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ShuWei Cup

# Summary

China is a large agricultural country, and the animal husbandry plays an important role in the national economy. The pig industry is the most important economic sector of animal husbandry with a long history. Pork has always been the largest source of meat for the people of China. Since the reform and opening up, China's pig industry has developed rapidly, which is one of the most important industries in animal husbandry. As a big country of pork production and consumption, the stability of pork price is very important for consumers, farmers and the government. However, the price of pork has not been satisfactory. As a result, sometimes the pig farmers suffer serious losses, sometimes the market price of pork rises rapidly. In this paper, a multi-standard screening model is established to study the factors of pork price fluctuation, pork price decline and pork supply and demand and reserve. The purpose is to find out a reasonable way to regulate the pork price in the whole country and meet the needs of farmers and consumers.

In the process of modeling, in order to calculate the factors that have a great influence on the fluctuation of pork price in the established model, we first use the analytic hierarchy process to analyze the pork price influencing factor index established in task I, then analyze the corresponding influencing factor reference coefficient values obtained from different influencing factors, and finally establish a multiple regression model, The influence factor analysis is carried out to prove the rationality of the model. At the same time, the price fluctuation of each year is discussed. Compared with the recent period, the model is optimized to determine the most important factors affecting the recent price fluctuation.

In the process of solving problem 2 and problem 3, the core point is that the established model must enable the breeding plan to quickly control the fluctuation of market pork price and at least keep the income and cost at the same level. In problem 2, considering the periodicity of pig breeding, the time of sow pregnancy and price fluctuation can be obtained by consulting the data, taking periodicity as the breakthrough point Line modeling, after the establishment of the model, it is reflected

in the preconditions of the designated breeding plan, and the final model is obtained after all the conditions are met. Finally, the model is validated. In question 3, considering the balance of supply and demand in the market, consulting the data to get the pork output and per capita consumption of each province in each year, the grey prediction model is established based on per capita consumption, and the cultivation mode is adjusted and controlled as a whole every year by comparing with the consumption and output of previous years.

**Key word:** pork supply and demand; price fluctuation; multiple regression model; impact factor analysis; grey prediction mod

# Content

# 1. Background

China is a large breeding country. Pork industry plays a leading role in animal husbandry. At the same time, pork has become one of the main sources of meat on people's table. With the increasing population, consumption and life have also improved.

On August 3, 2018, African swine fever was first diagnosed in China. In a short period of time, there was a sudden outbreak of African swine fever all over the country.

At the same time, many countries in Asia, Europe and other countries have emerged African swine fever and other epidemics. In the first half of 2019 alone, more than 5800 cases of African swine fever occurred in the world. Because of the spread of the global epidemic, the price of pork in the world as a whole has increased. Pork prices in the European Union have risen nearly 20%.

As a big pork consumption country, the rise of pig price has seriously affected people's daily living standards. Therefore, it is urgent to study the fluctuation of pork price and find a proper way to regulate the relationship between supply and demand of pork.

**Question 1: Analysis of the main influencing factors of pork price fluctuation**

A. Analyze the general influencing factors of pork price fluctuation by using the data over the years.

B. Is the recent fluctuation of pork price highly related to the common fluctuation of pork price? If not, what are the main influencing factors?

**Question 2: A Study on the fall of pork price**

A. Pork breeding usually has certain periodicity. When the price of pork is high, a reasonable breeding plan is proposed.

B. On the premise that pork breeding cannot be completed in a short period of time, a reasonable plan of purchasing from other countries is proposed to ensure the relative stability of domestic pork prices.

**Question 3:**

A. Study on the optimal supply and storage strategy of pork. When the demand of pork in different areas is relatively stable, the optimal breeding scheme in different areas is proposed.

B. In order to effectively cope with the peak demand of pork in a certain area, an effective pork storage strategy is proposed to ensure the stability of pork price.

# 2. Model Assumption

1. Do not consider fixed costs (such as land cost, buildings, pig drain, harmless treatment cost, etc.).

2. The sows are naturally fertilized, and the proportion of boars: sows is 1:30.

3. Assume that there is no war disaster in this country, and there are no major sudden disasters, such as earthquakes, hurricanes, etc.

4. It is assumed that there are only four main influencing factors: supply index, demand index, benefit index and environment index

5. Do not consider the interaction between the various influencing factors. And the unexpected factors of the given influencing factors are not considered.

6. It is assumed that the reference standard value of impact factor is selected according to the standard set by the United Nations.

7. It is assumed that in the selection process of the optimal value of the influence factor, only the size of the value is considered, and other influences are ignored.

# 3. Symbol System

Y: Pork price.
$Y_1$: Macro control system.
$Y_2$: Threat of animal diseases.
$Y_3$: Changes in feeding costs.
$Y_4$: Growth cycle of pigs.
$Y_5$: Changes in the number of meat reserves.
$Y_6$: Long term expectation of producers.
$Y_7$: Price change of substitutes.

U: Coefficient of change.
$U_1$: Coefficient of change of macro-control system.
$U_2$: Change coefficient of animal disease threat.
$U_3$: Coefficient of change of feeding cost.
$U_4$: Coefficient of change of growth cycle of pig.
$U_5$: Coefficient of change in the number of meat reserves.
$U_6$: Change coefficient of long-term expectation of producers.
$U_7$: Coefficient of change of substitute price.

$P_1$: Number of original sows in the farm.
$P_2$: Increase the number of sows in the farm.
X: Number of piglets per year.
$Z_1$: Total number of original pigs in the farm.
$Z_2$: Total number of pigs in one year.
$S_1$: Income of the farm in the first year.
$S_2$: Income after modification of breeding plan.
L: Half a year's benefits of the farm.
$C_1$: Cost of raising a sow.
$C_2$: Cost of raising a piglet.
x: Pork consumption per capital.

# 4. The Establishment and Solution of the Model

## 4.1 Build the solution model

China is the world's largest producer of pigs and a consumer of pork. As a traditional consumer food in China, pork consumption accounted for more than 85% of the meat consumption of residents in 1978. In 2011, this proportion still reached 60%, which is the most important meat food in China. The price level of live pigs is not only related to the income of farmers, but also to the quality of life of residents, and has an important impact on the national food security and the smooth operation of the national economy.

Since the reform and opening up, China's pork production has grown at an average annual rate of 5.2%, reaching 50.53 million tons in 2011. The production of pigs has shown a volatility. During the same period, the production price of live pigs increased by an average of 5.6%. Especially in the past decade, the price of live pigs has fluctuated frequently, and many new characteristics have appeared in cyclical fluctuations.

