Team Control Number

201909752

Problem Chosen

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2019

ShuWei Cup

Summary

China is a large pork consumption country with an annual pork consumption accounted for more than 60% of the world. It can be said that the stability of pork market is the premise of the harmonious life of our people. This year, China's hog market has frequent price fluctuations and have brought great distress to the vast number of consumers. Therefore, it is necessary to carry out the relevant mathematical analysis by computer, so as to accurately grasp the reasons and laws of pork price fluctuation.

In view of Part I, we study the factors influencing pork prices from three aspects: market supply, demand and out-of-market factors. We consider 8 analytical indicators such as piglet price, hog price, lamb, beef, corn, soybeans, eggs and piglet feed. Due to the large number of indicators, we use gray correlation to filter out the five indicators with the greatest correlation, and by designing a response surface secondary polynomial model, we fit the pork prices over the past 20 years. We used the p-value to detect the regression coefficient and found $p<0.0001$, thus the model is considered highly accurate. By analyzing the response surface factor diagram, it is concluded that the main factors affecting pork prices range from large to small: hog price>piglets price>lamb price >corn price>soybean price. Then, using the time series analysis method, the main influencing factors in 2019 are forecasted, and the pork price in 2019 is forecasted based on this result. The results show that the forecast price is much lower than the actual price. Through analysis, it is believed that African swine fever caused the market pork shortage, resulting in a surge in pork prices.

For Part II, in order to make a reasonable breeding plan, we first make a wavelet analysis in the time series model and forecast the trend of pork price fluctuations. The model calculates the two main cycles of pork price fluctuation, in which the first main cycle with a time step of 25 months reasonably reflects the periodicity of pork price fluctuation, and can get the change period of 50 months. The second main cycle with a time step of 4 months reflects the overall trend of pork prices, i.e. pork prices from low to high, from stability to volatility. In view of the choice of reasonable breeding land, we use annealing simulation model, by planning the optimal path, optimize the transportation of pork and hog. We can get the best breeding areas by calculating the

geographical coordinates of each province in China. The result are: Sichuan, Hebei, Henan, Hunan and Heilongjiang. Heilongjiang pork is mainly exported to Jilin, Liaoning, Beijing, Inner Mongolia; Sichuan pork is mainly exported to Gansu, Qinghai, Xinjiang; Hebei pork is mainly exported to Tianjin, Beijing, Inner Mongolia; Henan pork is mainly exported to Beijing, Tianjin, Anhui; Hunan pork is mainly exported to Anhui, Guizhou, Guangdong, Guangxi, Fujian; For pork procurement plan, we use a cost control model, in order to purchase pork to bring pork prices down for the purpose. The constraints should be the lowest pork cost. The model calculates that China's main pork importers should be the United States, Canada, Denmark, France and Spain. The largest imports were imported by Canada, with imports amounting to 50,400 tons.

For Part III, based on the K-means clustering results in Part II, the variation rate value volatility index (RV) is used to characterize the intensity of the time series fluctuation. The analysis found that the low-price area pork volatility is the largest, the volatility period is about 40 months, and in the next 1-2 years, the main production area prices have a downward trend; General, high-price area fluctuations are small, the volatility cycle is about 45 months, the next 2-3 years in the main production area pork prices have an upward trend. According to the historical fluctuation law of each region and the future prediction result, a reasonable breeding plan is put forward. At the same time, in order to meet the future demand for pork in a certain area, according to the variation rate (RV) , we divide China's future pig reserves into key breeding areas, general breeding areas and encouraging breeding areas. The division of the region can quickly respond to the surge in demand for pork in a region and maintain a stable pork market.

Key word： Pork Price, the Response surface design, Wavelet analysis, Cost and control model, Pork consumption

Content

1. Introduction

1.1 Background

China now raises and consumes 500 million pigs a year, nearly half of global pork production and consumption. The average Chinese consumes nearly 40 kilograms of pork a year, far more than beef, mutton and all other meats combined. Therefore, as a major consumer of meat products, maintaining its price stability is of great significance.

Nowadays, the price of pork is quite volatile. Since June this year, the price of pork has soared, which has affected people's life to some extent. So it is necessary for us to carry out relevant research with the help of computer tools and mathematical models, so as to provide a theoretical basis for future decision making.

1.2 Work

We tackle three main problems:

(1) We studied the influencing factors of pork price from three aspects of market supply, demand and factors outside the market, and used the response surface quadratic polynomial model to fit the trend of pork price, and analyzed the main factors affecting pork price.

(2) The periodic fluctuation law of pork price is obtained by the wavelet analysis, and on the basis of this, a reasonable breeding plan is formulated by using the annealing simulation model, and the breeding and transportation areas are determined. A reasonable procurement plan is developed using the cost control model.

(3) By calculating the variation value of pork price in different regions, we get the variation rule and trend. In order to meet the sudden increase of pork demand in a certain area in the future, according to the variation rate (RV), China's future pig reserve is divided into key breeding areas, general breeding areas and encouraged breeding areas. The division of the region can quickly respond to the surging demand for pork in a region and maintain the stability of the pork market.

2. Problem analysis

2.1 Data analysis

There are three main reasons for the price fluctuation of pork: supply factor, demand factor and some factors outside the market. Supply factors mainly include production costs, hog stock and column volume; demand factors are mainly pork substitutes to the price (such as beef and mutton), income level and seasonal consumption habits; the main outside market factors refer to national policies, natural disasters, outbreaks and so on.

This time, the pork price is analyzed, taking 8 analysis indicators into account, such as the piglet price, hog price, lamb, beef, corn, soybeans, eggs and piglet feed. To enable the model to more realistically reflect the laws of pork price fluctuations,

we collected data from nearly 20 years (see annex). Because the amount of data is relatively large and redundant, before the problem is solved formally, the data is analyzed and the pre-processed by the corresponding mathematical method, which helps to establish and solve the subsequent model.

1. Data integrity analysis

This model statistics the data integrity of individual variables, using data integrity rate C_i to represent, that is, the data loss rate of the ith variable.

$$C_i = \frac{The\ available\ data\ volume\ of\ \ the\ i-th\ indicator}{The\ total\ amount\ of\ \ data\ of\ \ the\ i-th\ indicator}$$

From this definition, we can see, the lower the C_i is, the higher the integrity of the variable i data is, and the more authentic and researchable it is. To this end, the data integrity of the analysis object (pork price) and the selected 8 indicators (2000.01-2019.11) is calculated as shown in the table.

Table 2.1 Site indicator integrity rate

Indicator	Pork	Piglet	Hog	Lamb	Beef	Corn	Soybean	Egg	Piglet feed
Data integrity	0.991	0.989	0.986	0.987	0.990	0.985	0.988	0.972	0.956

As we can see from Table 2.1, data integrity rate $C_i > 95\%$. Data integrity is high, and the selected object can fully and effectively reflect the laws of pork price change.

2. Variable correlation analysis

To avoid the possibility of duplication between variables, the correlation degree of the above variables has been analyzed. Here we choose the method of Pearson Correlation Coefficient Analysis.

The Pearson correlation coefficient is defined as the quotient of the covariance and standard deviation between the two variables. Assuming the correlation coefficient between is P_i and P_j is $R_{i,j}$, its expression is as follows:

$$\rho_{i,j} = \frac{\mathrm{cov}\left(P_i, P_j\right)}{\sigma_{p_i}\sigma_{p_j}} = \frac{E\left[\left(P_i - \mu P_i\right)\left(P_j - \mu P_j\right)\right]}{\sigma_{P_i}\sigma_{P_j}} \qquad (2.1)$$

Estimated covariance and standard deviation of samples, and we can obtain the Pearson correlation coefficient $R_{i,j}$:

$$R_{i,j}=\frac{\left(P_i-\bar{P}_i,P_j-\bar{P}_j\right)}{\left\|P_i-\bar{P}_j\right\|\left\|P_j-\bar{P}_j\right\|}=\frac{\sum_{m=1}^{n}\left(P_{im}-\bar{P}_i\right)\left(P_{jm}-\bar{P}_j\right)}{\left[\sum_{m=1}^{n}\left(P_{im}-\bar{P}_i\right)^2\cdot\sum_{m=1}^{n}\left(P_{jm}-\bar{P}_j\right)^2\right]^{\frac{1}{2}}},\quad -1\le R_{i,j}\le 1 \tag{2.2}$$

Because of the differentiation cosine decentralization, the Pearson correlation coefficient is obtained. Considering that the data in this question is affected by the level expansion (there are order-of-magnitude differences between some variable data), it is more acceptable to use the results of Pearson correlation analysis. Through programming, the correlation results between some variables are shown in Table 2.2.

Table 2.2 Analysis of variable Pearson correlation coefficients

ITEMS	Pork	Piglet	Hog	Lamb	Beef	Corn	Soybean	Egg	Piglet feed
Pork	1.000	0.855	0.946	-0.607	-0.203	0.623	0.634	0.551	0.569
Piglet	0.855	1.000	0.700	0.257	0.219	0.617	0.138	0.375	0.756
Hog	0.946	0.700	1.000	0.548	0.588	0.557	0.456	0.401	0.499
Lamb	-0.607	0.257	0.548	1.000	0.437	0.374	0.265	0.408	0.279
Beef	-0.203	0.219	0.588	0.437	1.000	0.447	0.305	0.127	0.436
Corn	0.623	0.617	0.557	0.374	0.447	1.000	0.675	0.315	0.676
Soybean	0.634	0.138	0.456	0.265	0.305	0.675	1.000	0.236	0.465
Egg	0.551	0.375	0.401	0.408	0.127	0.315	0.236	1.000	0.302
Piglet feed	0.569	0.756	0.499	0.279	0.436	0.676	0.465	0.302	1.000

According to the resulting table of relevant coefficients(Table 2.2), the correlation between pork price and hog price is 0.9457, piglet price and piglet feed correlation coefficient is 0.7564, hog price and corn correlation coefficient is 0.5567, the correlation is considered to be good. This conclusion is in line with the conventional understanding, indicating that the data obtained is more reasonable.

