Team Control Number

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Problem Chosen

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Analysis of the Pork Price Fluctuations in China

Summary

In this paper, in view of the fluctuation of pork price, the collected data is taken as the entry point, the relationship between various factors and pork price is integrated, and the gray correlation analysis method is used to establish the relationship model between pork price and its influencing factors. We draw a conclusion that the corn price and chicken price are the main factors affecting pork price fluctuations, with correlations of 0.85 and 0.8 respectively.

Then we use the cobweb theory to analyze the trends in the number and price of live pigs from 2010 to 2018, and then draw a reasonable pig raising plan: select the appropriate number of pigs and able sows as reserve farming according to the market supply and demand changes.

Finally, we use BP neural network time series method, control theory and pig growth cycle to predict the supply and demand of pork, and use the supply and demand balance model to solve the corresponding optimal balance quantity, and draw the following conclusions: 50,000 sows should be supplied at least a month; at the peak of demand, 25% of the total demand for frozen pigs should be stored.

Key word: Pork price, gray correlation analysis, cobweb theory, BP neural network

Content

1. Introduction

1.1 Background

At present, pork is one of the important livestock products in China and plays an important role in animal husbandry production and people's daily consumption. Pork is the most consumed meat in China, and fluctuations in pork prices have a major impact on residents' lives. In the past six months, the rapid rise in pork prices in China has attracted the attention of the government and a large number of residents. In less than 160 days, the price of pork rose from 14.68 yuan/kg on May 28, 2019 to 40.11 yuan/kg on November 1, 2019. Fortunately, there has been a certain downward trend recently. However, we are not sure whether pork prices are under control and whether pork prices can return to normal levels.

1.2 Work

According to the meaning of the question, the problems to be solved in this paper are:

1.Use the data from the past few years to analyze the common influencing factors of pork price volatility; to determine whether fluctuations in pork prices are highly correlated with the general fluctuations in pork prices, and if not, what are the main influencing factors;

2.Research on the fall in pork prices. Pork farming usually has a certain periodicity. When the price of pork is high, a reasonable breeding plan is proposed. Under the premise that pork farming cannot be completed in a short time, other reasonable purchasing plans can be proposed to ensure the relative stability of domestic pork prices;

3.Research on the best supply and demand strategy for pork. When the demand for pork in different regions is relatively stable, the best pork farming plan is proposed for different time zones in different regions; in order to effectively respond to the peak demand of pork in a certain region, an effective pork storage strategy is proposed to ensure the stability of pork prices.

2. Problem analysis

2.1 Analysis of question one

To analyze common factors that affect pork price volatility, and to find the main influencing factors. For the first problem, firstly, by analyzing and comparing the monthly data of pork prices in China from May 2010 to October 2019, it is concluded that the price of pork in China shows a linear growth trend in the short term, especially in May 2019 to 2019. In the month, pork prices showed a sharp increase.

Through the analysis of monthly data on the price of feed for pigs, corn, soybean meal, chicken and finishing pigs, using the above data and pork price data for correlation analysis, the price of pig, corn, chicken and finishing pig compound feed has a certain impact on pork prices. Then, using the gray correlation method, taking pork price as a reference sequence, the price of mixed feed of pig, corn, soybean meal, chicken and finishing pigs was used as a comparison sequence to determine the correlation between each influencing factor and pork price to determine the main factors affecting pork price fluctuation.

2.2 Analysis of question two

For the second problem, we can first obtain a fitted autoregressive model by analyzing the hog price chart from January 2010 to December 2018. After the time series is decomposed, we can clearly see the monthly average pig from the trend item. The price is slowly reduced first and then rises rapidly.

Combined with the cyclical fluctuations of prices in the production of pigs and the sale of pork. In the case of pork prices, farmers are chasing profits, increasing the supply of sows and pigs, causing pig prices to fall, farmers reducing supply, and pig prices rising again. This feature shows that the interaction between price and output restricts the price and output in the equilibrium situation. Therefore, this paper analyzes the price and supply quantity of live pigs from the perspective of supply and demand balance through the theory of spider web, and gives the corresponding feeding plan. The procurement plan has kept pork prices relatively stable.

2.3 Analysis of question three

For the third problem, this paper takes the supply and demand of pork in the Northeast for nearly ten years as the research object. The time series method was used to predict the demand for pork, and the predicted value of pork demand in Northeast China was obtained. Pork supply predictions are given by control theory and pig growth cycle. Finally, through the supply and demand balance regulation model, the predicted pork demand results and supply results are linked to obtain the solution of the model, and relevant suggestions are proposed based on the predicted supply and demand situation and the solution of the equilibrium model.

3. Symbol and Assumptions

3.1 Fundamental assumptions

1.Assume that the collected data are accurate and effective and do not affect the overall analysis;

2.Assume that there are no major epidemics, disasters or national policy interventions that cause sudden changes in pork prices;

3.Assume that the consumer's demand for pork does not change significantly;
4.Ignore the impact of pork imports and exports on domestic pork prices.

3. 2 Symbol Description

Table 1. Symbol Description

Notations	Definitions
P	Pork price
S	Pig price
Y	Corn price
D	Cardamom price
C	Chicken price
L	Feed price
i	Consider the number of factors
j	The number of values corresponding to the i factor
$\bar{x}_i(j)$	Average of all values of the i impact factor
ρ	Resolution coefficient
r_i	Correlation
P_e	Equilibrium price
$k_i(t)$	The proportion of demand in the first month of t-year to the total demand for the year
$z(t)$	Total number of pigs at t time

4. Establishment and Solution Model

4.1 Analysis of factors affecting pork price based on grey correlation method

4.1.1 Data collection and processing

Monthly data on pork prices, pig prices, corn prices, soybean meal prices, chicken prices, and feed prices for finishing pigs from May 2010 to October 2019 were collected. Figure 1 depicts the trend of pork prices in China from May 2010 to October 2019.