According to Guo Yuting et al. (2017), the main factors affecting pork price fluctuations are: macro-control system, threat of animal diseases, changes in feeding costs, growth cycle of pigs, changes in the quantity of stockpiles, and long-term producers. Expectations and changes in the price of alternatives, their respective coefficients of variation are shown in Fi. 1.

Multiple regression analysis is to study the statistical dependence of dependent variables on two or more explanatory variables. The multiple regression model is a regression model with two or more explanatory variables. Therefore, multiple regression models are established in Part I for problem analysis.

At the same time, the analytic hierarchy process is often used to influence the dynamic effects of different types of random variable disturbances on the system. Therefore, the analytic hierarchy process is used in A to discuss the problem. The analysis of variables and change weights is used to analyze the influence of different factors on pork price fluctuation. Pathway and degree of impact.

The pork price fluctuation data for the past ten years are shown in Table 1. At the same time, the price of corn is attached to the table, and the ratio of pig to grain is compared. The ratio of pigs and grains is, in layman's terms, the ratio of the price of live pigs to the price of corn as the main feed for pigs. According to China's relevant regulations, the ratio of live pig price to corn price is 6.0 to 1, and pig breeding is basically at a break-even point. At the same time, Figure 1 is a graph showing the price change of pork. From the analysis in the figure, it can be seen that pork price fluctuates significantly and has significant periodic characteristics.

Considering the relationship between parameters and various reference standards, model one can be established to derive the following formula:

$$Y = \sum_{i=1}^{n} Y_i U_i \ , \quad (n \le 7, n \in N^*) \tag{1}$$

Yi is the influencing factor, $-50 \le Y_i \le 50$ , When Yi is negative, it indicates that the influencing factor has a negative effect on pork prices, causing pork prices to fall; Ui is the weight of each influencing factor.

The influencing factors are brought into the formula (1), and the pork price is calculated and compared with Table 1, so as to verify the correctness of the model one.

In 2009,

$$Y = \sum_{i=1}^{n} Y_i U_i = 0 \times 0.1 + 10 \times 0.22 + 10 \times 0.3 + 0 \times 0.1 + 0 \times 0.02 + 20 \times 0.03 + 25 \times 0.23 = 11.55$$

In 2010,

$$Y = \sum_{i=1}^{n} Y_i U_i = 0 \times 0.1 + 10 \times 0.22 + 10 \times 0.3 + 0 \times 0.1 + 0 \times 0.02 + 20 \times 0.03 + 30 \times 0.23 = 12.70$$

In 2011,

$$Y = \sum_{i=1}^{n} Y_i U_i = 20 \times 0.1 + 10 \times 0.22 + 15 \times 0.3 + 0 \times 0.1 + 8 \times 0.02 + 25 \times 0.03 + 30 \times 0.23 = 16.51$$

In 2012,

$$Y = \sum_{i=1}^{n} Y_i U_i = 10 \times 0.1 + 20 \times 0.22 + 10 \times 0.3 + 10 \times 0.1 + 0 \times 0.02 + 20 \times 0.03 + 25 \times 0.23 = 14.58$$

In 2013,

$$Y = \sum_{i=1}^{n} Y_i U_i = 20 \times 0.1 + 10 \times 0.22 + 10 \times 0.3 + 0 \times 0.1 + 10 \times 0.02 + 20 \times 0.03 + 30 \times 0.23 = 14.90$$

The final calculation result is shown in table 2. The actual price is different from the theoretical price, but the difference is small, so the model I is correct.

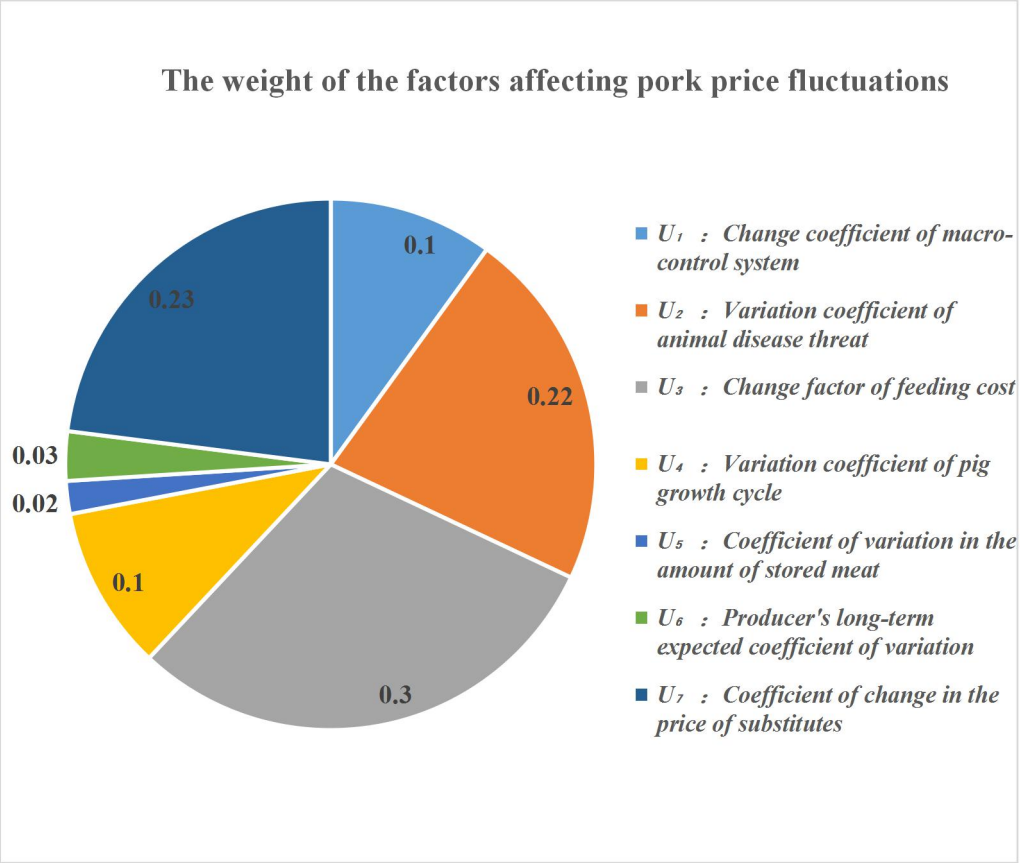


Fig.1 The weight of the factors affecting pork price fluctuations

Table 1 Pork and grain price lists for the last ten years

| Year | Pig price (yuan/kg) | Corn price (yuan/kg) | Pig grain price comparison |
|---|---|---|---|
| 2009 | 11.44 | 1.72 | 6.7 |
| 2010 | 11.76 | 2.02 | 5.82 |
| 2011 | 17.2 | 2.2 | 7.45 |
| 2012 | 15.18 | 2.44 | 6.22 |
| 2013 | 15.09 | 2.42 | 6.23 |
| 2014 | 13.53 | 2.46 | 5.49 |
| 2015 | 15.42 | 2.33 | 6.65 |
| 2016 | 18.66 | 1.97 | 9.48 |
| 2017 | 15.3 | 1.78 | 8.6 |
| 2018 | 13.12 | 1.95 | 6.74 |

