-th price series in period t, $R_{i,t}$ represents the price growth rate of the i-th price series in period t, where i=1 (PP), 2(BP), 3(MP), 4(CP);

and the statistical description of the growth rate of the price series is shown in Table 1 (J-B represents the statistics of Jarque-Bera, *** denotes significance at 1%) .

It can be seen from Table 1 that the average increase in pork price is 1.88%, the minimum is -17.20%, and the maximum is 59.13%. Its standard deviation is 0.1029, which is much higher than the standard deviation of the growth rate of other meat prices, indicating that pork prices are volatile. The average growth rate of chicken prices is the smallest, but its fluctuations are not the smallest. The price of beef and mutton has risen steadily with small fluctuations. The average growth rate of chicken prices is the smallest, but its fluctuations are not the smallest. The price of beef and mutton has risen steadily with small fluctuations. In addition, except for the chicken price growth rate which is a left skewed distribution function, the skewness of the other meat price growth rates is greater than 0, which is a right skewed distribution function. The kurtosis of all meat price growth rates is greater than 3, showing the characteristic of spikes. At the same time, the J-B test statistic is significant at the 1% significance level, indicating that the series of meat price growth rates do not follow a normal distribution.

**TABLE 1.** STATISTICAL DESCRIPTION OF MEAT PRICE GROWTH RATE

| | **Mean** | **Median** | **Min** | **Max** | **SD** | **Skewness** | **Kurtosis** | **J-B** |
|---|---|---|---|---|---|---|---|---|
| R1 | 1.88% | 0.52% | -17.20% | 59.13% | 0.1029 | 1.775 | 9.317 | 512.57*** |
| R2 | 1.82% | 0.95% | -2.25% | 15.84% | 0.0296 | 1.913 | 7.186 | 313.13*** |
| R3 | 1.58% | 1.30% | -7.00% | 11.55% | 0.0304 | 0.530 | 3.907 | 18.90*** |
| R4 | 0.49% | 0.26% | -15.99% | 13.15% | 0.0407 | -0.202 | 4.787 | 32.87*** |

## 3 MODEL DESCRIPTION

In traditional regression models, more emphasis is placed on the influence of explanatory variables on the conditional expectations of the explained variables, which is essentially mean regression. However, the use of mean regression not only has to satisfy the condition that the mean value of the disturbance term is zero and the variance is the same, but also is susceptible to the influence of extreme values. More importantly, when the conditional distribution y|x is not a symmetrical distribution, the mean regression is difficult to reflect the characteristics of the entire conditional regression. Quantile regression can better solve these problems. In the presence of extreme values, the quantile estimator is more robust than the least squares estimator.

Suppose the probability distribution of random variable Y: $F(y) = \mathrm{Prob}(Y \leq y)$ and Y's $\tau$ quantile is formula (2):

$$q(\tau) = \inf\{y: F(y) \geq \tau\}, \quad 0 < \tau < 1 \tag{2}$$

When $\tau$ is given, its linear function model is formula (3):

$$\hat{y}_\tau(x_i) = x_i'\beta_\tau \tag{3}$$

$\beta_\tau$ is the quantile regression coefficient of τ, and the estimator of $\beta_\tau$ can be defined as formula (4), a problem of minimizing the absolute value of the weighted residual:

$$\min_{\beta_\tau} \sum_{i:\ y_i \geq x_i'\beta_\tau}^{n} \tau \left|y_i - x_i'\beta_\tau\right| + \sum_{i:\ y_i < x_i'\beta_\tau}^{n} (1-\tau) \left|y_i - x_i'\beta_\tau\right| \tag{4}$$

The above formula contains absolute value, so it is solved by linear programming method. The quantile regression model is shown in formula (5):

$$R_{1\tau,\ t} = C(\tau) + \beta R_{i\tau,\ t} + \varepsilon_t,\ \ i=2, 3, 4, 5 \tag{5}$$

The form of the univariate linear regression model is formula (6):

$$R_{1,\ t} = C + \beta R_{i,\ t} + \varepsilon_t,\ \ i=2, 3, 4, 5 \tag{6}$$

Both models have only one explanatory variable, which not only avoids the spurious regression caused by false regression, but the regression coefficient means the correlation between the two, not the traditional causal relationship.

## 4 EMPIRICAL ANALYSIS AND DISCUSSION

It can be seen from Table 1 that all data series do not obey the normal distribution and have extreme values, which are more suitable for quantile regression. In this paper, OLS is used to estimate the coefficients in the mean regression model, and HAC standard errors are used to make the standard errors more accurate in the presence of heteroscedasticity and autocorrelation. The results are presented as OLS. In quantile regression, Q0.05, Q0.20, Q0.50, Q0.80 and Q0.95 correspond to the 0.05, 0.20, 0.50, 0.80, 0.95 quartile points, and the standard error and confidence interval of the parameters are estimated by the bootstrap method.