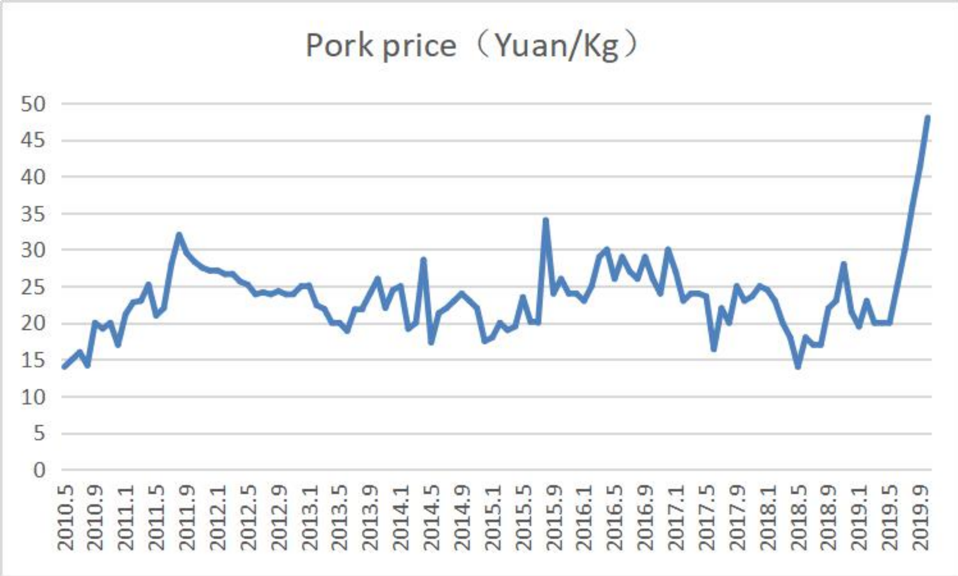

Fig 1. Trend of pork prices in China from May 2010 to October 2019

As can be seen from Figure 1, before May 2019, the overall trend of pork prices in China was relatively stable, and the highest pork price was 34 yuan/kg. Since May 2019, pork prices have shown a sharp increase, with a special reason for the spread of African swine fever. Figure 2 shows the trends in pig prices, corn prices, soybean meal prices, chicken prices, and feed prices for finishing pigs from May 2010 to October 2019.

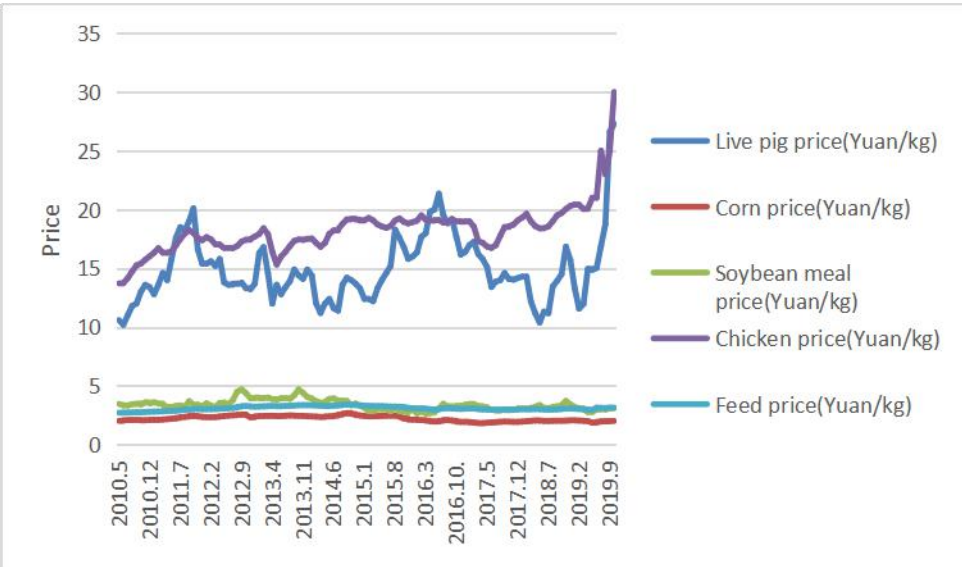

Fig 2. The trend of prices

As can be seen from the figure above, pig prices and chicken prices are generally on the rise, while the overall trend of corn prices, soybean meal prices and feed prices is relatively stable. By comparing Figure 1 and Figure 2, it can be clearly seen that the pork price and the pig price and the fluctuation of the chicken price show a consistent trend. Therefore, it can be preliminarily judged that the price of pigs and the price of chicken have a certain influence on the fluctuation of pork prices.

4.1.2 Correlation analysis between pork price and various influencing factors

The correlation coefficient can be used to describe the relationship between variables, and it is preliminary to determine whether there is a correlation between the dependent variable and the explanatory variable. Using R language to analyze the relationship between pork price (P) and pig price (S), corn price (Y), soybean meal price (D), chicken price (C) and fattening pig compound feed price (L), you can get the correlation coefficient matrix of the variable, such as Table 2 shows.

Table 2. Variable Pearson correlation coefficient matrix

	P	Y	D	S	C	L
P	1.00	0.83	0.01	0.72	0.87	0.85
Y	0.83	1.00	0.03	0.97	0.95	0.98
D	0.01	0.03	1.00	-0.06	0.22	-0.05
S	0.72	0.97	-0.06	1.00	0.89	0.95
C	0.87	0.95	0.22	0.89	1.00	0.92
L	0.85	0.98	-0.05	0.95	0.92	1.00

As can be seen from Table 2, the linear correlation between chicken price, feed price, corn price and pig price and pork price is significant and highly correlated. Their correlation coefficients are 0.87, 0.85, 0.83, and 0.72, respectively. The linear relationship between soybean meal prices and pork prices is not significant.