Table 2 The actual price and the theoretical price from 2009 to 2013

| Year | Actual price (yuan/kg) | Theoretical price (yuan/kg) |
|---|---|---|
| 2009 | 11.44 | 11.55 |
| 2010 | 11.76 | 12.7 |
| 2011 | 17.2 | 16.51 |
| 2012 | 15.18 | 14.58 |
| 2013 | 15.09 | 14.9 |

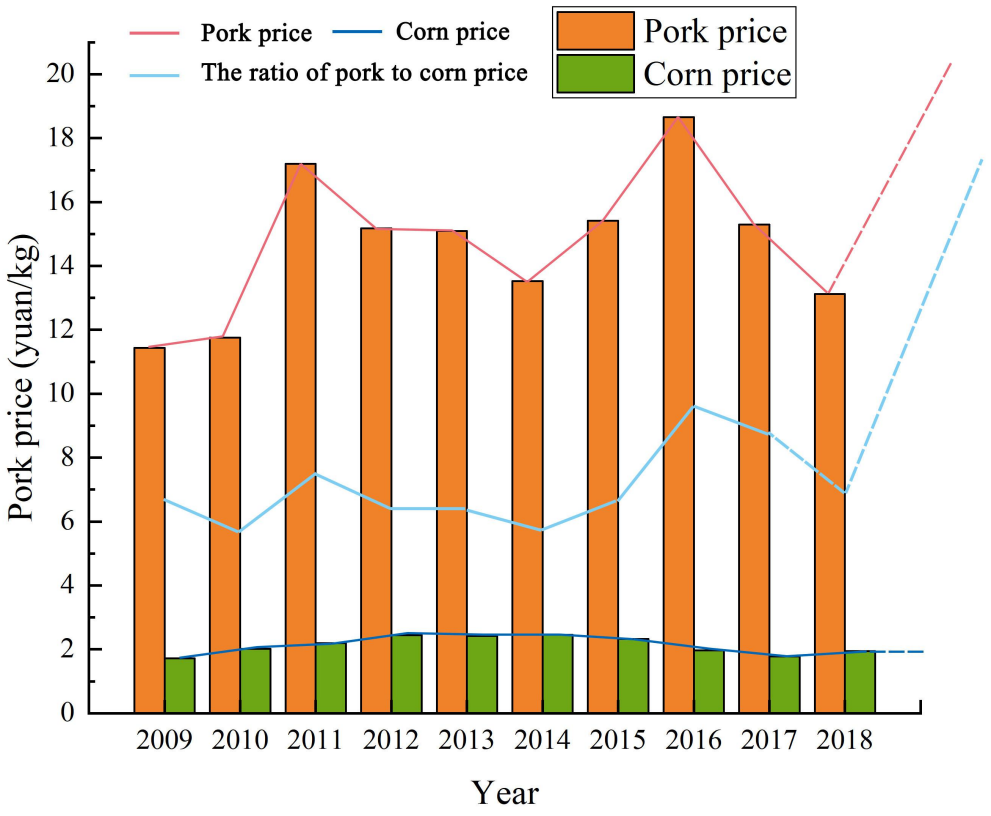


Fig. 2 Annual average curve of hog price, corn price and the ratio of pork and corn price in 2009-2018

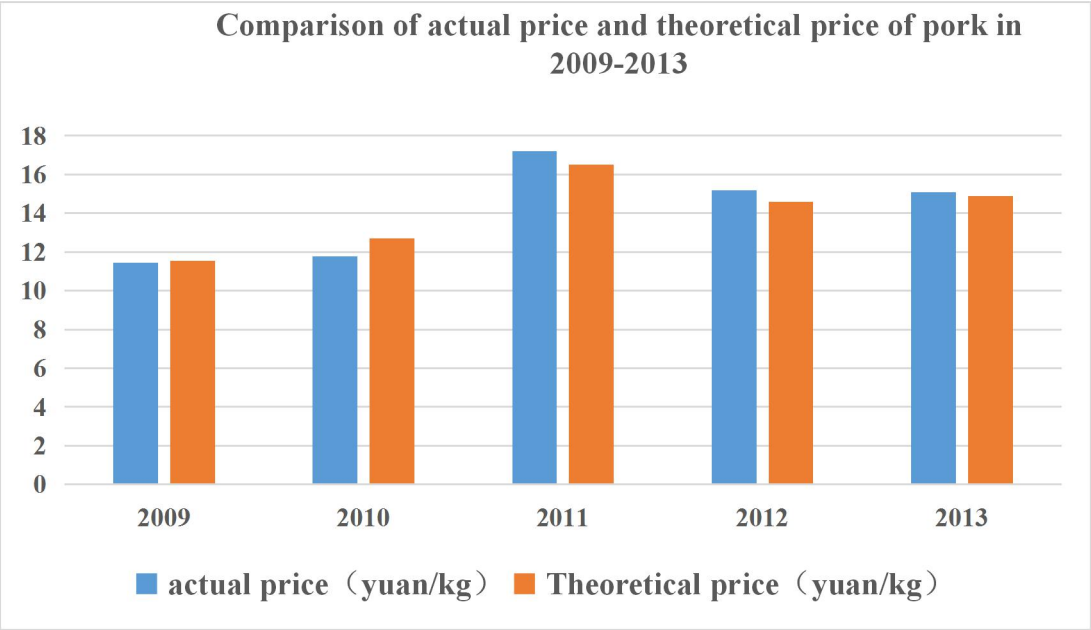


Fig. 3 comparison between theoretical price and actual price from 2009 to 2013

As can be seen from the foregoing, the main factors affecting pork prices are macro-control systems, threats of animal diseases, changes in feeding costs, periods of growth of pigs, changes in the quantity of stockpiles, long-term expectations of producers, and changes in the prices of alternatives. The pig food is nearly two to three times higher than that in the past ten years, indicating that the pig farming is profitable this year.