2.2 Analysis of question one

For PART A, due to the unusual high price of pork after 2019, the data were not taken into account at present in the analysis of the factors, and only take the data for the years from January 2000 to December 2018 into account. In the previous statistics, eight indicators were selected from three aspects: supply, demand and out-of-market. In order to compare the influence of the selected index on pork, we use the gray correlation analysis method to obtain the correlation between the index and pork price, so as to obtain the main influence factors.

For PART B, we choose the response surface design method. We establish the function relationship between the argument and the response value by using the multi-secondary linear regression method, which is used to predict the reasonable price of pork in 2019. And we analyze the main factors affecting pork price by

analyzing the factor diagram obtained by the response surface.

2.3 Analysis of question two

As for PART A, it is required to develop a reasonable breeding plan according to the fluctuation rule of pork price, and the primary goal is to find the periodic fluctuation rule of pork price. The wavelet analysis of time series was used to establish a pork price fluctuation model and explore the fluctuation cycle of pork price, so as to set a reasonable breeding plan according to its change rule. Due to the limitation of breeding land and the cost of pig transportation, a simulated annealing model should be established to make the transportation path shortest and determine the breeding land reasonably.

For PART B, if it is impossible to design a breeding plan in a short period of time to make pork fall back, that is to say, pork procurement is needed. In the procurement plan, the cost of pork should be controlled and not higher than the market price. The cost control model is established, and the reasonable procurement scheme is calculated by considering the factors that affect the cost of pork.

2.4 Analysis of question three

For question Part A, due to the change trend of pork price and demand in different regions. Therefore, in the problem analysis, the clustering analysis results in Part II were used to analyze the change trend of pork price in different regions since 2000, and to analyze the main consumption characteristics of different regions under different price regions, so as to formulate targeted measures.

For Part B, according to the analysis results of Part A, A pork storage scheme can be carried out for major pork producing areas in China, and the nearby pork consumption market can be selected to maintain the stability of the pork market.

3. Symbol and Assumptions

3.1 Symbol Description

Table 3.1 Symbols and Description

Symbol	Definition	Unit
C_i	The rate of data integrity	%
Price	The price of pork	yuan/kg
A	The price of hog	yuan/kg
B	The price of piglet	yuan/kg
C	The price of corn	yuan/kg
D	The price of lamb	yuan/kg
E	The price of soybean	yuan/kg

3.2 Fundamental assumptions

We make some general assumptions to simplify our model. These assumptions together with corresponding justification are listed below:

- **All the data we obtained from internet is authentic.**

We have collected the price data of different items in the recent 20 years, the amount of data is very huge.

- **The price of pork is mainly related to the index selected in the paper, and the other indexes have little influence on it and are not considered.**

Many factors are accountable for the fluctuations in pork prices, we can only select some representative factors form different aspects.

4. Models and Results

4.1 Part I Models and Results

4.1.1 Analysis of the main influencing factors

As mentioned earlier, there are three main aspects affecting pork prices: market supply; market demand; other factors outside the Market.

For the market supply, there are mainly hog costs, storage and column volume. In general, the higher the cost of pig, the higher the corresponding pork price (the previous Pearson coefficient is 0.946), and the cost of piglets, feeding costs (feed, food) and labor costs. Therefore, these factors can not be ignored when analyzing market supply. Although the pig stock and out of the column can not be quantified statistics, but its most direct embodiment is the hog and pork price fluctuations. Figure 4.1 and 4.2 show the relationship between pork prices and pig costs in Sichuan Province from 2000 to 2018, and it can be seen that pork prices are very closely related to pig prices and are basically the same.

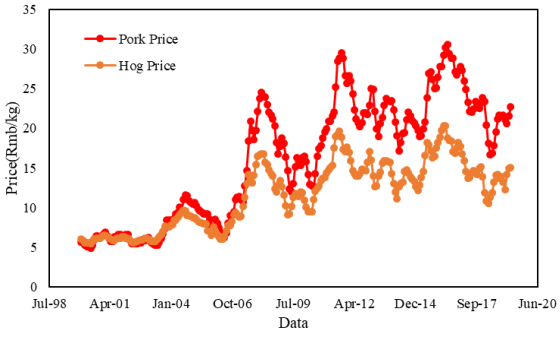

Figure 4.1 Pork price and hog price trend curve

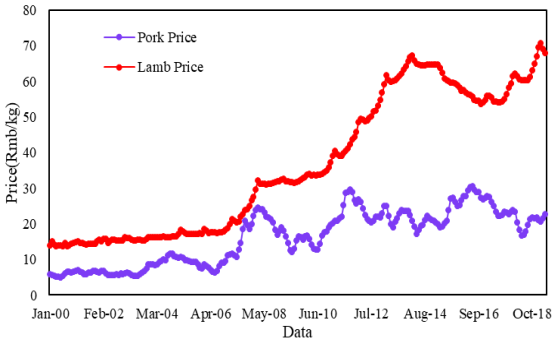

Figure 4.2 Pork price and lamb price trend curve

As for market demand, on the one hand, if the market demand is large, it will lead to higher pork prices, and vice versa, prices will fall. On the other hand, the price change of pork substitutes (e.g. chicken, beef and mutton, etc.) has some effect on the change in the price of hog (the previous pork price and lamb price Pearson coefficient is -0.607). Secondly, when the income level of the residents is low, pork occupies a larger proportion of their total living expenses, at which time the residents will reduce the demand for pigs, which in turn leads to a decline in pig prices; This in turn leads to a rise in the price of pigs. In addition, the demand for pork varies from season to season, which is also a factor affecting pork price fluctuations.

For other factors outside the market, such as the state to implement macro-control of pork. Increase or reduce the financial subsidies for pork will affect the price of pork; At the same time, a major outbreak and natural disasters can also change the market demand for pork, thus affecting pork prices.

4.1.2 Establishment and solution of factors evaluation model

Through the previous analysis, for a better representation of the factors affecting the price of pork. We considered eight main factors, namely: piglet price, hog price, lamb price, beef price, corn, soybeans, eggs and piglet feed. In order to characterize the importance of factors, we use gray correlation analysis method[1] to evaluate their correlation, according to the degree of association size to obtain the main influencing factors, which is also conducive to the analysis and solution of the latter problems.

The specific steps of the process of building a gray association analysis model are presented in Appendix.

By calculation, the gray correlations for each indicator are shown in the Table 4.1.

Table 4.1 Gray correlations for each indicator

Factors	Porklet	Hog	Egg	Lamb	Beef	Corn	Soybean	Pannage
Correlation degree	0.807	0.915	0.497	0.7075	0.508	0.810	0.753	0.520

To make the evaluation results more intuitive, a bar chart of the indicator association is drawn, as shown in the Figure 4.3.

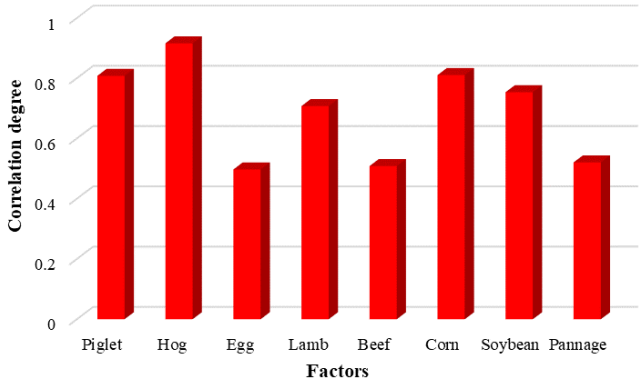

Figure 4.3 Indicator association

As can be seen from the figure, hog prices are the most correlated with pork prices, and the relationship is closer, and the impact of beef, eggs and feed on pork prices is relatively weak. Therefore, in the follow-up regression analysis, the five indicators with the greatest correlation were selected, namely: hog, piglet, corn, lamb and soybean prices.

4.1.3 Establishment and solution of Regression model

This time we chose the response surface design method for regression analysis. This method (Response Surface, RSM) by designing a reasonable experimental

method and obtaining the test result data through reasonable operation, using the multi-secondary linear regression method to establish the functional relationship between the argument and the response value, and analyzing the change trend of the response value by regression equation. This method is more common in solving multivariate problems.

This modeling uses Design-Expert[2], the world's top-level experimental design software, and box-Behnken Design (BBD) experimental design method. During the design process, the response face refers to the function relationship between the response variable (dependent variable) y and a set of input variables $x_1, x_2, ..., x_n$, and satisfy $y = f(x_1, x_2, ..., x_n)$.

In this question, the response variable refers to the price of pork, which is given by official data. The arguments take into account the prices of hog, piglets, corn, lamb and soybeans over the last 19 years.

Through the software, 29 sets of experiments (all of which come from official data) were designed to analyze the changes in pork prices under different factors in the past 190 years, and to determine the sensitivity of the influencing factors. Due to space constraints, the complete experimental design is attached.

By calculation, this pork price is a response value, with hog (A), piglets (B), corn (C), lamb (D) and soybean prices (E) as the arguments to establish a second polynomial on the response surface of pork price forecast, as condition 4.3.

$$\begin{aligned} Price = {} & 13.48 + 5.40A + 0.96B + 0.46C - 1.42D + 0.11E - 0.13AB - 0.37AC \\ & - 0.90AD - 0.60AE - 0.05BC + 0.20BD - 0.33BE - 0.25CD + 0.60CE \\ & + 0.13DE + 1.21A^2 - 0.41B^2 + 0.45C^2 - 0.72D^2 + 0.01E^2 \end{aligned} \tag{4.3}$$

Where the unit of each factor is RMB/kg.

In the process of response surface analysis, the significance of the statistical results is detected by using the F value, and the significance of the regression coefficient is detected by p-value, the smaller the p-value, the more significant the result is. Table 4.2 shows some of the response surface analysis results, as detailed in the annex. Available from the table, the model F is 11.95, p<0001, which shows that the model has significant adaptability, and the nonlinear relationship between the factors and the response values in the regression equation is significant, that is, the model has high confidence and can be used to predict the future pork price.。

In general, when analyzing the data, the closer the probability of the residual normal distribution is to the straight line, the more chaotic the residual and equation prediction swords, the higher the confidence of the model. Through analysis, the corresponding correspondence of the model is shown in Figure 4.4-Figure 4.7.