4.1.3 Main factors affecting pork prices---Grey correlation analysis

The main factors affecting pork price volatility were analyzed using the grey correlation analysis method[1]. The grey relational analysis method is a quantitative comparative analysis method, which compares the similarity between the target series and the reference series to determine the closeness of the relevant factors in the reference series and the target factors, thereby reflecting the degree of association.

The main steps of the grey correlation analysis method are as follows:

(1) Determination of reference sequence matrix and target sequence matrix

Reference sequence X includes various factors $[X_1, X_2, X_3, \cdots, X_i]$ that affect the target sequence. Here, five factors including pig price, corn price, soybean meal price, chicken price, and feed price are selected as reference sequences; The target sequence Y selects the price of pork, and its sequence factor is $[Y_1, Y_2, Y_3, \cdots, Y_i]$. X and Y are also referred to as subsequences and parent sequences, respectively. The expression of the matrix is as follows:

Where $x_i(j)$ is the j-th value of the i-th influence factor X_i; $y_i(j)$ is the j-th value of the i-th target factor Y_i ; i is the number of factors considered; j is the number of values corresponding to the i-th factor.

(2) No-quantization of the data matrix

Because the data is different and the data is different, it is necessary to quantify the data. The commonly used non-classification processing methods are the range change method and the mean value conversion process; the calculation methods are:

$$x_i'(j)=\frac{x_i(j)-\min(x_i(j))}{\max(x_i(j))-\min(x_i(j))}$$

$$x_i'(j)=\frac{x_i(j)}{\bar{x}_i(j)}$$

Where X_i represents each value of the i-th influence factor; $\bar{x}_i(j)$ represents the average of all values of the i-th influence factor. Similarly, the non-class quantization matrix of the target sequence can be obtained as follows:

$$y_i'(j)=\frac{y_i(j)-\min(y_i(j))}{\max(y_i(j))-\min(y_i(j))}$$

Further processing the matrix without the quantization to obtain the difference sequence matrix Δ.

$$\Delta=\left|x_i'(j)-y_i(j)\right|$$

Take the maximum value $\Delta_{\max}$ and the minimum value $\Delta_{\min}$ in the difference sequence matrix Δ.

$$\Delta_{\max}=\max\Delta$$

$$\Delta_{\min}=\min\Delta$$

(3) The correlation coefficient matrix L has a value of l_{ij} ,

$$l_{ij}=\frac{\Delta_{\min}+\rho\Delta_{\max}}{\Delta+\rho\Delta_{\max}}$$

Where ρ is the resolution coefficient, and the value is $\rho\in(0,1)$, which is generally 0.5.

Relevance r_i is an indicator to measure the similarity of the indicator sequence, $r_i\in[0,1]$. And when the degree of association r_i is close to 1, the more sensitive the subsequence is to the parent sequence; conversely, the closer the degree of association is to 0, the less sensitive it is to the parent sequence. Its calculation can be obtained by:

$$r_i = \frac{1}{n}\sum_{j=1}^{n} l_{ij}$$

Where n is the number of influencing factors considered when calculating the relevance.

(4) Sensitivity evaluation and weight

The relevance degree r_i is sorted from large to small, which is the sensitivity ranking of the influencing factors. At the same time, the weight value a_i can be used to measure the influence degree of each influencing factor on the parent sequence. The weighting of each influencing factor can be obtained by the normalization of the influencing factors. The expression is as follows:

$$a_i = \frac{r_i}{\sum_{i=1}^{m} r_i}$$

Gray correlation analysis was used to solve the correlation between pork price and corn price, soybean meal price, chicken price, feed price and pig price. The pork price data sequence from May 2010 to October 2019 is:

$$Y = [14,15,16,14.2,20,19.2\cdots,25,30,36,41.4,48]_{k=114}$$

The corn price data sequence is: $X_1 = [2.03,2.09,2.1,\cdots,2.00,1.991,2.02,2.014]_{k=114}$

Soybean price data sequence is: $X_2 = [3.47,3.35,3.32,\cdots,3.056,2.972,3.102,3.105]_{k=114}$

Chicken price data sequence is: $X_3 = [13.72,13.76,14.16,\cdots,25,23,25,30]_{k=114}$

Feed price data sequence is: $X_4 = [2.72,2.73,2.73,\cdots,3.12,3.13,3.16,3.2]_{k=114}$

The hog price data sequence is: $X_5 = [10.6,10.2,11,\cdots,16.9,18.74,26.61,27.29]_{k=114}$

Initialize the data, dividing each sequence by the first data:

$$Y = [1,1.07,...,3.43]_{k=114}$$

$$X_1 = [1,1.02,\cdots,0.99]_{k=114}$$

$$X_2 = [1,0.97,...,0.89]_{k=114}$$

$$X_3 = [1,1,\cdots,2.19]_{k=114}$$

$$X_4 = [1,1,\cdots,1.18]_{k=114}$$

$$X_5 = [1, 0.96, \cdots, 2.57]_{k=114}$$

Find the absolute value of the sequence difference:

$$Y - X_1 = [0, 0.46, ..., 1.37]$$

$$Y - X_2 = [0, 1.29, ..., 2.15]$$

$$Y - X_3 = [0, 0.05, ..., 1.40]$$

$$Y - X_4 = [0, 0.49, ..., 1.04]$$

$$Y - X_5 = [0, 0.59, ..., 2.36]$$

Find the global maximum M and the global minimum m:

$$M = \max(\max_i (Y - X_i)) = 6.49$$

$$m = \min(\min_i (Y - X_i)) = 0$$

The coefficient formula based on the grey correlation analysis:

$$\zeta_i = \frac{m - \rho M}{(Y - X_i) + \rho M}$$

Where $i = 1, 2, ..., 5$, $\zeta_i = (\zeta_{i1}, \zeta_{i2}, ..., \zeta_{i114})$, j in ζ_{ij} indicates the number of components in the absolute value difference of each sequence. Finally, the five correlation coefficients are obtained as:

$$\zeta_i = \sum_j \frac{1}{114} \zeta_{ij}$$

$$\zeta_1 = 0.81, \zeta_2 = 0.58, \zeta_3 = 0.85, \zeta_4 = 0.80, \zeta_5 = 0.74$$