Assuming that no major events occur in 2019, and all influencing factors are brought into model 1 for calculation, it can be obtained:

$$Y=\sum_{i=1}^{n} Y_i U_i = 10\times 0.1+10\times 0.22+10\times 0.3+0\times 0.1+8\times 0.02+25\times 0.03+30\times 0.23=14.91$$

By theoretical calculation can be concluded that pork prices in 2019 should be 15 yuan, pork have far more than the price recently, however, is mainly due to last year's environmental problems, many health substandard pig closures of pig breeding stock exists to a certain extent, this year the national African swine fever outbreak of, reduced the number of live pigs, pig breeding stock conservative reduce more than sixty percent, so the market inflation, appear shortage phenomenon, caused the recent pork price rise sharply.So one of the main reasons why pork prices have fluctuated so much this year is $Y_2$, the threat of animal disease.

China's pig breeding is widely distributed, but it is relatively concentrated in the main grain producing areas. The top ten major producing provinces are: Sichuan, Henan, Hunan, Shandong, Yunnan, Hubei, Guangxi, Guangdong, Hebei, and Jiangsu. Sichuan's aquaculture quantity ranks first in the country, and its slaughter volume accounts for about 10% of the total national output. The consumption flow is relatively good. The residents' consumption habits of pork in China are mainly based on hot fresh meat consumption, which determines that the pig breeding grounds and

consumption areas are relatively close. In addition, the temperature in the central and eastern regions is suitable, the water source is convenient, and it is conducive to the growth of pigs. The economy in the central and eastern regions and the south is relatively developed, and the population is relatively large. In many ways, the pig breeding in China is mainly concentrated in East China, Central China, Southwest China and South China. The amount of aquaculture in the northeast region is also relatively large, mainly for the Beijing-Tianjin-Hebei area. The northeast region also has breeding advantages, the feed cost is relatively low, the railway land transportation is convenient, and the vast territory is suitable for large-scale enterprise development. Therefore, we suggest that pig breeding can be increased in major grain producing areas, and in some remote areas, such as Qinghai Province, pork prices in the region have remained stable and low in recent years, with no skyrocketing, indicating the region. People's demand for pork is small and affected by the epidemic. Therefore, pig breeding can be appropriately increased in a more remote area like Qinghai Province to supply other areas with higher demand.

**Chinese hog and pork price analysis framework**

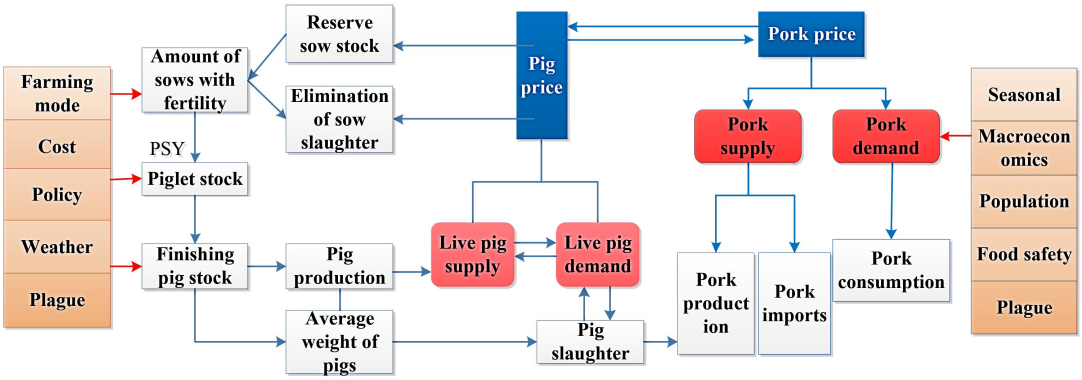


Fig. 4 China pig and pork price analysis framework

Pigs have a growth and development cycle. It takes a certain period of time from production to market. Farmers often need to arrange the next phase of production according to the current market price. Once the production is determined, it is difficult to change midway before the production process is completed. Therefore, the market The change in price can only affect the output of the next cycle, that is, the price of the current period determines the output of the next period, and the output of the current period depends on the price of the previous period. After a production cycle, when the pig grows to a certain extent, it must be put into the market to sell. At this time, the price of pork is determined by the demand curve of the current period. Due to the existence of the time lag effect of pork price regulation, when the price of pork rises, the enthusiasm of the farmers will increase, and the scale of breeding will be rapidly expanded, and the stock of capable sows will be increased, which will lead to oversupply of pork when it is listed, causing prices to fall. When the price falls, the farmers will reduce the scale of breeding, reduce the stock of the sows, reduce the supply, supply less than demand, and increase the price.

As can be seen from Fig.5, the price of live pigs soared in October, so the pig

farmers will definitely increase the output of live pigs. However, in order to prevent excessive increase of production and oversupply, a reasonable breeding plan must be specified.

Establish a breeding program for pigs, which must first meet two requirements:

1. Reducing the decline in pork prices in the short term;
2. Realizing the break-even point of pig raising, that is, satisfying income / cost > 1

First of all, according to the requirements of the topic, to achieve a short-term price decline, the literature can be seen, a sow will have two pregnancy periods a year, a total of 20 births, therefore, our custom cycle is half a year. Assume that the original sow of the farm is $P_1$, the output of one sow is X head, that is, the $P_1X$ head is produced in half a year, and the cost of breeding one pig is C yuan.

According to the research, the number of pigs in the farm is the head. In order to achieve the short-term fall of pork prices, increase the sow $P_2$ head and increase the pig head, that is, increase the piglet yield $P_2X$. On this basis, we establish model 2 :

$$Z_2 = P_1 + P_2 + (P_1 + P_2)X + \frac{P_1 + P_2}{10} = (P_1 + P_2)(X + \frac{11}{10})$$

$$L_i = P_1 X S_i - C_1 Z_i - C_2 X \ , L_i > 0, \quad i = 1,2 \tag{2}$$

Among them, the data of a farm in Shandong Province is used to test the model 2.

$$Z_2 = P_1 + P_2 + (P_1 + P_2)X + \frac{P_1 + P_2}{10} = (P_1 + P_2)(X + \frac{11}{10}) = 31500$$

Benefits of breeding sites in 2018:

$$L_1 = P_1 X S_1 - C_1 Z_1 - C_2 P_1 X = 1000 \times 10 \times 13 \times 200 - 3568 \times 1100 - 970 \times 10000$$

$$= 12375200 \text{ yuan}$$

Benefits of breeding sites in 2019:

$$L_1 = P_1 X S_1 - C_1 Z_1 - C_2 P_1 X = 800 \times 10 \times 40 \times 200 - 3568 \times 880 - 970 \times 8000$$

$$= 53100160 \text{ yuan}$$

After analysis, the income obtained in 2019 is about 3 times that of 2018. After optimization, the number of live pigs and income from new farms can be obtained:

$$L_2 = (P_1 + P_2) X S_2 - C_1 Z_2 - C_2 (P_1 + P_2) X = 985 \times 10 \times 15 \times 200 - 3568 \times 985 - 970 \times 20 \times 985$$

$$= 15570023 \text{ yuan}$$

Because of $\frac{S_2}{CZ_2} \geq 1$, and $L_1 / L_2 \approx 3$, the modeling is correct.