### 4.1 Pork and Beef Price Correlation Test

The regression results are shown in Table 2 (*, **, *** denote significant at the level of 10%, 5%, and 1% respectively, The parentheses are standard errors, and The following table is the same).

**TABLE 2.** OLS AND QUANTILE REGRESSION RESULTS OF PORK AND BEEF PRICE GROWTH RATES

| | OLS | Q0.05 | Q0.20 | Q0.50 | Q0.80 | Q0.95 |
|---|---|---|---|---|---|---|
| R2 | 1.1899** | 0.0436 | 0.6844* | 0.6384*** | 2.1047* | 3.0373*** |
| | (0.5603) | (0.4204) | (0.3659) | (0.2065) | (1.1100) | (0.9430) |
| C | -0.0028 | -0.1158*** | -0.0664*** | -0.0051 | 0.0604*** | 0.1249*** |
| | (0.0108) | (0.0124) | (0.0114) | (0.0060) | (0.0141) | (0.0158) |

From the OLS parameter estimation results in Table 2, beef and pork prices are significantly correlated. For every 1% increase in beef prices, pork prices increase by 1.19% over the same period.

In order to more intuitively display the change of the coefficient of quantile regression, Figure 1 shows the regression coefficient and 95% confidence interval (gray area) under different quartiles, and the regression coefficient and 95% confidence interval estimated by OLS are used as the reference system (the same figure below).

Combining Figure 1, we can see that at the low quintiles of 0.05, that is, when the price of pork falls by a large margin, there is no significant correlation between pork prices and beef prices; When the pork price growth rate is at the median 0.50 quartile (the median is about 0.5%) and its close quartile, the coefficient is stable at about 0.65, and the standard error of the estimated coefficient is small. This shows that when the pork price growth rate fluctuates within an appropriate range, that is, when the pork market is stable, the correlation between pork and beef prices is stable. Represented by the median regression coefficient (the same below), for every 1% increase in beef prices, pork prices increase by approximately 0.64% over the same period, which is lower than the estimated coefficient of OLS; At the 0.95 quintiles, pork prices have risen by a large margin, and beef and pork prices are closely related. For every 1% increase in beef prices, pork prices increase by about 3.04% over the same period, which is about 4.7 times the value of the pork market during the stable operation period.

### 4.2 Pork and Mutton Price Correlation Test

The regression results are shown in Table 3, and the quantile regression coefficient changes are shown in Figure 2.

**TABLE 3.** OLS AND QUANTILE REGRESSION RESULTS OF PORK AND MUTTON PRICE GROWTH RATES

| | OLS | Q0.05 | Q0.20 | Q0.50 | Q0.80 | Q0.95 |
|---|---|---|---|---|---|---|
| R3 | 0.8850** | 0.0570 | 0.0958 | 0.4955** | 0.8875 | 1.8729*** |
| | (0.4336) | (0.3539) | (0.2929) | (0.2291) | (0.6075) | (0.5632) |
| C | 0.0048 | -0.1158*** | -0.0544*** | 0.0001 | 0.0623*** | 0.1698*** |
| | (0.0126) | (0.0132) | (0.0128) | (0.0047) | (0.0143) | (0.0172) |

From the OLS results in Table 3, there is a significant correlation between the prices of mutton and pork. For every 1% increase in mutton prices, pork prices increase by 0.86% over the same period.

Combined with Figure 2, at the low quintiles of 0.05 to 0.40, that is, when the price of pork falls, there is no significant correlation between the price of pork and the price of mutton; At the 0.40 to 0.80 quintiles, that is, when the price of pork has a small increase, the correlation between the price of mutton and the price of pork rises slightly. However, the test failed to pass the 10% significance level (P=0.2846) when the regression coefficients at the 0.40 and 0.80 quantiles were equal. It can be considered that when the pork market is running smoothly, the correlation between the price of mutton and the price of pork is stable. For every 1% increase in the price of mutton, the price of pork increases by about 0.50% over the same period. At the 95% quintiles, that is, when the price of pork has increased significantly, the price of mutton and pork is closely related. For every 1% increase in the price of mutton, the price of pork will increase by approximately 1.87% over the same period, which is 3.7 times the stable operation of the pork market.

### 4.3 Pork and Chicken Price Correlation Test

The regression results are shown in Table 4, and the quantile regression coefficient changes are shown in Figure 3.