According to the degree of correlation, the impact of various factors on pork price fluctuations is: chicken price (0.85) > corn price (0.81) > pig feed price (0.80) > pig price (0.74) > soybean meal price (0.58).

In summary, chicken prices and corn prices are the main factors affecting pork price volatility.

4.2 Pig farming plan based on cobweb model

4.2.1 Data collection and processing

Draw a time series of monthly pork prices from May 2010 to October 2019, as shown in Figure 3.

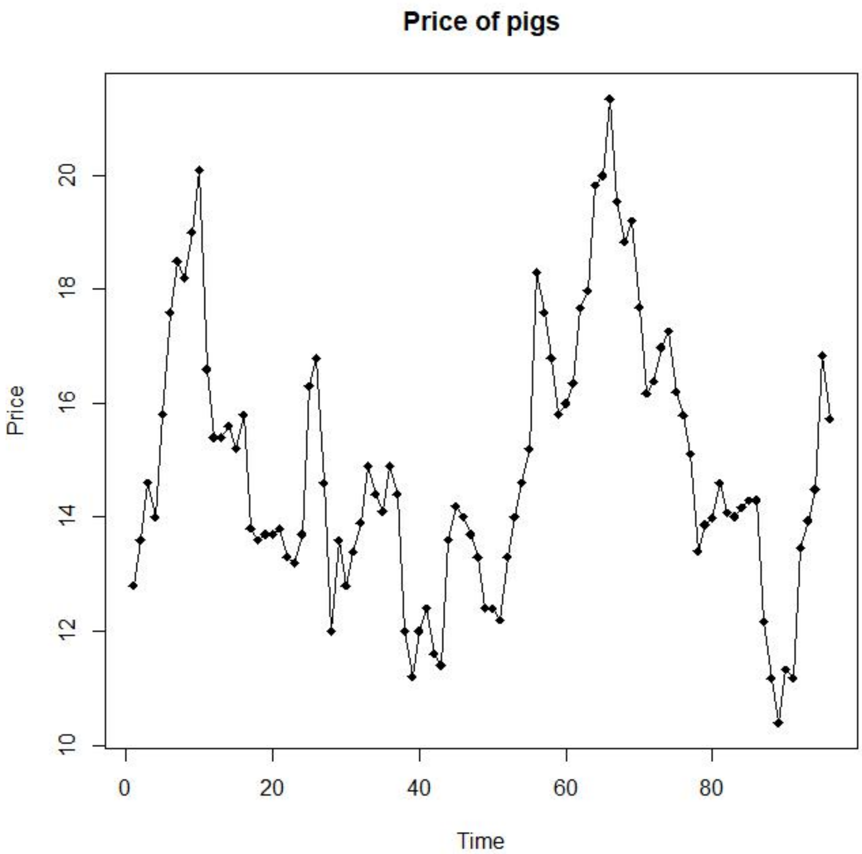

Fig 3. Timing chart of pork prices

The horizontal coordinate represents the time of month from January to February 20, 2010. As can be seen from the figure, the price of pork is seasonal.

4.2.2 Time series model and Cobweb model

4.2.2.1 Time series model

Fit the monthly data of the pork price to get:

$$P_t = 1.0501P_{t-1} - 0.2035P_{t-2} + \varepsilon_t$$

Where P_t represents pork price at t time, and ε_t represents random error[3].

As can be seen from the pig price chart, every time a pig price rises, it will cause a price drop, showing a very obvious cobweb periodicity.

The cobweb theory in pork prices, the cyclical fluctuation of pig prices exists objectively in the hog industry, and is the focus of many scholars and experts.

4.2.2.2 Cobweb model theory

As can be seen from the pig price chart, every time a pig price rises, it will cause a price drop, showing a very obvious cobweb periodicity.

The cobweb theory[2] in pork prices, the cyclical fluctuation of pig prices exists objectively in the hog industry, and is the focus of many scholars and experts.

The application of spider web theory can effectively explain the price fluctuation law of some products. The cobweb model assumes that the commodity price P_t of the previous period determines the Q_t of the current commodity, and uses S_t to indicate the supply and demand of the market pork. The formula of the fluctuation of the pork price with the supply and demand of the market is:

$$S_t = c_1 + c_2 P_{t-1}$$

$$D_t = c_3 + c_4 P_t$$

If the market supply and demand of a commodity is not balanced and cannot reach the corresponding equilibrium state after market regulation, it is called unsteady equilibrium; otherwise it is called stable equilibrium. When the market balances supply and demand:

$$c_1 + c_2 P_{t-1} = c_3 + c_4 P_t$$

By simplifying:

$$P_t = \left(\frac{c_2}{c_4}\right)^t P_0 + \frac{c_1 - c_3}{c_4 - c_2}\left[1 - \left(\frac{c_2}{c_4}\right)^t\right]$$

If the equilibrium is reached in the market, there is an equilibrium price P_e equal to P_t equal to P_{t-1}.

$$P_e = \frac{x_1 - x_3}{x_4 - x_2}$$

$$P_t = \left(\frac{c_2}{c_4}\right)^t P_0 + \frac{c_1 - c_3}{c_4 - c_2}\left[1 - \left(\frac{c_2}{c_4}\right)^t\right] = P_E + \left(\frac{c_2}{c_4}\right)^t (P_0 - P_E)$$

Obviously, when $c_2 / c_4 < 1$, the slope of the demand curve is greater than the absolute value of the slope of the supply curve. As t does not increase, P_t and P_e are getting closer and closer. When the time changes, the pork price Pt will revolve around the equilibrium price. P_e fluctuates at the same amplitude; when $c_2 / c_4 > 1$, the slope of the demand curve is less than the absolute value of the slope of the supply curve, and P_t will gradually move away from the equilibrium price P_e.