Table 3 Information on a farm in Shandong Province

| Number of original sows | 1000 |
|---|---|
| The number of live pigs due to the epidemic | 200 |
| A sow production | 10 |
| Breeding a sow cost | 3568 yuan |
| Breeding a pig cost | 970 yuan |
| Increase the number of sows | 185 |
| Pork price in 2018 | 13 yuan/kg |
| Pork price in 2019 | 40 yuan/kg |

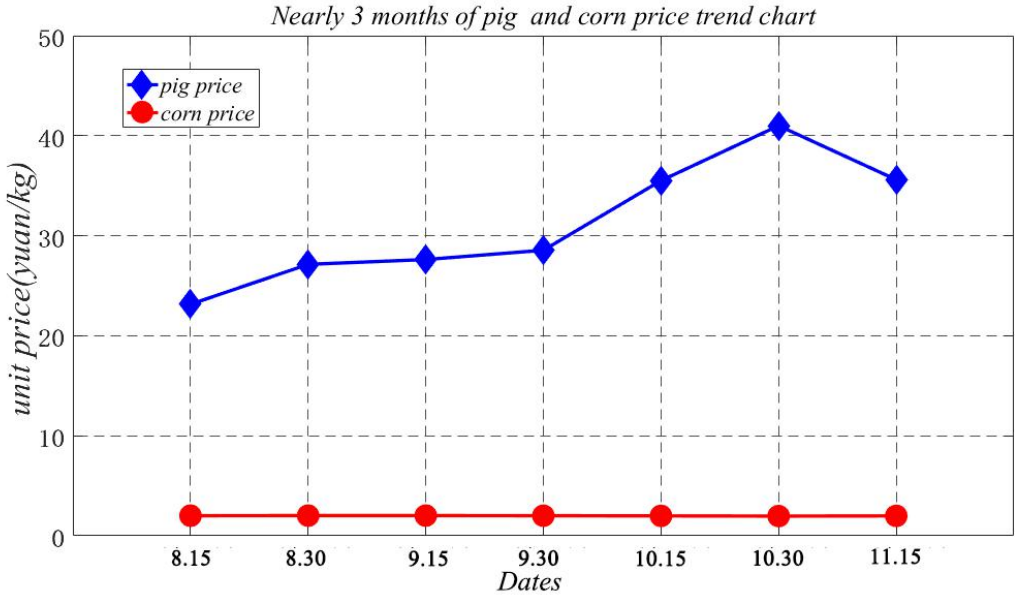


Fig.5 Pork price chart for the most recent March

Due to the need to digest the Chinese New Year, the second quarter of the year is the traditional low season of pork consumption. However, the price of pigs jumped after 2019, and the overall trend of national pig prices remained stable in April and May. Although there was no big increase in expectations in May, from the overall trend of the year, it has obviously maintained the trend of not being weak in the off-season, and it also reflects that the tight supply and demand situation does exist.

Due to the serious epidemic situation in China, the number of live pigs has fallen sharply. As shown in Figure 7, it was reduced to 23% in May 2019. However, it is necessary to increase the amount of pigs to keep the amount of pork in the market. Global pork imports have become a certain trend.

Fig.7 shows China's global pork imports in the past 20 years. As can be seen from the figure, the import volume is increasing, and the import volume reached the highest in 2019. However, it should be noted that increasing the global pork import volume is indeed an inevitable trend. However, due to tariffs and freight charges, the price of imported pork is high. Therefore, it is necessary to be cautious in the choice

of importing countries. According to the national pork production, the distance and China's foreign policy is regulated. In previous years, China's main pork importing countries were the United States, Germany and other countries. However, due to the serious epidemic situation in China this year, the original pork importing countries could not meet the numbers needed by China, so it is necessary to increase the choice of exporting countries.

Therefore, for the procurement of pork from other countries, we recommend mainly considering tariffs, freight rates, distances, exporting national pork production and the amount required in the country. First, we can consider the principle of proximity and consistency, increase the import of pork to China's neighboring countries, and secondly choose some large trading countries with low tariffs, countries with diplomatic ties with China, or other countries with higher pork production.

It is worth noting that although the increase in global pork imports has become a certain trend, it is necessary to rationally choose a procurement plan to minimize import costs, and at the same time strengthen the country's macro-control, and strive to maintain pork prices in a relatively stable state.


Fig.6 Live pig stocking rate

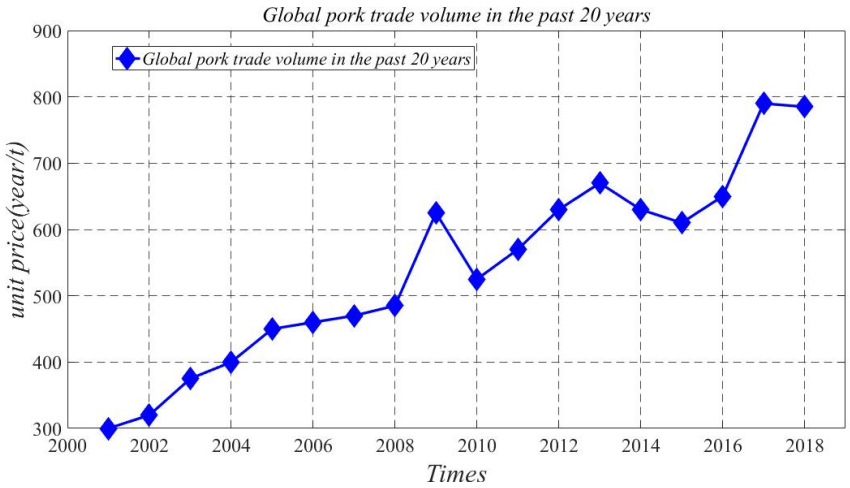


Fig.7 Global pork trade volume

China's pig breeding is mainly concentrated in Henan, Hubei, Hunan, Shandong, Sichuan, Jiangsu, Hebei, Guangdong, Heilongjiang, Liaoning, Jiangxi, Zhejiang, Guangxi, Anhui, Yunnan and other provinces, autonomous regions and municipalities directly under the Central Government. These areas are slaughtered and meated in China. The important areas of the processing industry are rich in pig resources and huge potential for meat consumption.