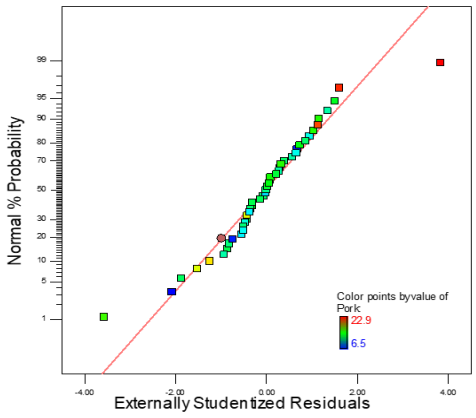

Figure 4.4 Residual normal probability map

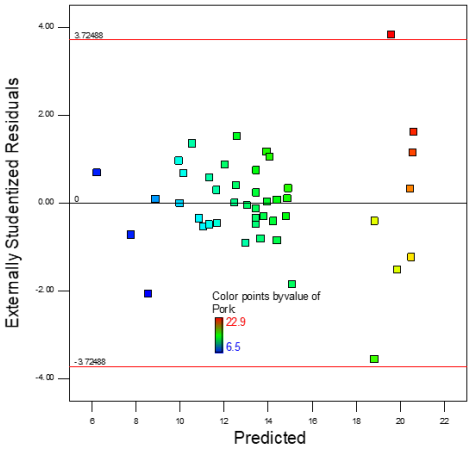

Figure 4.5 Residual vs predict distribution map

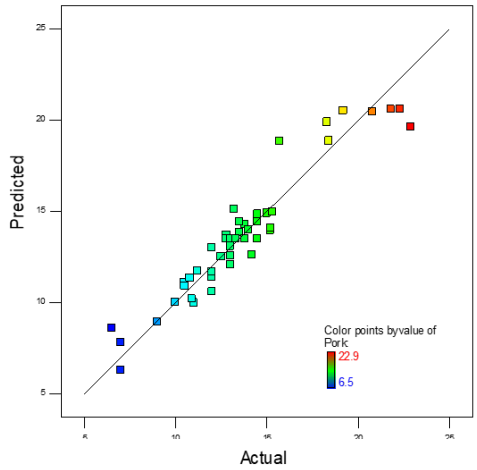

Figure 4.6 Predict vs Actual distribution map

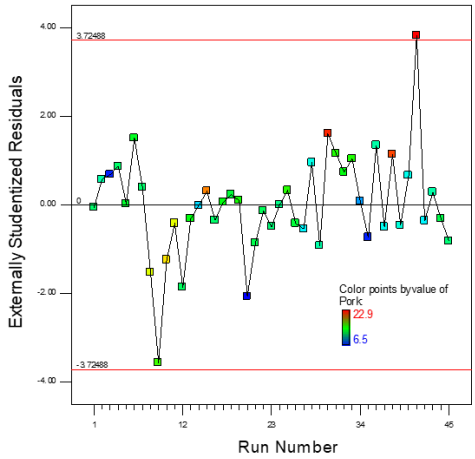

Figure 4.7 Residuals vs Run distribution map

As can be seen from Figure 4.4-Figure 4.7, the residual normal probability distribution curve obtained by this model is basically close to the straight segment, the distribution is reasonable, the residual and equation prediction corresponding graph dispersion is high, and the predicted value obtained by the response face quadratic polynomial calculation is basically close to the same line, Explain that the model obtained by this method has some accuracy.

Next, a two-factor diagram is drawn to analyze each factor, as shown in Figure 4.8-Figure 4.13.

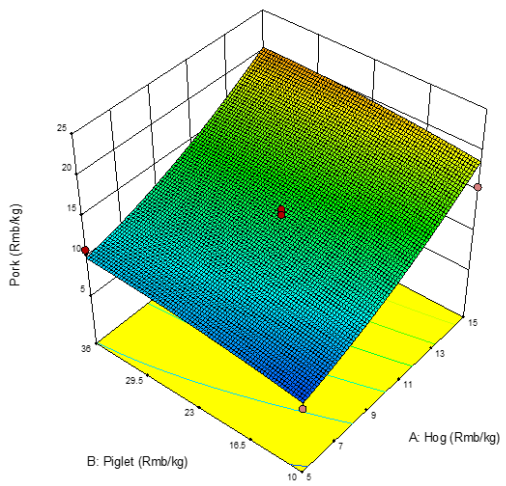

Figure 4.8 Factor AB Diagram

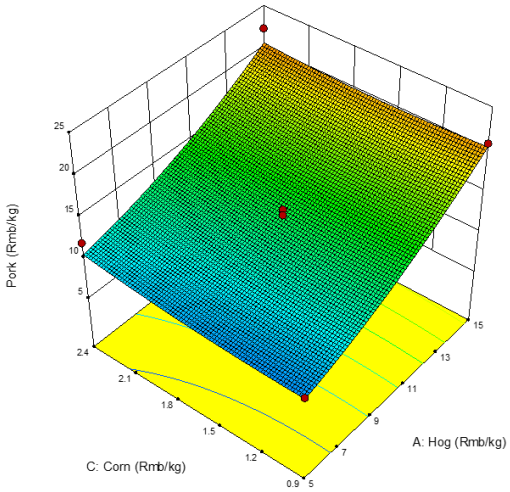

Figure 4.9 Factor AC Diagram

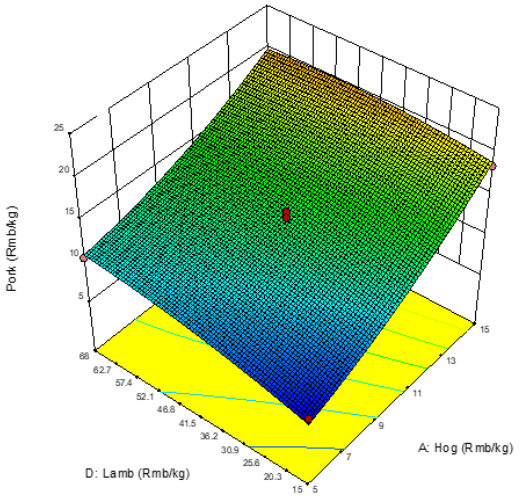

Figure 4.10 Factor AD Diagram

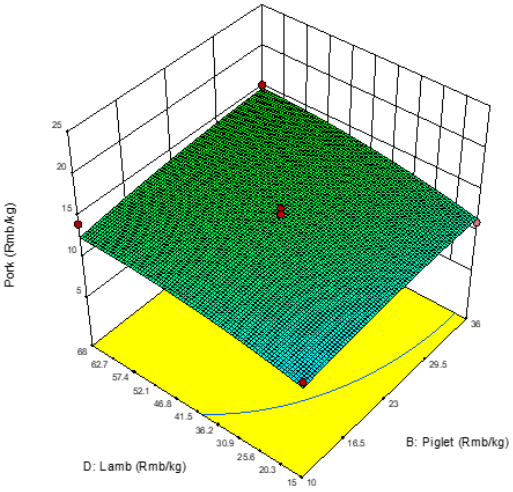

Figure 4.11 Factor BD Diagram

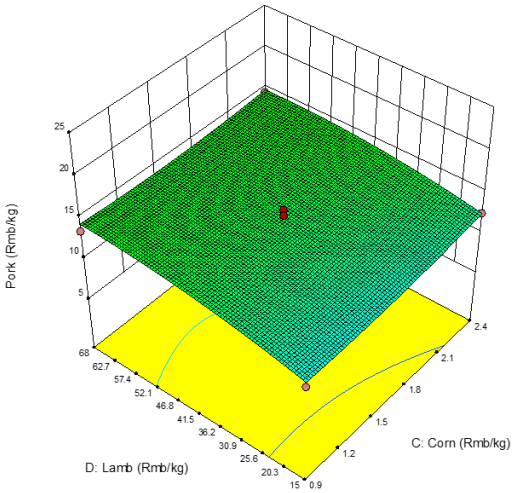

Figure 4.12 Factor CD Diagram

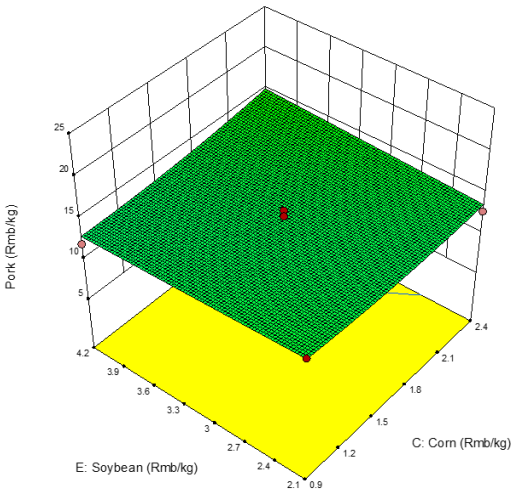

Figure 4.13 Factor CE Diagram

It can be seen that the price of pork increases with the increase of pig and piglet price, of which the price of pig is the most obvious, the price of lamb has some influence on pork price, but not the main factor, corn and soybean price fluctuations

have little effect on pork price. In general, the sensitivity of the five factors to pork prices can be expressed as: hog prices, piglets, lamb, corn, soybean prices. This is consistent with the conclusion reached as associated with the previous gray correlation.

4.1.4 Analysis of pork price anomalies

By May 2019, there will be a significant increase in pork prices. In order to explore the main factors affecting pork prices, the first analysis of the price changes of each indicator. As shown in the figure, piglet and pig prices have increased significantly since May 2019, while the changes in beef and mutton, corn and soybeans are not significant. Therefore, it can be judged that the direct factor sledging up pork is the price of pigs and piglets, which provides a theoretical basis for the next quantitative analysis.

Since pork price fluctuations are short, with only 6 data points, we use the moving average method to predict the prices of pigs and piglets for the last 6 months, based on the principle of time series. Based on the prediction results, combined with the previous response surface secondary polynomial, the difference between the actual price of pork and the forecast price is analyzed, and quantitative analysis is carried out.