4.2.3 Program proposal

From the price of pork in the table below, the fluctuations of pig prices, corn prices, soybean meal prices, and feed price changes during 2010-2018 can be seen, and the price of live pigs fluctuates greatly.

Table 3. Fluctuation analysis

Years	Pig price	Corn price	Soybean meal price	Feed price
2010	16.43	2.29	3.37	2.92
2011	14.37	2.45	3.84	3.13
2012	14.20	2.45	4.03	3.30
2013	12.95	2.49	3.48	3.35
2014	14.65	2.36	2.86	3.24
2015	18.38	2.37	3.26	3.06
2016	15.14	2.02	2.94	3.01
2017	14.90	1.91	3.15	3.02
2018	13.34	2.04	3.26	3.02

Further, we perform multiple regression fitting on the price of pigs - corn price, soybean meal price and feed price.

$$S = 37.09 + 4.85Y - 10.62L$$

The regression results show that the price of corn is positively correlated with the price of live pigs, and the effect of feed price on the price of live pigs is negatively correlated. It is costly to rationally arrange the feeding of pigs when breeding pigs.

Due to the current round of the super pig cycle, the increase is large and the speed is fast. The four reasons are: environmental protection prohibition expansion, large-scale farming strategy, African piglet, and endogenous pig cycle.

First, in recent years, especially since 2015, the impact of environmental protection policies on pig farming has been highlighted. Various localities have formulated plans for the relocation of detained areas and polluted farmers in the area, and the layers have been enlarged and expanded across the board.

Second, the large-scale farming upgrade has led to a large number of retail investors withdrawing, and the supply of pork has declined, but it has not changed the pattern of high-volume retailing and low-scale farming in China. The number of free-range farmers with an annual output of less than 100 has dropped from 81.7 million in 2007 to 36.9 million in 2017. In the same period, the number of large-scale farms with more than 1,000 heads increased from 39,000 to 80,000. However, the proportion of farmers with less than 500 heads is still as high as 90%, the number of farmers with more than 500 heads is 0.6%, and the number of stalls with more than 500 heads accounts for less than 50% (about 48.3%).

Third, African swine fever caused a large number of pigs to be infected. As of July 2019, there were 143 cases of African swine fever in the country, killing more than 1.16 million pigs. Before the African swine fever, the excess capacity accumulated in the last round of the pig cycle gradually cleared, and a new round of pig cycle has started, and the pork price has an endogenous rising power. The current round of pigs began in mid-2018, but the stocking of sows and live pigs was a 10-year low, and the current supply gap was as high as 10 million tons. China's pork consumption accounts for 49.3% of the world's total, far higher than the EU's 19% and the United States' 8.7%. The domestic consumption of pork in meat consumption is as high as 73%. In the short term, cattle and poultry are difficult to replace. Second, China's imports of pork accounted for only about 3% of domestic pork consumption for a long time, accounting for 18% of global pork exports. Although the import intensity has increased this year, it still cannot make up for the lack of supply.

The essence of the pig cycle is the supply-demand relationship, the demand side is generally stable, and the key is at the supply end. China's environment dominated by retail farming has amplified the volatility of prices.

First, pork consumption demand is determined by the income level, population growth and consumption structure of residents in the long run, and is affected by seasonal eating habits, epidemic diseases, food safety and consumption substitution effects.

Second, the pork supply end is mainly affected by factors such as farming profits, policy interventions, and natural disasters. Policy interventions include environmental protection, financial subsidies, and the system of receiving and storing. Since pork directly affects residents' living standards, CPI and monetary policy, there are relatively many policy interventions, mainly based on indicators such as pork price, pig-to-food ratio, and breeding profit, to observe the market supply and the profit and loss of farmers.

Third, China's aquaculture industry is dominated by farmers' free-range, producers have higher homogeneity, industry concentration is low, and individual producers have weaker influence on market prices, making it easier to “catch up and down” and prevent disease. The technology and funds are insufficient, and it is easier to make a big ups and downs. The price of pork presents a more obvious characteristic of the cobweb cycle.

For the analysis of the pig cycle, we can only directly fill the piglets for about 6 months. The monthly pig stocks indicate the supply of pigs in the next six months; but it takes about 18 months from the pigs to increase the supply of pork. The cycle of pigs is about 3 years. In combination with the characteristics of the time series model of the above hog prices, the following basic conclusions can be drawn:

1. Improve the corresponding pork reserve system: If you want to effectively alleviate fluctuations in pork prices on the market, you need to stock the right pork. Because when pork production is relatively surplus, it will inevitably lead to lower pork prices, which will reduce the profits of related industries and suppress the enthusiasm of raising pigs; if pork prices continue to rise in a short period of time, it will stimulate the enthusiasm of the relevant personnel of the industry to lead to the phenomenon of intensive pig raising. In order to avoid this situation, it is necessary not only to improve the role of market price monitoring and management, but also to give certain reserves to prevent the impact of large price fluctuations caused by unexpected situations on the market.