In China, the pork industry has six distinct characteristics: First, pork is an important part of meat food, closely related to the national economy and people's lives; second, pork production has been in a growing state; Third, the supply of pork in China The form is still mainly free-range, and the scale of pig breeding is still at a low level. Fourth, all links in the pork industry chain are closely linked, and any problem in any one of the links may affect the entire industrial chain; The wide variety of diseases has caused great losses to the production and supply of pork. Sixth, one of the important components of the aquaculture industry is pig breeding. In this case, the stability of pork prices is crucial for consumers, producers of pigs and the government. In addition, the unreasonable arrangement of production activities by pig farmers and the untimely response of government departments to changes in pork prices are not conducive to the stability of the pork market and socio-economic development.

Pork farming is affected by many factors, such as cost, live pig stocks, slaughter, culture structure, policies, and diseases. The demand for pork is influenced by many factors, such as pork prices, economic levels and disposable income of residents.

In order to solve the problem that the demand for pork in different regions is relatively stable, the optimal breeding schemes in different time zones in different regions are proposed to ensure the supply of pork in each time zone of each region. Now the MATLAB is used to realize the grey forecasting method, and the per capita consumption level of several regions in 2020 Make predictions to determine the amount of pork aquaculture supply and determine the breeding plan.

A gray system is a system that contains both known information and unknown or non-confirmed information. One of the important contents of his research is how to abstract and establish a model from a system that is not clear and lacks overall information. The model can make the gray system factors from unclear to clear, from little knowledge to knowledge. More research basis is provided. Grey prediction is to discover and master the law of system development through the processing of raw data and the establishment of gray model, and make scientific quantitative prediction of the future state of the system.

The main steps of the grey prediction:

Set the per capita consumption of pork in the provinces from 2009 to 2018 as $x^{(0)}$, and establish a time series:

$$x^{(0)} = \left\{x^{(0)}(1), x^{(0)}(2), ..., x^{(0)}(\mathrm{n})\right\}$$

Level ratio $\lambda(k) = \dfrac{x^{(0)}(k-1)}{x^{(0)}(k)}$, after calculation, all the levels are satisfied, so

the GM (1, 1) model can be established.

Generate a new sequence by accumulating one time:

$x^{(1)} = \{x^{(1)}(1), x^{(1)}(2), ..., x^{(1)}(n)\}$, $x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i), k = 1,2,\cdots,n$。

Find the average generation sequence: $z^{(1)}(k) = \frac{1}{2}(x^{(1)}(k-1) + x^{(1)}(k))$ , $k = 2,3,\cdots n$

Then $z^{(1)} = (z^{(1)}(1), z^{(1)}(2), \cdots z^{(1)}(n))$

So the gray differential equation is established as $x^{(0)}(k) + az^{(1)}(k) = b$ , $k = 2,3,\cdots n$.

The corresponding whitening differential equation is $\frac{dx^{(1)}}{dt} + ax^{(1)}(t) = b$,

Then the expressions of the parameters a, b are:

$$\begin{pmatrix} a \\ b \end{pmatrix} = (B^T B)^{-1} B^T Y, \quad B = \begin{pmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z^{(1)}(n) & 1 \end{pmatrix}, \quad Y = \begin{pmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{pmatrix}$$

If $C = \sum_{k=2}^{n} z^{(1)}(k)$, $D = \sum_{k=2}^{n} x^{(0)}(k)$, $E = \sum_{k=2}^{n} z^{(1)}(k)x^{(0)}(k)$, $F = \sum_{k=2}^{n} (z^{(1)}(k))^2$,

Then the expressions of the parameters a, b are:

$$a = \frac{CD - (n-1)E}{(n-1)F - C^2}, \quad b = \frac{DF - CE}{(n-1)F - C^2}$$

Whitening differential equation: $x^{(0)}(k) + az^{(1)}(k) = b$ , $x^{(1)}(0) = x^{(0)}(1)$ , Get the time response function.

By substituting the per capita pork demand of each year in the selected province, the pork demand is calculated when the pork demand is stable. According to the situation of China's economic and social development, the country is divided into four major economic regions, in which a province is selected as the representative to calculate the supply. They are Liaoning Province in the northeast, Hubei Province in the middle, Shandong Province in the East and Sichuan Province in the West. The supply and demand of pork in the four provinces are all in the forefront of all provinces in China, which are relatively representative.

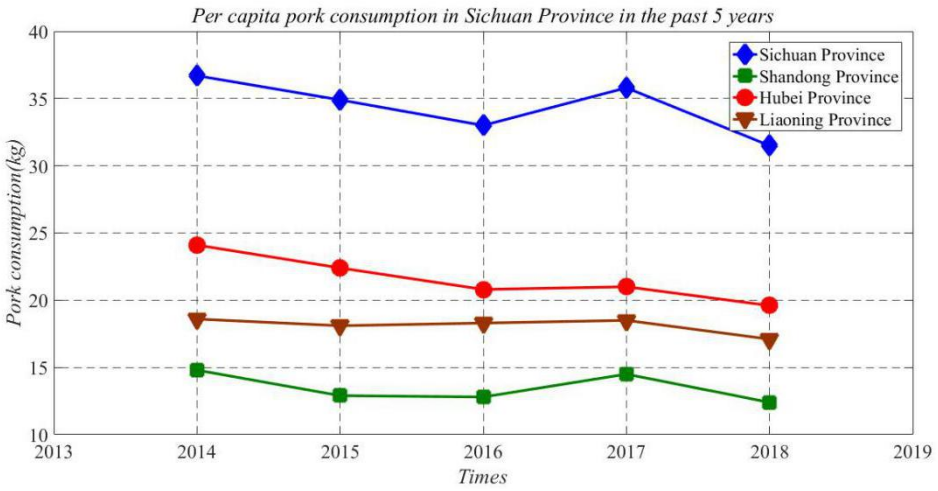


Fig.9 The per capita consumption level of pork in the four provinces from 2014 to 2018