**TABLE 4.** OLS AND QUANTILE REGRESSION RESULTS OF PORK AND CHICKEN PRICE GROWTH RATES

| | OLS | Q0.05 | Q0.20 | Q0.50 | Q0.80 | Q0.95 |
|---|---|---|---|---|---|---|
| R4 | 1.4354*** | 0.9182*** | 1.1259*** | 1.2468*** | 1.3738*** | 2.0380*** |
| | (0.3083) | (0.2166) | (0.2803) | (0.2050) | (0.2986) | (0.3841) |
| C | 0.0118 | -0.1131*** | -0.0472*** | -0.0025 | 0.0737*** | 0.1578*** |
| | (0.0111) | (0.0120) | (0.0066) | (0.0048) | (0.0142) | (0.0172) |

From the OLS results in Table 4, the prices of chicken and pork are significantly correlated. For every 1% increase in chicken prices, pork prices increase by 1.44% over the same period, which is higher than the estimated value of the OLS regression of beef and mutton with pork prices, indicating the strongest correlation between chicken and pork prices.

Combining Figure 3, unlike beef and mutton, at the low quintiles of 0.05, the correlation between chicken and pork prices is still stable and strong. And the test fails the 10% significance level (P=0.1890) when the regression coefficients at the 0.05 and 0.80 quantiles are equal, and there is no significant difference. It can be considered that when the pork market is running smoothly, the correlation between the price of chicken and the price of pork is stable. For every 1% increase in the price of chicken, the price of pork will increase by about 1.25% over the same period; at the 95% quintiles, that is, when the price of pork has increased significantly, the price of chicken is closely related to the price of pork. For every 1% increase in the price of chicken, the price of pork rises by approximately 2.04% over the same period. This is the value of the stable operation of the pork market 1.6 times. In short, the relationship between chicken price and pork price is relatively stable and close, which also shows from the price perspective that chicken is a good substitute for pork throughout the period.

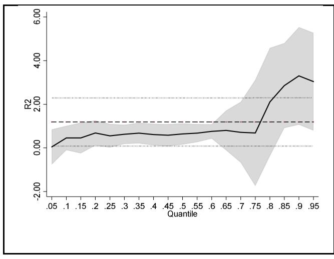


**Figure 1.** Changes in regression coefficients of pork and beef prices in different quartiles

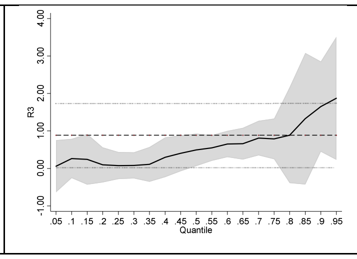


**Figure 2.** Changes in regression coefficients of pork and mutton prices in different quartiles

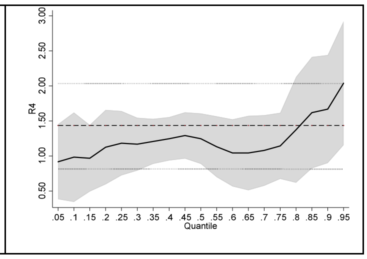


**Figure 3.** Changes in regression coefficients of pork and chicken prices in different quartiles

## 5 CONCLUSION

First, the OLS regression results show that all meat prices are significantly correlated with pork prices in the same direction; at the low quantile points, only chicken prices and pork prices have a significant correlation. Secondly, the coefficient of the median regression is closer to the correlation when the pork market is running smoothly, that is, pork and chicken prices are the strongest. For every 1% increase in pork prices, the price of chicken will increase by 1.25% and the price of beef by 0.64% during the same period and the price of mutton increased by 0.50%. Finally, at the high quantile point, all meat and pork prices are closely related, which is much higher than the median regression result. In the same period, for every 1% increase in pork price, beef price increased by 3.04%, chicken price increased by 2.04% and mutton price increased by 1.87%, which are 4.75 times, 1.63 times and 3.74 times of the correlation when the pork market operates smoothly. By comparing the univariate linear regression model and the quantile regression model, a different conclusion is reached, which shows that the use of the quantile regression model can dig deeper into the relationship between meat prices.

By comparing the univariate linear regression model and the quantile regression model, a different conclusion is reached, which shows that the use of the quantile regression model can dig deeper into the relationship between meat prices. Nowadays, the price of pork in China fluctuates greatly, and the price of beef and mutton continues to run at a high level. Combined with the results of the quantile regression in this article, it may be possible that when the price of pork changes, the price of beef and mutton will rise or fall, leading to a continuous increase in the price of beef and mutton in my country in the long run. There is a close correlation between the prices of pork and chicken at all quantiles, indicating that chicken is a good substitute for pork. It is possible that consumers have similar preferences for chicken and pork, and the cost of preference shift is relatively small. Regulating the chicken market can help stabilize the pork market, thereby curbing the trend of continued high prices of beef and mutton.

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