2. Reasonable farming program: Pork prices are 2nd-order autocorrelation by analyzing the AR(2) model of pork price changes. Because the price changes involve many complicated factors, the model considers the impact of the changes in the price of the first two periods on the current price. According to the pig growth cycle law: it takes six months to directly supply piglets to supply and demand, and the supplementary sows need 18 to meet the supply and demand. Therefore, the appropriate amount of live pigs and capable sows, the amount of slaughter, and the amount of slaughter are selected.

3. In the first three quarters, China imported about 1.26 million tons of pork, up 43.6% year-on-year; the amount exceeded 18.3 billion yuan, up 74.6% year-on-year. The relevant data showed that the volume of imported pork continued to increase due to the large number of vacancies of pork; the highest price of pigs in the first half of the year was 40 yuan/kg, although it will take the purchase of imported pork to make up for the imbalance caused by the shortage, the impact of the number of imported pigs on the market price is lagging. In the short term, imported pork will not reach the market immediately. The number of domestic pig farmers is stable. If the demand for pork is calculated according to the current market conditions, the purchase of pork will inevitably lead to a drastic decline in pork prices and lead to The pig farmers have suffered losses. On the contrary, if appropriate (slightly lower than the pig demand in balance) can effectively promote the development of related industries.

4.3 Prediction of pork demand supply and demand balance model

4.3.1 Pork supply forecasting model

BP neural network time series sequence prediction method predicts the supply of pork, the model includes time series $\{x(t) \mid t = 1,2,...,n\}$,and a three-layer BP neural network, the number of input layer neurons in the network is $q+1$,the input to the neuron is:

$$x_0(t), x_1(t), x_2(t+1), \ldots, x_{q-1}(t-q-2), x_q(t+q-1)$$

$$x_0(t) = \text{-}1, x_1(t) = x(t), x_2(t) = x(t+1), \ldots, x_q(t) = x(t+q-1)$$

Where $y = 1,2,\ldots,n-q$.

By transform:

$$x(t+1) = wx(t)$$

Thereby obtaining:

$$x(t) = x(0)w^t$$

If the activation function is linear, there is a very complex nonlinear relationship between the input and the output. So for the BP neural network model, once the linear function is selected as the activation function, the nonlinear mapping of the input and output can be completed.

Because the number of pigs is divided into: boar + sow + pig, the pork supply forecasting model is constructed as follows:

$$z(t) = z^W(t) + z^M(t) + z_o(t)$$

$z(t)$ indicates the total number of pigs at t time, and $z^W(t), z^M(t), z_o(t)$ indicate the total number of sows, boars, and piglets at time t. Thus, if a pig is assumed to produce an average of c, the pork supply model can be written as:

$$z_R(t) = cz^R_{r_{12}}(t)$$

Where $z_R(t), z^R_{r_{12}}(t)$ respectively represent the total amount of pork in t time, and the number of live pigs in t -time 12 months. The results of calculating the number of stalls and pork supply from 2010 to 2018 are shown in Table 4:

Table 4. The number of stalls and pork supply from 2010 to 2018

Years	Number of pigs released (10,000 heads)	Pork supply (tons)
2010	204.955	153715.994
2011	207.513	155634.811
2012	226.091	169696.861
2013	226.262	169568.446
2014	213.171	159878.536
2015	214.696	161021.760
2016	233.040	174780.044
2017	233.197	174898.053
2018	220.251	165188.174

4.3.2 Demand price relationship model

Definition $p(t)$ is the annual average price, $p_i(t)(i=1,2,...,12)$ is the average monthly price for the year:

$$p(t)=\frac{1}{12}\sum_{i=1}^{12}p_i(t)$$

The function of pork demand and annual average price is:

$$\hat{y}(t)=a+bp(t)$$

Definition $y_i(t)$ is the demand for pork in the i-th month of the t-th year, so:

$$\hat{y}(t)=k_i(t)\,\hat{y}(t)$$

$k_i(t)$ represents the ratio of the demand for the i-month in t-year to the total demand for the year. We want to get the relationship between $y_i(t)$ and $p_i(t)$ and then sort out the above formula:

$$\hat{y}_i(t)=\frac{a+bp_i(t)}{\sum_i\left[a+bp_i(t)\right]}\left[a+bp(t)\right]$$

$$\hat{y}_i(t)=\frac{a+bp_i(t)}{12}$$

The pork demand and annual average price in Northeast China in 2010-2018 are as follows:

Table 5. Annual average and average price of pork from 2010 to 2018

Years	Total demand (tons)	Average price (yuan/kg)
2010	1144917	16.89
2011	1168987	22.37
2012	1283623	19.78
2013	1333430	22.78
2014	1425493	24.41
2015	1465738	24
2016	1488950	23.8
2017	1497880	23.6
2018	1530490	25

According to the above table data, we can draw a scatter plot of total pork demand and average price from 2010 to 2018, as shown in Figure 4:

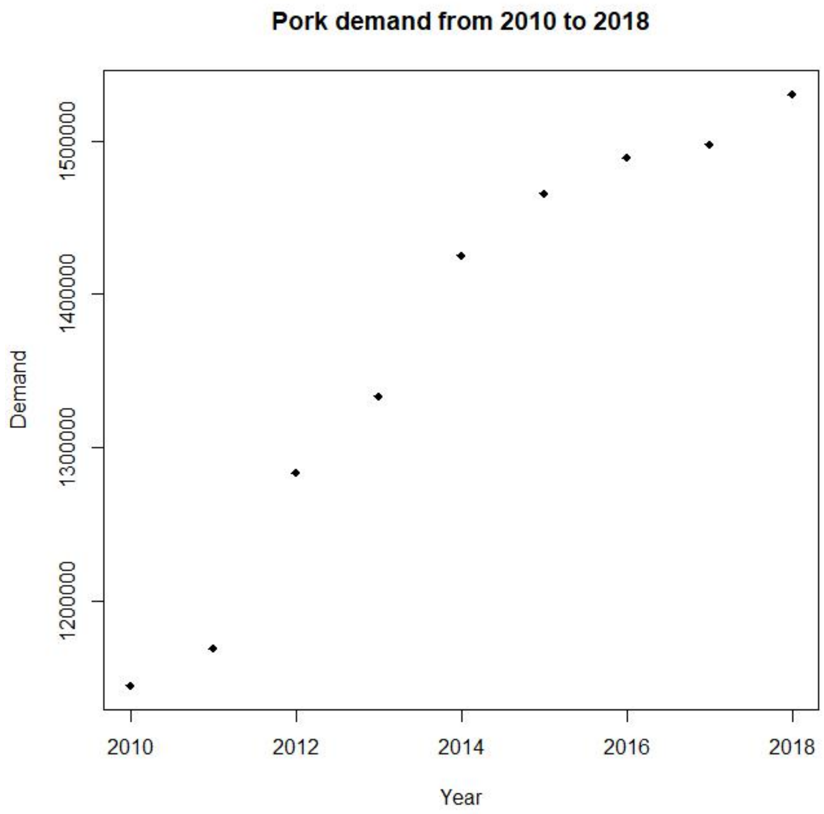

Fig 4. Relationship between pork demand and annual average pork price

It can be seen from the figure that demand $y(t)$ is approximately linear with annual average pork price $p(t)$. So we can assume that the relationship between the two is:

$$\hat{y}(t) = a + bp(t)$$

Regression analysis of the data using R software, the results are as follows:

$$\hat{a} = 345817, \hat{b} = 45537, \quad R^2 = 0.6652$$

So the regression result is:

$$\hat{y}(t) = 345817 + 45537\, p(t)$$

In addition, the relationship between the demand for pork in the month of t and the average price of pork in the month can be obtained as follow:

$$\hat{y}(t) = \frac{1}{12}[345817 + 45537\, p(t)]$$

4.3.3 Optimal Solution for Supply and Demand Balance Model

The regulation model of pork supply and demand balance[4] is essentially a far-reaching nonlinear unconstrained optimization model. The essence of regulation is to control the number of new sows $z_1^W(t)$ per year. The model can be written as:

$$\min \sum_{i=1}^{n} \left[\hat{Z_R}(t) - Z_R(t) \right]^2$$

In the formula, $\hat{Z_R}(t)$ indicates the demand for pork; $z_R(t)$ indicates the total amount of pork in t time. $z_R(t)$ indicates the number of pigs at t -month and month-old, $d_r^R(t)$ indicating the mortality of pigs at t -months and months.

$$z_R(t) = cz_{r_{12}}^R(t) \text{ ;}$$

$$z_{r+1}^R(t+1) = \left[1 - d_r^R(t)\right] z_r^R(t), r = 1,2,...,n \text{ ;}$$

$$z_1^R(t) = z_1(t) - z_1^W(t) - z_1^M(t) \text{ ;}$$

$$z_1^M(t) = kz_1^W(t)$$

$$z_1(t+1) = [1 - d_0(t)] z_0(t)$$

After calculation, the optimal solution results are shown in Table 6 below:

Table 6. Supply and demand balance, the optimal number of new sows

Years	Optimal solution (quantity: 10,000 heads)
2010	27.33
2011	31.75
2012	19.87
2013	14.63
2014	21.18
2015	19.46
2016	19.59
2017	25.90
2018	26.70

Through the BP neural network time series model, regression model and supply and demand balance regulation model, this paper gives the optimal solution of the model to the supply of pigs and the supply of pork in a certain area of Northeast China, through the optimal sow new the increase can be found:

1. When the overall market tends to balance, with the increase of the year, the average number of new sows is increasing, which is related to the increase of pork consumption in some areas in China in recent years.

2. The results in Table 5 show that the demand for pork has increased year by year from 2010 to 2018, but overall the future trend does not necessarily change abruptly.

China's pork consumption accounts for 49.3% of the world's total, and domestic pork consumption accounts for as much as 73% of pork consumption. In the short term, it is difficult to replace cattle and poultry; China's imports of pork accounted for only about 3% of domestic pork consumption for a long time, accounting for 18% of global pork exports. In summary, in view of the recent increase in pork prices, the breeding pig program proposed in this paper is to fill at least 50,000 sows per month to maintain a balanced market in the coming months.

5. The Evaluation of Model

5.1 Strengths

1. Use Excel, R and other software to process data and create a variety of charts to display results in a simple, intuitive, fast and accurate way;

2. The model algorithm is targeted: the grey relational analysis method is used to establish the relationship model between pork price and its influencing factors; the spider web theory is used to give the corresponding feeding plan and purchasing plan to make the pork price relatively stable;

3. The model is easier to implement and the complexity is not high.

5.2 Weaknesses

1. In the process of building the model, some minor influencing factors are neglected to make the calculation easier and the results are more ideal;