The basic principle of moving average[3]: set the observation sequence as $y_1,...,y_T$. Take the number of items that move average N, when the underlying trend of the target of the forecast is to fluctuate up or down at a certain level, the prediction model can be established using the one-time moving average method, i.e.

$$\hat{y}_{t+1} = M_t^{(1)} = \frac{1}{N}(y_t + ... + y_{t-N+1}), \quad t = N, N+1, ..., T \tag{4.4}$$

The standard error of this prediction is:

$$S = \sqrt{\frac{\sum_{t=N+1}^{T} (\hat{y}_t - y_t)^2}{T-N}} \tag{4.5}$$

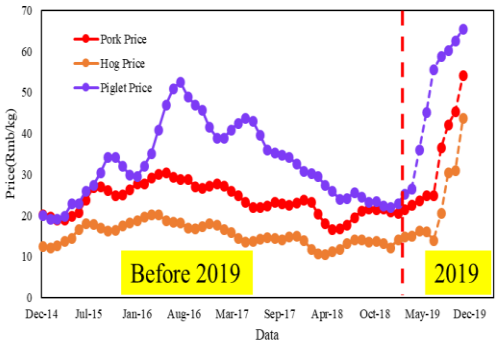

Figure 4.14 Time series of hog, pork and piglet price

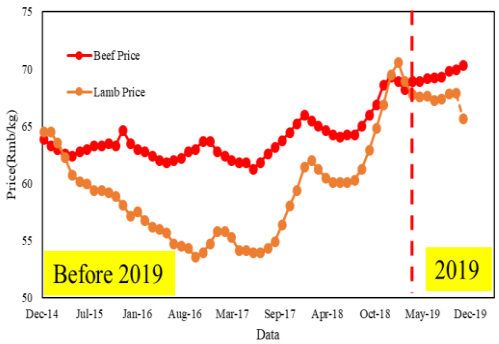

Figure 4.15 Time series of beef and lamp price

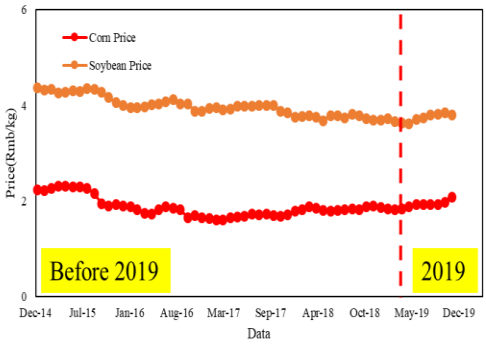

Figure 4.16 Time series of corn and soybean price

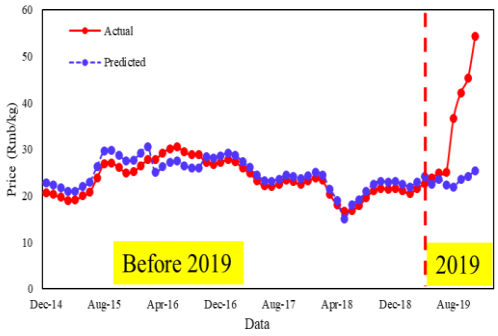

Figure 4.17 Time series of actual and predicted price

The results of the time series of the price of hog and piglet in the last 6 months based on the moving average are shown in the annex. Based on the resulting time series values, the price fluctuations of pork obtained, using the response surface secondary polynomial prediction, are small and the results are shown in the Figure 4.14-Figure 4.17. As can be seen, the actual price is much higher than the forecast price, therefore, we believe that the direct factor of pork price in the last 6 months and the difference between the normal price fluctuations of pork is that the market supply can not meet the demand for pig prices to cause a surge in pig prices, resulting in a sharp increase in pork prices.

4.2 Part II Models and Results

4.2.1 The establishment and solution of wavelet analysis model

In order to predict the change law of pork price in a reasonable way, a wavelet analysis model is established to analyze its period changing rule and find the peak of pork price (the data belongs to Sichuan province). At present, wavelet analysis theory has been widely used in many nonlinear science fields such as signal analysis, image processing, pattern recognition, seismic exploration and atmospheric science. In the time series study, the method is mainly used for noise reduction, filtering of time series, obtaining information coefficients and fractal dimensions, monitoring mutation points, identifying the variation cycle law and analyzing the multi-time scale, which is just the key point of this problem[5-6].

4.2.1.1 Establish the model

The specific process is showed in Appendix.

4.2.1.2 Solution of the model

(1) Wavelet Data Extension

In the process of analysis, for this time series problem, the two ends of the time series may have an impact on the results, so-called "border ingress". In order to eliminate this effect, the temperature data needs to be extended. After a wavelet transformation, then the extended data will be deleted and the original number and appearance of the data will be restored. Figure 4.18 represents the original data in the

red box and the extended data in the brown box. As can be seen from the data, the original time series extended 8 to the left and 9 to the right respectively.

Figure 4.18 Wavelet Data Extended Graph

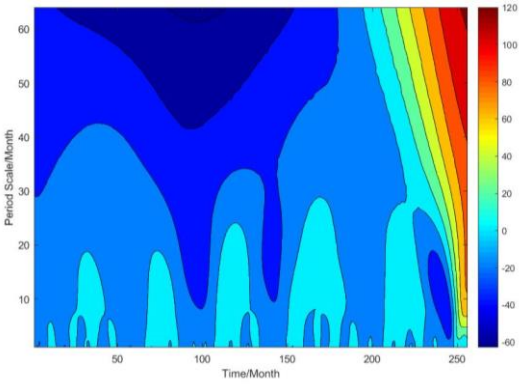

Figure 4.19 Wavelet Real Contour Chart

(2) Draw a Wavelet Real Contour Chart of the wavelet coefficient

The real contour isometric line chart of the pork price wavelet coefficient is shown in Figure 4.19.

It can be seen in Figure 4.19, in the evolution of 20 years, there are a number of shock cycles of pork prices. The entire time scale has a small center and a large center, respectively corresponding to the beginning and end of the sequence, which can show that the overall pork price presents an upward trend and the current average of pork prices is the largest.

(3) Draw a wavelet coefficient pattern and contour plot

The die and the die square of the wavelet coefficient are calculated first, and then the die and die contour plots are drawn. (Figure 4.19)

(4) Draw a wavelet variance map

The wavelet variance chart can reflect the fluctuation energy of the pork price time series with the scale distribution, and can be used to determine the main period in the process of pork price change, as shown in Figure 4.20.

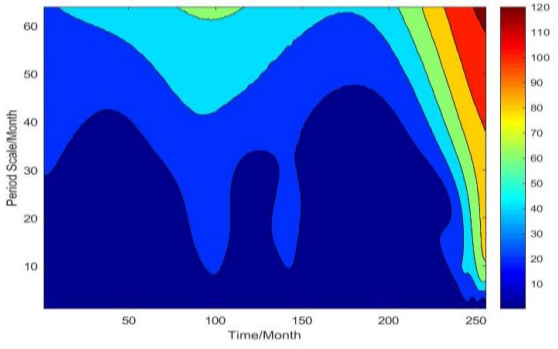

Figure 4.20 Wavelet coefficient pattern and contour

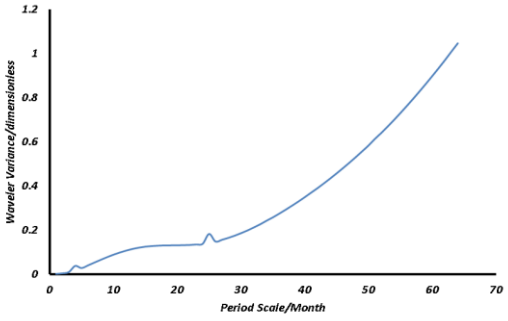

Figure 4.21 Wavelet variance map

As can be seen from Figure 4.21, there are two peaks in the wavelet variance chart of the time series, corresponding to the 4-month time scale and the 25-month time scale respectively from small to large. Among them, the peak of the 25-month time scale is the largest, indicating that the cycle shock is the strongest under the time

scale, which is the largest main period of pork price evolution in 20 years, and the peak of the 4-month time scale is small, corresponding to the second main cycle of pork price change. Therefore, the fluctuations of the four-month scale and the 25-month time scale control the characteristics of the changes in pork prices over the entire time domain.

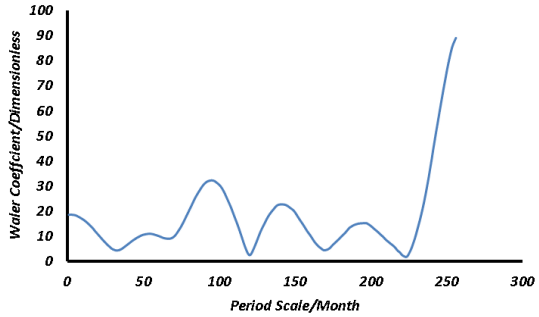

Figure 4.22 the first main cycle trend

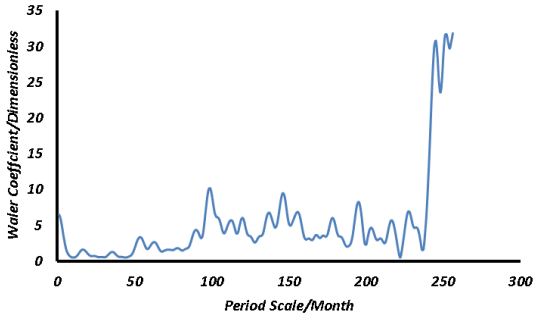

Figure 4.23 the second main cycle trend

In the first main cycle trend chart (Figure 4.22), we can see that in the first main cycle of the 25-month time scale, the trend of periodic fluctuation is more obvious, the period size varies from 53 months to 45 months, more in line with the real fluctuation of pork prices, take its average volatility of the late 50 months, As a forecast for changes in pork prices.

In the second main cycle of the 4-month time scale (Figure 4.23), the pork price in the early period is relatively stable, there is no obvious large fluctuation. In the middle, there is obvious cyclical fluctuation, the average period is about 8 months. At this time the cycle fluctuation of pork price is relatively stable. At the later stage, the cycle of pork price change is shortened, the average period is 4 months, indicating that the change of pork price in recent years is in an unstable state. It needs further artificial regulation to make a rational breeding plan. This part more represents a historical change in pork prices overall trend, but is not helpful for the forecast of cyclical changes.

4.2.2 Simulating annealing model establishment and solution

4.2.2.1 Model establishment

The specific process is exhibited in Appendix.