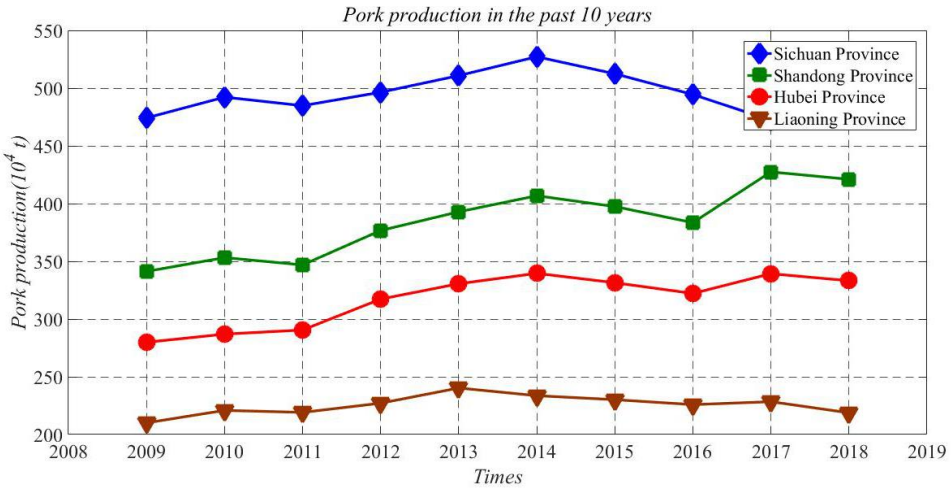


Fig.10 Pork production in four provinces from 2009 to 2018

According to the Matlab calculation:

It is estimated that the per capita consumption level of pork in Liaoning Province is 17.65kg, which is higher than that in 2018 but much lower than that in 2014 and the previous years. Therefore, it is suggested that farmers should not expand the number of pigs, increase the quality or growth cycle of pigs, control the number of pigs and ensure the price of pork, so as to obtain greater profits, such as breeding pig substitutes or breeding high-quality pigs.

It is estimated that the per capita consumption level of pork in Hubei Province is 18.24kg, which is far less than the previous pork consumption level. Therefore, it is suggested that farmers reduce the number of pigs raised, or carry out export trade, and reduce the number of pigs in the province to ensure the price of pigs, so as to ensure their own and consumer profits.

It is estimated that the per capita consumption of pork in Shandong Province is 13.23kg. According to the data, the per capita demand of pork in Shandong Province is negatively related to the price of pork. Shandong Province is also a major pork

breeding Province, so the price of pork fluctuates greatly. It is suggested that farmers should appropriately adjust pig breeding or improve pig breeding varieties to ensure income in combination with previous years' pork breeding quantity.

It is estimated that the per capita consumption level of pork in Sichuan Province is 32.02kg, similar to that in Liaoning Province, but Sichuan Province is a province with high pork consumption level and breeding level. Therefore, compared with 2018, the farmers can appropriately increase the number of live pigs to control the stability of pork price. In addition, it can also export pork to neighboring provinces and guarantee the income of farmers.

In order to meet the demand of the residents for the quantity and price of pork at the peak of pork demand, the following suggestions are put forward for pork storage strategies:

In order to ensure the National Pork storage capacity and timely supplement the market when pork demand is tight, the most direct way is to ensure the number of live pigs. Therefore, the following suggestions are made:

**(1) Standardized breeding**

In recent years, many places, especially those with rapid economic development, have begun to strictly implement the policy of prohibition and restriction. This is the result of many comprehensive factors. First, the contribution of the pig industry to the local government's tax revenue is not large. Even the local government has to bear many additional costs of environmental protection, land and epidemic prevention. In addition, the development of highly market-oriented family scale breeding has promoted the formation of a unified pork market in China, but there is still a lack of national coordination in pig breeding. In recent years, a large number of pig production areas have been reducing production capacity, which is a rational choice for some farmers and local governments, but at last, it has resulted in the phenomenon of "partial rationality, overall irrationality", seriously affecting the market safety.

Therefore, on the premise that the pig industry has changed, if we want to establish a long-term stable pork supply market, the key is to do a good job in the scale of breeding, unified scheduling, unified production, in order to better supply market demand.

**(2) Good pork reserve**

The most direct way to deal with the problem of the high price of pork caused by the short supply of pork in the market is to put the central reserve frozen pork on the market. Under the control of the central government, in the years with high pork output, the state purchases pork and enters the central reserve. In the case of low pork output, the central government enters the market.

In addition, in the year of large demand for pork, the transportation cost of pork should be adjusted appropriately, such as reducing the transportation cost of pork, so that the pork in remote areas can enter the local market. This not only eases the difficulty of pork supply, but also greatly improves the economic income of farmers in remote areas.

**(3) Make import plan**

In terms of import, the influence of pork and its products import on pork price is

mainly considered. The United States, Germany and other countries are sparsely populated, and animal husbandry mostly exists on a large scale. And because of the high level of equipment, the breeding cost is often very low. The same reason is that there are fewer people and less demand. Many of the pork cultivated are exported to foreign countries, and the export price is generally not high.

At the peak of demand, while doing a good job of Customs epidemic prevention inspection, importing pork and its products that meet the requirements can greatly supplement the market gap. At the same time, part of the imported pork can also be put into the central cold storage as the pork reserve when the next supply is insufficient.

**(4) Government Regulation**

When the government predicts that there is a high positive risk in the future pork price, it can guide the pig farmers to make up the market in advance and increase the future pig production; while when the government predicts that there is a high negative risk in the future pork price, it can guide the pig farmers to increase the pig production in advance.

When the price of pork rises sharply, the government should release information in time to avoid the price risk caused by the blind supplement of pig farmers. When the price of pork falls sharply, the government should increase subsidies and insurance for sows to cover the loss of sows, ensure the stability of piglet supply, and avoid the scarcity of piglets and pork price caused by the sale of sows Rise.

# 5. Model Verification

## 5.1 Model Validation

Table 4 2016-2018 Pig price list

| Year | Pig price(Yuan / kg) |
|---|---|
| 2016 | 18.66 |
| 2017 | 15.3 |
| 2018 | 13.12 |

According to the information in Table 4, model I is verified.