2. Due to limited time, no other combination methods have been tried for impact analysis.

References

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Appendix

```
##### 07--08 pig price
y<- c(13.9,13.5,13.1,12.8,14.5,16.3,18.8,24.02,25.64,25.98,26.7,28.8,
      24.00,24.00,24.00,24.00,23.50,22.50,22.00,23.50,24.00,22.80,20.00,21.75)
length(y)
##### 07--08 corn price
x<- c(1.49,1.50,1.53,1.53,1.55,1.63,1.65,1.66,1.67,1.65,1.69,1.75,
     1.75,1.76,1.76,1.75,1.75,1.78,1.80,1.79,1.76,1.74,1.65,1.60)
length(x)

s1=1;
s2=0.98;
s3=1.08;
s4=1.13;

price<- function(x ,k)
{
 for(j in 1:k)
{ for(i in 1:length(x))
   {
   if ( 3*k-2<=i & i<=3*k) P<- (x-1.316-5.19*s1)/4.4
   if ( 3*k-2<=i & i<=3*k) P<- (x-1.316-5.19*s2)/4.4
   if ( 3*k-2<=i & i<=3*k) P<- (x-1.316-5.19*s3)/4.4
   if ( 3*k-2<=i & i<=3*k) P<- (x-1.316-5.19*s4)/4.4
   }

}
return(P)
}

########################################
##### read data
############################################

pork.price<- read.csv("C:\\Users\\FYLT\\Desktop\\zhurou.csv" ,head=T, sep = ",")$pork.price
doupo<- read.csv("C:\\Users\\FYLT\\Desktop\\zhurou.csv" ,head=T, sep = ",")$doupo
if( class(doupo)=="numeric" & class(pork.price)=="numeric" )
{

price<- function(x ,k)
{
 for(j in 1:k)
{ for(i in 1:length(x))
```

```
  {
  if ( 3*k-2<=i & i<=3*k) P<- (x-1.316-5.19*s1)/4.4+rnorm(1,1.4,2.5)
  if ( 3*k-2<=i & i<=3*k) P<- (x-1.316-5.19*s2)/4.4+rnorm(1,2,1.59)
  if ( 3*k-2<=i & i<=3*k) P<- (x-1.316-5.19*s3)/4.4+rnorm(1,0.5,1.8)
  if ( 3*k-2<=i & i<=3*k) P<- (x-1.316-5.19*s4)/4.4+rnorm(1,0.9,1.4)
  }

}
return(P)
}
yumi<- price(x,k=8)

}

alpha<-mean(pork.price)
pork.price=pork.price/0.8*alpha+2

plot(pork.price ,pch=16,ylim=c(0,30))
lines(pork.price,col="blue");
par(new=T)

yumi=price(pork.price,k=8)
plot(yumi,pch=18,ylim=c(0,30))
lines(yumi,col="red");
par(new=T)

plot(doupo, pch=18,ylim=c(0,30))
lines(doupo,col= "black");legend('top',legend=c('yumi','pork'),col=1:2,lty=1:2)

plot(pork.price,dopo)

data1= read.csv("C:\\Users\\FYLT\\Desktop\\zhurou.csv" ,head=T, sep = ",")[1:40,2:7]
class(data1)
y=data1$pork.price<- (data1$pork.price-mean(data1$pork.price))/sd(data1$pork.price)
x1=data1$yumi<- (data1$yumi-mean(data1$yumi))/sd(data1$yumi)
x2=data1$doupo<- (data1$doupo-mean(data1$doupo))/sd(data1$doupo)
x3=data1$chiken<- (data1$chiken-mean(data1$chiken))/sd(data1$chiken)
x4=data1$siliao<- (data1$siliao-mean(data1$siliao))/sd(data1$siliao)
x5=data1$shengzhu
round( cor(data1,method =c("pearson")),2)      ### corrolation matrix

### the grey correlation analysis

y= y/y[1]     ### normalization
```

```
x1= x1/x1[1];
x2= x2/x2[1];
x3= x3/x3[1];
x4= x4/x4[1];
x5= x5/x5[1];

min1<- min(abs(y-x1))
min2<- min(abs(y-x2))
min3<- min(abs(y-x3))
min4<- min(abs(y-x4))
min5<- min(abs(y-x5))
global.min<- min(min1,min2,min3,min4,min5)

max1<- max(abs(y-x1))
max2<- max(abs(y-x2))
max3<- max(abs(y-x3))
max4<- max(abs(y-x4))
max5<- max(abs(y-x5))
global.max<- max(max1,max2,max3,max4,max5)

rho <- 0.5    ### set the parameter

zeta1<- (global.min+rho*global.max)/(abs(y-x1) + rho*global.max)
zeta2<- (global.min+rho*global.max)/(abs(y-x2) + rho*global.max)
zeta3<- (global.min+rho*global.max)/(abs(y-x3) + rho*global.max)
zeta4<- (global.min+rho*global.max)/(abs(y-x4) + rho*global.max)
zeta5<- (global.min+rho*global.max)/(abs(y-x5) + rho*global.max)


gamma1<- mean(zeta1);gamma1
gamma2<- mean(zeta2);gamma2
gamma3<- mean(zeta3);gamma3
gamma4<- mean(zeta4);gamma4
gamma5<- mean(zeta5);gamma5


########################
#######    Time series model
##########################
library(TTR)
#install.packages("TSA")
library(TSA)
#install.packages("fUnitRoots")
library(fUnitRoots)
```

```
#install.packages("forecast")
library(forecast)
#install("stats")
library(stats)


### ARIMA model for shengzhu price
data1$shengzhu<- ts(data1$shengzhu ,frequency =12)
plot(data1$shengzhu,pch= 18,xlab= "Time",ylab="Price",main="Price of pigs");lines(data1$shengzhu)
unitrootTest(data1$shengzhu)
component<- decompose(data1$shengzhu);
plot(component);dev.new()
fit1<- auto.arima(data1$shengzhu, lambda= "auto");
summary(fit1)
print("outcome of model 1");checkresiduals(fit1);


##############################
###### 2010-2018 regression
##############################

data2<-read.csv("C:\\Users\\FYLT\\Desktop\\zhu.csv" ,head=T, sep = ",")
y= data2$pig
x1= data2$corn
x2= data2$doupo
x3= data2$feed

summary(lm(y~x1+x2+x3))
round( cor(data2,method =c("pearson")),2)
```