4.2.2.1 Solution of the model

(1) Location identification

Analyze the statistics of the latitude and longitude of each province in China to ensure the reasonable expression of the required geographical coordinates, and lay the foundation for the later annealing simulation. The specific data of geographical coordinates of different provinces are showed in Appendix.

(2) Classification

Due to the vast territory of our country, the population, consumption preferences, traffic conditions, economic level, pork farming and corn production in different regions are also different. Therefore, there are differences in pork price level and

fluctuations in different regions. Some of the geographical proximity areas, areas with a level of economic development, and areas where local pork supplies can meet local needs, their pork price level and volatility may be very close. So, in order to study China's pork market better and avoid redundancy, it is necessary to divide it regionally, so that the characteristics of the pork market in the same region are similar. The characteristics of the pork market are different from region to region, and then the characteristics of the pork market in each region are analyzed. Reasonable suggestions are put forward for the different reasons affecting the pork market in each region, so that the pork market in the whole country becomes stable.

The K-means[7] cluster analysis has been used to solve the problem. Based on the monthly price time series data of pork in different provinces, autonomous regions and municipalities from January 2000 to December 2018, taking full account of the long-term fluctuations in pork prices in provinces and urban areas, the pork market in China is divided into low, general and high three categories. The K-means analysis process and result are as follows (see Appendix for specific principles):

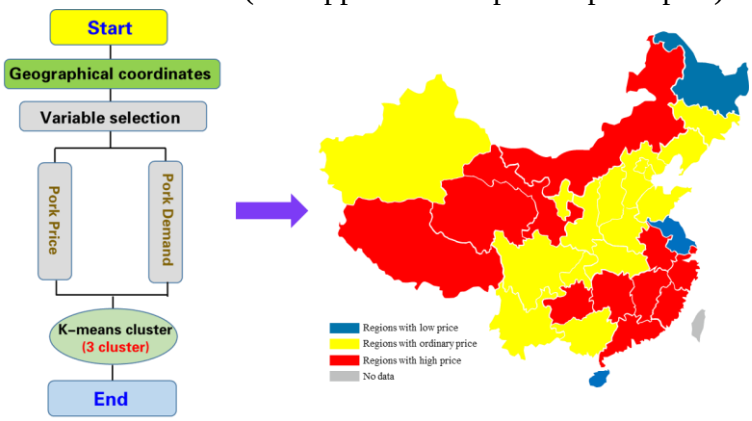

Figure 4.24 Clustering analysis results based on pork price

(3) Reasonable farming and transporting plan

According to the related ideas of the simulated annealing, the solution process of the above problem has been programmed. The simulation annealing algorithm objective function adaptability curve for calculating the minimum path of pork transport in the problem is shown as the simulation of the objective function fitness curve, and it can be found that an approximate solution to the problem has been found after 500 iterations.

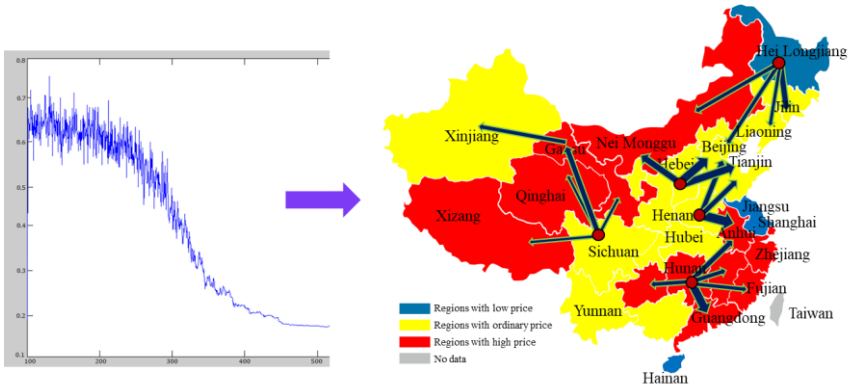

Figure 4.25 Calculation results

As shown in the Figure 4.25, according to the calculation results, the optimal breeding land is obtained. Draw the optimal transport route, the thickness of the segment represents the size of the volume of transport. The obvious trends in the resulting graph represents proximity principle, as well as two-line transportation, which meets the expectations for the optimal route.

4.2.3 Cost control model

If pork prices cannot be brought down in a short period of time through a breeding plan, a reasonable procurement plan needs to be developed, and the main factor to be considered in the formulation of the procurement plan is the control of pork costs[8]. A cost control model can be established to develop a reasonable procurement plan, which is showed in Appendix.

The main cost items of pig procurement are: feed purchase price, purchase fee, handling fee, storage fee. Purchase price is up and down due to the purchase volume. Procurement fees are generally only related to the number of purchases, not related to the purchase volume. Handling fees are related to the total weight of the purchase and relatively stable. Storage fees and procurement volume are closely related.

Calculated by the model, the amount of pork imported from the world within three months is shown. (Table 4.2)

Table 4.2 China's worldwide pork import within three months

Importing countries	Import volume (ton)
America	30800
Canada	50400
Spain	16800
French	12600
Denmark	22400

4.3 Part III Models and Results

4.3.1 Regional optimization strategy analysis

Part II uses K-means cluster analysis to divide the country into three regions based on pork price fluctuations over the past 20 years. Therefore, this part, using the previous analysis results, uses the variation rate formula to analyze the fluctuation of pork prices in different regions, and divide it periodically, so as to provide the relevant theoretical basis for decision-making.

4.3.1.1 Low-price area aquaculture optimization strategy

According to the results of the previous cluster analysis, the low-price areas mainly refer to Heilongjiang and Hebei provinces. Due to space limitation, we take Heilongjiang as an example and analyze the law of fluctuation and countermeasure of such regional fluctuation.

Before we analyze, let's define a variable, so called variation rate. The variability value volatility index, which is used to represent the intensity of time series fluctuations, can be calculated as:

$$RV(t) = \frac{Y_t - Y_t^{'}}{Y_t^{'}} \times 100\%$$

In this condition， Y_t represents the actual observation of the t-moment, $Y_t^{'}$ is the prediction for t-moment (also known as trend value), $Y_t - Y_t^{'}$ is the absolute change in economic variables after excluding long-term trends. RV（t）not only reflects the relative fluctuation of a variable against the time trend value, but also reflects the stability of a variable. The greater the absolute value, the worse the stability.

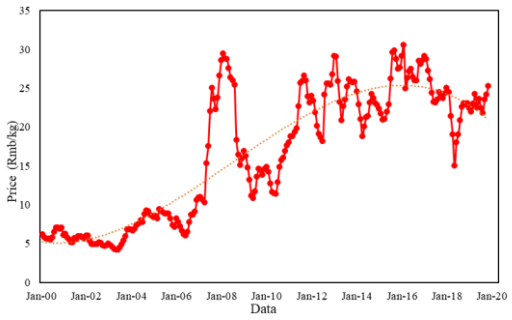

Figure 4.26 The actual and forecast of pork price in Heilongjiang Province

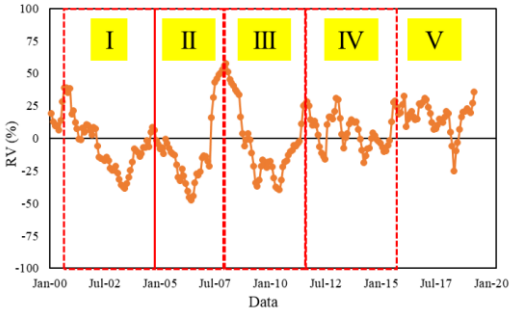

Figure 4.27 The grain curve of pork price variation in Heilongjiang Province

The parameters of specific characteristics for each period can be found in the Table 4.3.

Table 4.3 Heilongjiang pork price fluctuation cycle table

Cycle	Duration (month)	Wave (%)	Trough (%)	The amplitude (%)	Average amplitude (%)
I	46	38.05	-38.5	76.55	
II	39	51.17	-47.80	98.97	
III	45	51.17	-39.57	90.74	74.18
IV	48	28.14	-18.73	46.87	
V	40	32.50	-25.29	57.79	

For low-price areas, pork fluctuations in the last 20 years can be divided into 5 cycles (ignoring small fluctuations caused by seasonal causes), each cycle duration of about 40 months. Such areas are low in consumption and geographically advantageous, with pig-breeding conditions, and their pork is responsible for supplying other provinces in addition to local consumption, and therefore has a greater impact on external market environments.

According to the calculated variation rate, Heilongjiang Province in the future

pork fluctuations will soon enter the sixth cycle, pork prices are more likely to fall. Therefore, in the next two years, we should give full play to its geographical, resources and the advantages of pig breeding in the market, rational planning of breeding areas, and give good policy subsidies, increase capital investment, so that farmers can expand the scale of farming, and ready to transport pork to the central price area (such as Beijing, Shanghai).

4.3.1.2 General price area aquaculture optimization strategy (Appendix)

4.3.1.3 High-priced regional aquaculture optimization strategy (Appendix)

4.3.2 Stability analysis

According to The Prat I analysis, we found that pork prices are mainly related to pig prices, and pork out-of-the-box ratios are closely related to pig prices. Therefore, in order to ensure the amount of pigs out of the column, we can refer to the corresponding measures proposed in Part II. For the main pork production area, we should maintain and gradually increase the amount of pork farming, increase technical input. The government gives large-scale subsidies to farmers and does a good job in disease prevention and control measures, and for pork consumption, pork reserves should be increased, pork purchase channels should be broadened, the early warning mechanism for pig prices should be improved, and local resources should be developed to properly carry out pork farming. The specific responses are shown in the Table .

In the future, in order to prevent market instability caused by the high demand for pork in a certain place, it is necessary to increase the pork reserves of the main pork producing areas and to appropriately encourage pig farming in the consuming areas. Therefore, we mainly divide China's future pig reserves into three regions, namely, key breeding areas, general breeding areas and encouraging breeding areas, the specific classification results are shown in the Figure 4.28.

Figure 4.28 Specific classification results

5. Sensitivity Analysis

In the process of Part III analysis, we use three polynomials to fit the historical volatility price trend, and get the corresponding fluctuation period and law. Therefore, taking Heilongjiang as an example, we choose the secondary function and the linear function for trend fitting, analyze the change characteristics of the fluctuation period and law under the different fit function, so as to verify the adaptability and sensitivity of the fitted model.