2016,

$$Y=\sum_{i=1}^{n}Y_iU_i=15\times0.1+30\times0.22+10\times0.3+10\times0.1+10\times0.02+20\times0.03+25\times0.23=17.58$$

2017,

$$Y=\sum_{i=1}^{n}Y_iU_i=20\times0.1+10\times0.22+10\times0.3+0\times0.1+10\times0.02+20\times0.03+30\times0.23=14.90$$

2018,

$$Y=\sum_{i=1}^{n}Y_iU_i=10\times0.1+10\times0.22+10\times0.3+0\times0.1+8\times0.02+25\times0.03+30\times0.23=13.51$$

The final results are shown in Table 5. The maximum theoretical and practical error is 2016, but the error is less than 5%, so the model is correct.

Table 5 Comparison of actual and theoretical pork prices in 2016-2018

| Year | Actual price(yuan / kg) | Theoretical price(yuan / kg) |
|---|---|---|
| 2016 | 18.66 | 17.58 |
| 2017 | 15.3 | 14.9 |
| 2018 | 13.12 | 13.51 |

# 6. Model Evaluation

### 6.1 Advantages of the model

The three models established in this paper are simple and easy to understand, easy to test and apply in practice, and can be applied to the comprehensive evaluation of pork price fluctuation. The main advantages are as follows:

(1)For each question in the topic, this paper establishes a suitable model corresponding to it, which solves each difficult problem well;

(2)Making full use of the subject data, using a lot of statistical knowledge, using software such as MATLAB and Excel to ensure the accuracy of the results;

(3)In our model, we use a large number of processed tables to express various contents more intuitively and clearly, which greatly improves the readability of the paper;

(4)Determine the route and train of thought step by step, This paper first establishes a general model with computational obstacle avoidance constraint formula, and then establishes a simplified model with no intersection point to simplify the multi-variable value-taking relationship;

(5)Two heuristic algorithms are given to make each factor more credible to the whole. At the same time, the first heuristic algorithm can obtain the global optimal solution. The second heuristic algorithm is constructed to reduce the solving time for NP attributes of the problem. Both of the two algorithms are of great significance;

(6)Several schemes are used to optimize the path, and the optimal solution is obtained in the relative optimization.

### 6.2 Shortcomings of the model

(1)When abstracting practical problems into mathematical models, many assumptions have been made, which makes the mathematical models deviate from reality to a certain extent and can not fully represent the real situation;

(2) The model has certain subjectivity when it can not give the selection criteria quantitatively, and may deviate from the actual situation.

## 7. Model Optimization and Promotion

### 7.1 improvement of multivariate statistical index analysis model

The model 1, model 2 and model 3 selected in this paper turn the global optimization problem into the problem of multi-part internal optimization and then reach the global optimization, so the optimization degree of the model may decline, and the established model is relatively simple. Through the multi-element linear regression of the data, the influencing factors on the fluctuation of pork price are analyzed, and the model has certain Limitations. The model can be improved from the following aspects:

(1) the multiple non-linear regression method is considered in data access;

(2) the macro-control system, the threat of animal epidemics, the change of feeding cost, the growth cycle of pigs, the change of reserve meat quantity, the long-term expectation of producers and the price change of substitutes need further detailed statistics, such as whether the growth cycle of pigs is an index that must be changed, etc;

(3) for the selection of multi variables, principal component analysis, factor analysis, typical correlation analysis and other methods can be considered.

### 7.2 promotion and Application

Through the above analysis, we find that the three models established in this paper can solve practical problems quickly and effectively. In order to achieve this idea, we transform the problem into a quantitative analysis of the degree of influence, that is, the goal to be considered is not only one. When there are multiple goals, we need a relatively optimized solution, so that it can comprehensively consider each goal in multiple goals Mark. In the multi-objective model, in addition to this method of dealing with the problem, we can also use the goal reaching method to set the weight value to transform the multi-objective problem into a single objective problem, or use the penalty function method, or can transform a certain goal into a constraint,

but there are different and appropriate methods for different problems, and we can not adopt the same method for different multi-objective problems Method. So this model can solve many problems that single target model can not solve. It can be said that the multi-objective model established in this paper is of universal practical significance and has strong practical application ability.

In addition, we can make full use of the data collected by the Internet for analysis and statistics, and consider the operability of the scheme. In practice, we can collect a variety of index data from many angles and sides, and use this method to evaluate the influence of each index on the fluctuation of pork price, and also to evaluate the influence of similar models. Because they all belong to the model of materializing abstract things, which brings great convenience for problem solving. In conclusion, the methods used in this paper have good universality and generalization.

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# Appendix

**Matlab source program**

```
function []=greymodel(y)
% This program is mainly used to calculate the prediction value of the model established according to the grey theory.
```

```
% The mathematical model of application is GM(1,1)。
% The processing method of the original data is one-time summation.
y=input('Please input data ');
n=length(y);
yy=ones(n,1);
yy(1)=y(1);
for i=2:n
    yy(i)=yy(i-1)+y(i);
end
B=ones(n-1,2);
for i=1:(n-1)
    B(i,1)=-(yy(i)+yy(i+1))/2;
    B(i,2)=1;
end
BT=B';
for j=1:n-1
    YN(j)=y(j+1);
end
YN=YN';
A=inv(BT*B)*BT*YN;
a=A(1);
u=A(2);
t=u/a;
i=1:n+2;
yys(i+1)=(y(1)-t).*exp(-a.*i)+t;
yys(1)=y(1);
for j=n+2:-1:2
    ys(j)=yys(j)-yys(j-1);
end
x=1:n;
xs=2:n+2;
yn=ys(2:n+2);
plot(x,y,'^r',xs,yn,'*-b');
det=0;

sum1=0;
sumpe=0;
for i=1:n
    sumpe=sumpe+y(i);
end
pe=sumpe/n;
for i=1:n;
    sum1=sum1+(y(i)-pe).^2;
end
```

```
s1=sqrt(sum1/n);
sumce=0;
for i=2:n
    sumce=sumce+(y(i)-yn(i));
end
ce=sumce/(n-1);
sum2=0;
for i=2:n;
    sum2=sum2+(y(i)-yn(i)-ce).^2;
end
s2=sqrt(sum2/(n-1));
c=(s2)/(s1);
disp(['The posterior difference ratio is:',num2str(c)]);
if c<0.35
    disp('Good prediction accuracy of the system')
else if c<0.5
        disp('The prediction accuracy of the system is qualified')
    else if c<0.65
            disp('The prediction accuracy of the system is poor')
        else
            disp('System prediction accuracy is unqualified')
        end
    end
end

disp(['The next fitted value is ',num2str(ys(n+1))]);
disp(['The next fitting value is',num2str(ys(n+2))]);
```