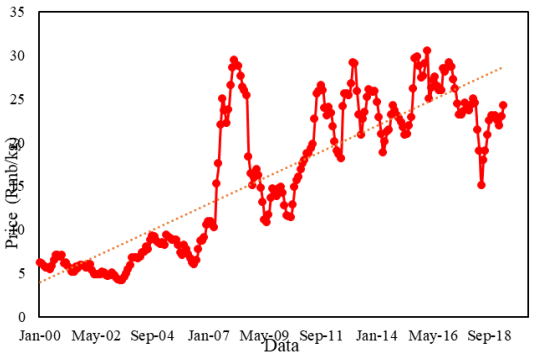

Figure 5.1 Heilongjiang pork price prediction value under linear function

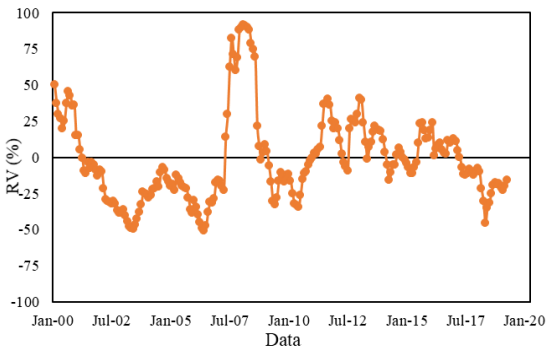

Figure 5.2 The value of Heilongjiang pork price variation under linear function

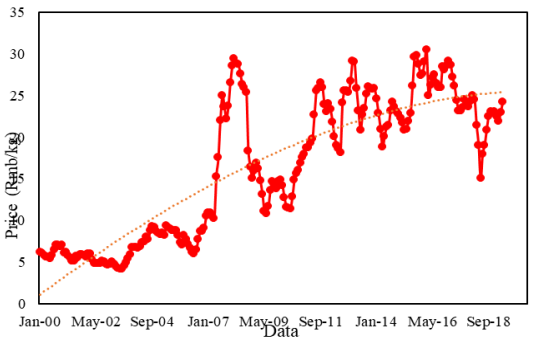

Figure 5.3 The prediction value of Heilongjiang pork price under the secondary function

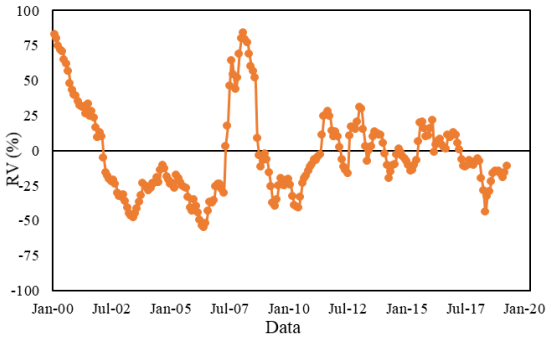

Figure 5.4 The value of Heilongjiang pork price variation under the secondary function

Table 5.1 Pork price fluctuation cycle table under different fitting functions

Fitting function	Cycle	Duration (month)	Wave (%)	Trough (%)	The amplitude (%)	Average amplitude (%)
Linear fitting	I	58	50.12	-46.35	96.47	103.55
	II	42	90.00	-50.79	140.79	
	III	42	90.00	-34.26	124.26	
	IV	54	39.85	-10.85	50.7	
	V	--	24.12	--	--	
Quadratic function fitting	I	55	83.00	-47.74	130.74	109.11
	II	40	84.44	-55.02	139.46	
	III	47	84.44	-39.56	124	

	IV	58	28.12	-14.15	42.27
	V	--	21.48	--	

It can be seen that the choice of different fitting functions, Heilongjiang Province in the past 20 years pork price cycle has still experienced 4 cycles, is currently in the final stage of the fifth cycle, will enter the sixth cycle, and the average amplitude is relatively large, which is consistent with the three functions selected by the Part III model conclusions. Therefore, we think that the different fitting functions have little effect on the conclusion, and the model is less sensitive to the fitted function, and the results are more realistic.

6. Strengths and Weakness

6.1 The Strengths of models

(1) We counted the price data on pork, hog, piglet, soybean, beef, lamb, corn and eggs from 2000 onwards, which ensured the authenticity and reliability of the conclusions.

(2) In Part I, the top five factors of correlation were selected using gray correlation, and the response surface design method was used for secondary polynomial fitting, which was simple and intuitive and easy to analyze.

(3) In Part II, K-means clustering method is used to classify pork prices in different regions, and the farming and transportation plans are proposed using the optimization algorithm, making the scheme more targeted.

(4) In Part III, the variation coefficient is used to analyze the fluctuation law and trend of pork in different regions, and the future pork farming in China is divided into three levels according to the region, and corresponding breeding and reserve plans are carried out, so that it can cope with various situations with ease.

6.2 The Weakness of models

Due to the difficulty of obtaining data, only some representative areas are selected in the analysis of the problem, and the next step can be to consider a detailed analysis of the evolution of pork prices in each region.

7. Conclusion

Through the solution of the above problems, we find that pork prices are affected by many factors, and have a certain periodicity. In the pork market, different regions play different roles, some regions are the main export type, some regions are the main consumer type, and some places are home-grown and self-marketing. Therefore, in the formulation of the corresponding breeding, reserve plan, the targeted measures should be carried out based on the role of the region, so as to make the development decision more scientific and reasonable and ensure the smooth operation of China's pork market.

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Appendix

Models and part of the solutions

1. Grey correlation analysis

(1) Determine the evaluation object and reference series

Determine the comparison object and reference series. There are m evaluation objects, and n evaluation indicators, then the reference series satisfy $x_0 = \{x_0(k) \mid k = 1, 2...n\}$ .The comparison sequence satisfies $x_i = \{x_i(k) \mid k = 1, 2...n\}, i = 1, 2, ..., m$. This reference number is listed as pork prices between 2000 and 2019, and the evaluation target is the 8 indicators selected.

(2) Calculate the metric weights. All indicator weights in the invention are set to 1.

(3) Calculating the gray correlation coefficient.

$$\xi_i(k)=\frac{\min\limits_s\min\limits_t\left|x_0(t)-x_s(t)\right|+\rho\max\limits_s\max\limits_t\left|x_0(t)-x_s(t)\right|}{\left|x_0(k)-x_i(k)\right|+\rho\max\limits_s\max\limits_t\left|x_0(t)-x_s(t)\right|}$$

To compare the correlation coefficient on the k indicator of sequence x_i to reference sequence x_0, $\rho\in[0,1]$ is resolution coefficient. $\min\limits_s\min\limits_t\left|x_0(t)-x_s(t)\right|$ and $\max\limits_s\max\limits_t\left|x_0(t)-x_s(t)\right|$ are two minimum differences and two maximum differences, respectively.

In general, the higher resolution factor ρ, the greater the resolution; the lower ρ, the smaller the resolution.

(4) Calculating gray weighted correlation

The calculation formula for gray weighted correlation is:

$$r_i=\sum_{k=1}^{n}w_i\xi_i(k)$$

In this condition, w_i is the weights for each metric. $\boldsymbol{\omega}=[\omega_1,\omega_2,...\omega_8]$, r_i are the *i-th* gray weighted correlation to ideal object.

(5) Analysis of evaluation results

According to the size of the gray weighted correlation, sort each evaluation object, and the correlation sequence of the evaluation object can be established. The greater the correlation, the better the evaluation effect.

2. K-means clustering analysis

(1) description

Algorithm analysis: the commonly used clustering methods include k-means clustering, DBSCAN, hierarchical clustering, mean shift clustering, etc. Except k-means, it is not necessary to specify the number of clusters for the latter three.However, since the number of clusters is known to be 3, k-means clustering algorithm is chosen. Meanwhile, k-means also has the advantages of fast speed and simple calculation.

Principle of k-means algorithm: suppose there is an initial data set, and each vector is a dimension (the dimension vector is composed of several variables of the original data). The purpose of k-means clustering is to divide the original data into K categories and result clusters under the condition of a given number of classification groups K (K n).

When using k-means clustering, the general steps are as follows:

Step1: select 3 events as cluster centers at the initial stage;

Step2: calculate the distance from each clustering object to the cluster center and

divide it into clusters with the shortest distance;

Step3: update cluster center;

Step4: repeat Step2 and Step3 until the cluster center is no longer changed to obtain clustering results.

(3) Results

Pig price area:

Low-price area (level 3): Heilongjiang, Jiangsu, Hainan Province

General price area (level 2): Jilin Province, Liaoning Province, Hebei Province, Shanxi Province, Xinjiang, Beijing, Henan Province, Shandong Province, Shaanxi Province, Tianjin, Guangxi, Chongqing, Sichuan, Hubei, Yunnan and Ningxia

High-priced region (level 1): Tibet, Inner Mongolia, Anhui Province, Fujian Province, Guangdong Province, Guizhou, Zhejiang, Shanghai, Qinghai, Gansu, Hunan province and Jiangxi Province

Not considered area (not considered at this time): Hong Kong, Macau, Taiwan.

3. Response surface design

The design table

Plan	Hog	Piglet	Corn	Lamb	Soybean
1	10	10	2.4	41.5	3.15
2	10	23	1.65	15	2.1
3	5	23	1.65	15	3.15
4	10	10	0.9	41.5	3.15
5	10	23	0.9	41.5	2.1
6	10	10	1.65	68	3.15
7	10	10	1.65	41.5	4.2
8	15	23	1.65	68	3.15
9	15	10	1.65	41.5	3.15
10	15	36	1.65	41.5	3.15
11	15	23	1.65	15	3.15
12	10	23	2.4	41.5	4.2
13	10	23	2.4	68	3.15
14	5	23	1.65	41.5	4.2
15	15	23	0.9	41.5	3.15
16	10	23	1.65	41.5	3.15
17	10	23	1.65	68	4.2
18	10	23	1.65	41.5	3.15
19	10	36	2.4	41.5	3.15
20	5	23	1.65	41.5	2.1
21	10	23	0.9	68	3.15
22	10	23	1.65	41.5	3.15

23	10	23	1.65	41.5	3.15
24	10	23	2.4	15	3.15
25	10	36	1.65	68	3.15
26	10	36	1.65	41.5	2.1
27	10	23	0.9	15	3.15
28	5	36	1.65	41.5	3.15
29	10	23	0.9	41.5	4.2
30	15	23	2.4	41.5	3.15
31	10	23	1.65	68	2.1
32	10	23	1.65	41.5	3.15
33	10	36	0.9	41.5	3.15
34	5	23	0.9	41.5	3.15
35	5	10	1.65	41.5	3.15
36	5	23	2.4	41.5	3.15
37	10	23	1.65	15	4.2
38	15	23	1.65	41.5	2.1
39	10	36	1.65	15	3.15
40	10	10	1.65	15	3.15
41	15	23	1.65	41.5	4.2
42	5	23	1.65	68	3.15
43	10	10	1.65	41.5	2.1
44	10	36	1.65	41.5	4.2
45	10	23	2.4	41.5	2.1

4. The location of different provinces

Latitude and Longitude of China's Provinces

Region	longitude E	latitude N	Region	longitude E	latitude N
Beijing	116.395645	39.929986	Shanghai	121.4788	31.2303
Tianjin	117.210813	39.14393	Jiangsu	118.778074	32.057236
Hebei	114.522082	38.048958	Zhejiang	120.219375	30.259244
Shanxi	112.550864	37.890277	Anhui	117.282699	31.866942
the Nei Monggol Autonomous Region	111.660351	40.828319	Fujian	119.330221	26.047125
Liaoning	123.432791	41.808645	Jiangxi	115.893528	28.689578
Jilin	125.3222	43.816	Shandong	117.024967	36.682785
Heilongjiang	126.657717	45.773225	Henan	113.649644	34.75661
Hubei	114.3162	30.581084	Hunan	112.979353	28.213478
Guangdong	113.30765	23.120049	The Guangxi Zhuang Autonomous	108.297234	22.806493

			Region		
Hainan	110.330802	20.022071	Guizhou	106.709177	26.629907
Chongqing	106.55	29.5647	Yunnan	102.714601	24.882
Sichuan	104.0648	30.57	Tibet	91.111891	29.662557
Shanxi	108.939	34.342	Gansu	103.823305	36.064226
Qinghai	101.767921	36.64.739	Ningxia	106.206479	36.064226
the Xinjiang Uygur Autonomous Region	87.564988	43.84038			

5. Model establishment of cost

(1) Parameters

The purchase price should be measured in real terms, and the purchase price varies depending on the purchase volume, and the price applied in the digital model must be scientifically processed. If the purchase volume is lower than q_0, the procurement price is p_1; If the purchase volume is higher than q_0, the procurement price is p_2. Assuming that the actual purchase volume is q, purchase prices p in the mathematical model is $p=\left[p_1\times q_0+(q-q_0)\times p_2\right]/q$, that is $p_2+(p_1-p_2)(q_0/q)$.

If the purchase volume is q, the inventory reduction varies from 0 to q in a procurement cycle. In a mathematical model, the average inventory can be approximated q/2

(2) Cost model

The annual total cost F(q) that constitutes the procurement process mainly includes the annual feed purchase price C_1, the annual purchase fee C_2, the annual handling fee C_3, the annual storage fee C_4. The annual consumption of some feed is easier to estimate in terms of the scale of culture and the structure of culture. Suppose the storage cost rate is i, each purchase fee C_0, unit handling fee is a, unit vehicle freight is b, unit vehicle volume is q. The: annual feed total purchase price C_1 = annual consumption Q × purchase price p; annual procurement fee C_2=annual purchase number (Q/q) × per purchase fee C_0; annual handling fee C_3= unit vehicle freight b vehicles(q/q_l) × annual purchase number (Q/q) + warehouse handling fee Qa; annual storage fee C4 s average inventory q/2 × storage cost i. Therefore: $F(q)= C_1+ C_2+ C_3+ C_4$.

$$F(q)=Qp+(Q/q)C_0+\left[b\left(q/q_1(Q/q)+Qa\right)\right]+(q/2)i$$

The minimum point of this function is $q_{e1}=\sqrt{2QC_0/i}$, corresponding minimum value is :

$$F(q_{e1})=(i/2)q_{e1}+(QC_0)/q_{e1}+(p_1Q+aQ+bQ/q_1)$$

Assuming $F_2(q)=(i/2)q_{e1}+(QC_0)/q_{e1}+(p_1Q+aQ+bQ/q_1)$

The minimum point of this function is $q_{e2}=\sqrt{\left[2QC_0 2(p_1-p_2)Qq_0\right]/i}$, corresponding minimum value is :

$$F(q_{e2})=(i/2)q_{e2}+(QC_0)/q_{e2}+(p_1Q+aQ+bQ/q_1)$$

Compare $F(q_{e1})$ and $F(q_{e2})$, the smallest purchase volume, the best economic batch.

6. Simulating annealing model establishment

(1) Solution Space and Initial Solution

Represent a solution of TPS as a circular arrangement $\pi=(\pi_1,\pi_2,\cdots,\pi_n)$. π_i is represented as the ith passing place of the path, and satisfy $\pi_i\neq\pi_j$. A collection of all possible solutions constitutes a solution spatial vector $S=\left\{(\pi_1,\pi_2,\cdots,\pi_n)|_{(\pi_1,\pi_2,\cdots,\pi_n)}\right\}$, which is the circular permutation of $\{1,2,\cdots,n\}$. Each of these loops represents a loop in n cities, and make sure $\pi_{n+1}=\pi_1$. Initial solution $\{1,2,\cdots,n\}$.

(2) Objective function

$$f(\pi)=\sum_{i=1}^{n}d_{\pi_i,\pi_{i+1}}$$

In this condition: $\sum_{i=1}^{n}d_{\pi_i,\pi_{i+1}}$ is the length of path to all cities. To minimize the transport distance, is to minimize the target function.

(3) The emergence of a new solution

Set the solution for the previous iteration as $\pi_1\cdots\pi_{u-1}\pi_u\pi_{u+1}\cdots\pi_{v-1}\pi_v\pi_{v+1}\cdots\pi_n$. The new path after the transformation is $\pi_1\cdots\pi_{u-1}\pi_{v\text{-}1}\cdots\pi_{u+1}\pi_v\pi_{v+1}\cdots\pi_n\,(u<v)$.

(4) Reception rule

$$p_i(i \Rightarrow j) = \begin{cases} 1 & f(j) \le f(i) \\ \exp\left[\dfrac{f(i) - f(j)}{t}\right] & f(j) > f(i) \end{cases}$$

7. The establishment and solution of wavelet analysis model

（1）Wavelet function establishment

The basic idea of wavelet analysis is to represent or approximate a signal or function through a cluster of wavelet function systems. Therefore, this function is the basis of wavelet analysis, which refers to a class of functions that are oscillating and can quickly decay to zero. So the wavelet function $\psi(t) \in L^2(R)$ must satisfy:

$$\int_{-\infty}^{+\infty} \psi(t)dt = 0 \qquad (1)$$

In this condition， $\psi(t)$ is a base wavelet function. A cluster of function systems can be formed by dilation scale and panning timelines:

$$\psi_{a,b}(t) = |a|^{-1/2} \psi(\frac{t-b}{a}) \qquad (2)$$

In this condition， $a,b \in R, a \neq 0$， a is scale factor，reflecting cycle length of the wavelet. b is shift factor, reflecting translational possibilities of time. $\psi_{a,b}(t)$ is sub wavelet. In this question, the base wavelet function is judged by comparing the results obtained by different wavelet analysis processing signals and the error size of the theoretical results. Then the desired base wavelet function is selected is chosen.

（2）Wavelet transform

If $\psi_{a,b}(t)$ is given by condition(2)， for a particular energy finite signal $f(t) \in L^2(R)$, the continue wavelet transform is:

$$W_f(a,b) = |a|^{-1/2} \int_{-\infty}^{+\infty} f(t)\psi(\frac{t-b}{a})dt \qquad (3)$$

In this condition，$W_f(a,b)$ is wavelet transform coefficient，$f(t)$ represents a signal or square-to-product function, a is dilation scale，b is translation parameters; $\bar{\psi}(\frac{t-b}{a})$ is complex conjugate to $\psi(\frac{t-b}{a})$. In this question, because the obtained temperature data points are discrete points, set the function $f(h\Delta t)$，（h=1，2，…，N），Δt is time interval, units are usually days or months.

By transformation, the discrete wavelet transformation of the formula (3) can be expressed as:

$$W_f(a,b) = |a|^{-1/2} \Delta t \sum_{k=1}^{N} f(k\Delta t) \bar{\psi}(\frac{k\Delta t - b}{a}) \quad (4)$$

The basic principle of wavelet analysis can be understood by the equation (3) or (4), that is, the frequency information of the signal is obtained by changing the dilation scale a, and then the generality or detail of the signal is analyzed to realize the analysis of the different time scale of the signal and the local characteristics of space.

（3）Wavelet variance

By integrating the average of the wavelet coefficient on the b-domain, the wavelet variance is obtained：

$$Var(a) = \int_{-\infty}^{+\infty} |W_f(a,b)|^2 db \quad (5)$$

The wavelet variance changes with the curve of scale a, called the wavelet variance graph. As can be seen from (5), it can reflect the distribution of the energy of the signal fluctuation over time scale a. Therefore, the wavelet variance graph can be used to determine the relative intensity and main time scale of the pork price data body with different kinds of scale disturbance, that is, the main period, and the law contained in the historical data of pork price.

8. Summary of Future Trends and Countermeasures

Summary of Future Trends and Countermeasures

territorial classification	Regional function		Future Trend	Countermeasure
Low price area	Main origin	Heilongjiang, Hainan	In the next 1-2 years, the price of pork in the main origin is on a downward trend, and the price of pork is high.	Stabilize pig farming programs, increase government subsidies and broaden pork export channels (Beijing, Jilin and other places)
	Main consumer	Jiangsu	In the next 2-3 years, the price of pork in the consumer areas has risen steadily.	Prepare for in pork reserves and broaden the purchase channels for pork (Henan)
General price area	Main origin	Sichuan, Henan, Shandong, Yunnan, Hubei, Guangxi, Hebei、	In the next 2-3 years, the price of pork in the main origin will rise.	Increase pig farming, stabilize domestic demand, prepare for the supply of pork consumption areas around, and prepare for disease prevention.
	Main consumer	Guangdong, Jilin,	In the next 2-3 years, the main	Prepare for pork reserves, broaden the purchase

		Liaoning, Shanxi, Xinjiang, Beijing, Shanxi, Tianjin, Chongqing, Ningxia	consumption of pork demand is large, pork prices are on the rise, but the price increase is small.	channels of pork, improve the early warning mechanism of pig prices.
High price area	Main origin	Hunan	In the next 2-3 years, the price of pork in the main origin is on the rise	Increase pig farming, stabilize domestic demand, improve transportation conditions between consumption areas, and control transportation costs
	Main consumer	Tibet, Inner Mongolia, Anhui, Fujian, Guizhou, Zhejiang, Shanghai, Qinghai, Gansu, Jiangxi	In the next 2-3 years, the demand for pork in the main consumption areas will continue to increase, and pork prices will rise, but the volatility will be small.	Do a good job in pork reserves, broaden the purchase channels of pork, improve the early warning mechanism of pig prices, make every effort to develop local resources and properly carry out pig farming

9 General price area aquaculture optimization strategy

According to the results of the previous cluster analysis, the general price areas are Jilin Province, Liaoning Province, Hebei Province, Shanxi Province, Xinjiang, Beijing, Henan Province, Shandong Province, Shaanxi Province, Tianjin, Guangxi, Ningxia, Chongqing, Sichuan Province, Hubei Province and Yunnan Province. Some of these areas are the main pork producing areas in China, such as Henan, Sichuan, Hubei and so on, some are convenient pork sales areas, such as Beijing, Tianjin and so on. Because there are more regions, we take Tianjin as an example to carry out the relevant analysis.

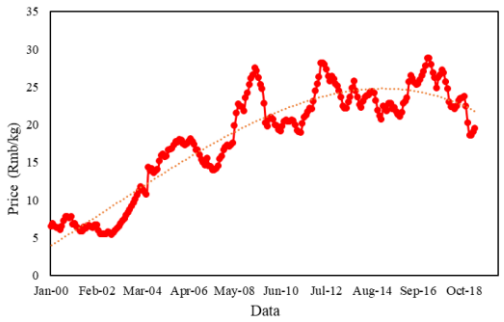

Figure The actual and predicted pork price in Tianjin

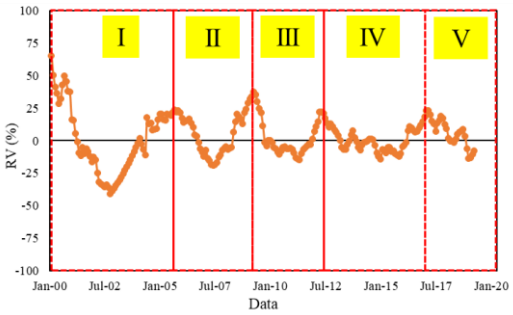

Figure The grain curve of pork price variation in Tianjin

The parameters of specific characteristics for each period can be found in the Table.

Figure Tianjin pork price fluctuation cycle table

Cycle	Duration (month)	Wave (%)	Trough (%)	The amplitude (%)	Average amplitude (%)
I	68	45.35	-40.94	86.29	
II	46	34.93	-18.84	53.77	
III	40	34.93	-10.19	45.12	55.06
IV	61	20.60	-14.46	35.06	
V	--	19.80	--	--	

For the general price area, the price of pork is higher than in the low price area, but the volatility is relatively small. In Tianjin, for example, there have been four cycles in the last 18 years, with an average period of 50 months. Tianjin pork prices are currently in the fifth cycle, it can be predicted that in the next 2-3 years, pork prices have an upward trend.

For the next 2-3 years, the demand in the main market area of the general price area will increase, so for such areas, pork reserves should be done to prevent a sharp increase in pork prices due to uneven supply and demand. For pork-producing areas in such areas, pork farming should be expanded and disease prevention should be done, and it is necessary to make plans for the supply of the main selling areas (e.g. Beijing and Tianjin) as the main pig-producing province.

10. High-priced regional aquaculture optimization strategy

According to the results of the previous cluster analysis, the general price areas are Tibet, Inner Mongolia, Anhui Province, Fujian Province, Guangdong Province, Guizhou Province, Zhejiang Province, Shanghai, Qinghai Province, Gansu Province, Hunan Province and Jiangxi Province. Some of these areas are high-economic areas along the eastern coast and have less pig farming and require the purchase of pork from other regions. In Guangdong Province, for example, it needs to buy more than 10 million pigs a year from the province, and the other part is inland, where the pig industry is less and relies on foreign provinces for supply, but it is far from the main pig-producing area, making pig transportation costs higher, so the price is high.

Because there are more regions, we take Shanghai as an example to carry out the relevant analysis.

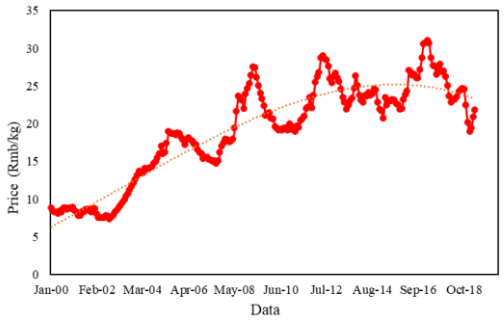

Figure The actual and predicted pork price in Tianjin

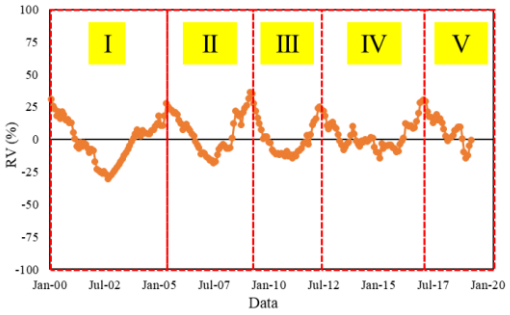

Figure The grain curve of pork price variation in Tianjin

The parameters of specific characteristics for each period can be found in the Table.

Figure Shanghai pork price fluctuation cycle table

Cycle	Duration (month)	Wave (%)	Trough (%)	The amplitude (%)	Average amplitude (%)
I	64	30.98	-28.87	59.85	
II	48	34.88	-18.53	53.41	
III	37	34.88	-14.77	49.65	51.69
IV	59	29.32	-14.53	43.85	
V	--	29.32	--	--	

Shanghai pork prices are higher than in Heilong, Tianjin, but price fluctuations are relatively small, with average amplitudes being the lowest in the three regions. Shanghai pork has gone through four cycles in the past 20 years, similar to Tianjin. Shanghai pork volatility cycle of about 45 months, is currently in the middle of the fifth cycle, the forecast in the next 2-3 years pork prices will rise.

For areas in high-priced areas, regulation should be carried out in two ways. On the one hand, we should do a good job in pork reserves, on the other hand, we should improve the traffic conditions between such areas and the main pork producing areas, reduce transportation costs. At the same time, we should also try our best to develop local resources for proper pig farming.

According to the previous analysis results, pork price dynamics and countermeasures in different parts of China in the next 3 years are showed in Appendix.

Codes

1 Grey correlation

```
clc,clear
a= load('data1.txt');
cankao= load('cankao.txt');
for j =[1:2 6:8]
    a(:,j)=(a(:,j)-min(a(:,j)))/(max(a(:,j))-min(a(:,j)));
end
for j =[3:5]
    a(:,j)=(max(a(:,j))-a(:,j))/(max(a(:,j))-min(a(:,j)));
end
cankao(:)=(cankao(:)-min(cankao(:)))/(max(cankao(:))-min(cankao(:)));
[m,n]=size(a);
t=abs(cankao-a);
mmin=min(min(t));
mmax=max(max(t));
rho=0.5; %分辨系数
xishu=(mmin+rho*mmax)./(t+rho*mmax)
guanliandu=mean(xishu)
[gsort,ind]=sort(guanliandu,'descend')
```

2. K-means cluster

(2) Code

```
Centers = p(:,1:ClusterNum);
NumberInClusters = zeros(ClusterNum,1); %
IndexInClusters = zeros(ClusterNum,SamNum); %
while 1,
NumberInClusters = zeros(ClusterNum,1); %
IndexInClusters = zeros(ClusterNum,SamNum); %
% 按最小距离原则对所有样本进行分类
for i = 1:SamNum
%计算所有样本输入与聚类中心的距离
AllDistance = dist(Centers',p(:,i));
%按对小距离原则对样本进行分类
[~,Pos] = min(AllDistance);
```

```
NumberInClusters(Pos) = NumberInClusters(Pos) + 1;
IndexInClusters(Pos,NumberInClusters(Pos)) = i;
end
% 保存旧的聚类中心
OldCenters = Centers;
%重新计算各类新的聚类中心
for i = 1:ClusterNum
Index = IndexInClusters(i,1:NumberInClusters(i));
Centers(:,i) = mean(p(:,Index)')';
end
% 判断新旧聚类中心是否一致，是则结束聚类
EqualNum = sum(sum(Centers==OldCenters));
if EqualNum == InDim*ClusterNum,
break,
end
end
% 根据各聚类中心之间的距离确定各隐节点的扩展常数（宽度）
AllDistances = dist(Centers',Centers); % 计算隐节点数据中心间的距离（矩阵）
Maximum = max(max(AllDistances)); % 找出其中最大的一个距离
for i = 1:ClusterNum % 将对角线上的 0 替换为较大的值
AllDistances(i,i) = Maximum+1;
end
spread = Overlap*min(min(AllDistances)'); % 以隐节点间的最小距离作为扩展常数
%spread = Overlap*min(AllDistances)' % 以隐节点间的最小距离作为扩展常数
% 训练与测试
net = newrbe(p,t,spread);
a = sim(net,p);                          % 测试 - 输出为预测值
err1 = sum((t-a).^2);                    % 训练误差的平方和
```