Market Concentration Rate and Market Performance of China's Swine Industry

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Abstract Empirical study on market concentration rate and market performance of China's Swine Industry indicates that higher market concentration rate brings higher overall performance of swine industry. There exists no obvious causal relation between market concentration rate and market performance, but market performance is highly correlated with market concentration rate. The improvement in performance of swine industry is dependent on further optimization of market concentration rate and other factors.

Key words Market concentrate rate, Market performance, Market share

1 Introduction

Agriculture is the primary industry of China and the foundation of China's economic development. Development of animal husbandry drives agricultural development. Swine industry is a main sector of animal husbandry and also a fundamental industry concerning the national economy and the people's livelihood. At present, there are extensive researches about development of swine industry. In terms of the entire swine breeding mode, China's swine breeding can be divided into scattered breeding and large-scale breeding. Before the 1980s, the swine breeding was mainly scattered breeding; in the 1980s, industrialized swine breeding appeared; in the 1990s, large-scale swine breeding realized rapid development[1]. In recent 10 years, the percentage of scattered swine breeding rapidly declined. According to data of *China Animal Industry Yearbook* in 1998-2010, the percentage of slaughter pigs of scattered breeding and large-scale breeding in 1998 was 76.8% and 23.2% separately, and 44% and 56% in 2008, 38.7% and 61.3% in 2009, showing rise of large-scale swine breeding[2]. These indicate the market concentration rate of China's swine industry is increasingly high. Shen Yinshu *et al*. demonstrated large-scale development will generate scale effect, and finally reduce product costs and increase profit. Wu Linhai *et al*. studied possible external problems of large-scale and high concentration rate, such as environmental pollution resulted from large-scale breeding, which can not be solved by existing technologies, so it will greatly reduce the market performance.

2 Related theoretical basis

In foreign countries, there are extensive researches about the relation between market concentration rate and market performance. Joe S. Bain (1951) developed the Structure-Conduct-Performance (SCP) paradigm and classified market structure into 7 types according to the market concentration rate, and introduced the famous Bain Criterion. He surveyed 42 industries and found the profit rate of less concentrated industries was 7.5%, and the profit rate of higher concentrated industries was 11.8%. On the basis of entry barrier, he concluded that industries with higher concentration rate and higher entry barrier would have higher profit rate. Findings of Bain manifest that with increase in the concentration rate, the industry profit rate will also increase. Using this criterion, we can analyze market structure of industry, so as to judge whether the industry is competitive or monopolistic industry.

Following Bain, Mann (1966) proved findings of Bain, that average industry profit rate with higher entry barrier and higher concentration rate is higher than industries with lower entry barrier and lower concentration rate. Later, Weiss (1974) also reached the conclusion that there exists significant positive correlation between profit rate, concentration rate and entry barrier. Harold Demsetz (1973) stated that the positive correlation between market concentration rate and profit rate has precondition that the market concentration rate should reach certain level. Specifically, when the market concentration rate falls within 10%-50%, the profit rate will not rise with increase in market concentration rate, instead, it will decline; when the market concentration rate exceeds 50%, the positive correlation appears between the market concentration and profit rate. Gale and Branch (1982) found the relation between market share and profit rate is closer than the relation between market concentration rate and profit rate. Martin (1983) studied the relation between market effect and market structure and performance and found that the significance of negative effect concentration rate is higher than positive effect concentration rate. Pedro Marin and Georges Siotis (2007) held that intense market competition will lead to increase in market concentration rate, but also bring increase in R&D inputs, and finally promotes industry innovation. In other words, there exists positive correlation between market concentration rate and innovation.

In China, there are few researches about the market concen-

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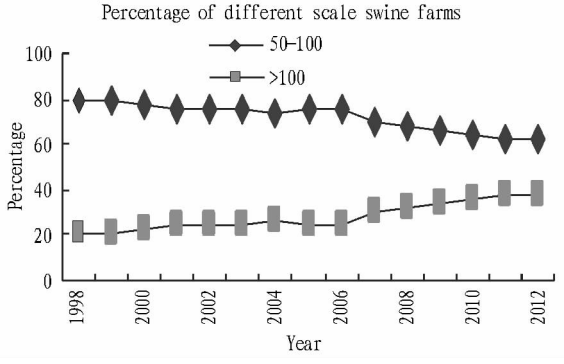
tration rate and market performance, and most researches are not systematic. Thus, most domestic researches follow findings of foreign researches. According to modern economics, competition and monopoly degree of an industry greatly influences business behavior of this industry and accordingly influences the entire industry performance. In SCP paradigm, research of industry concentration and performance is a hot spot. However, most researches of SCP paradigm remain in some business behaviors of foreign countries , application to related industries in China, like swine industry, needs empirical analysis.

3 Analysis on market concentration rate of China's swine industry

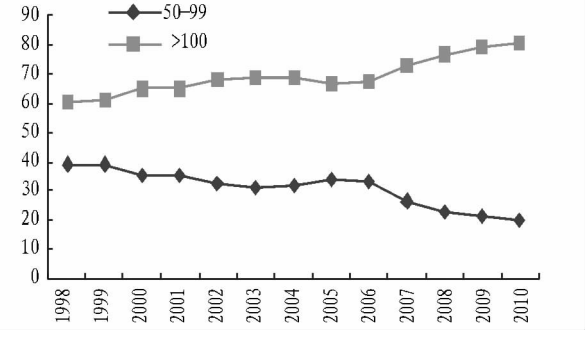
Market concentration is the extent to which sales in a market are dominated by one or more businesses, and it is an essential concept reflecting market competition and also an important factor deciding market structure[1]. For swine industry, market entities are mainly individual consumers and food processing factories providing raw materials. The buyer's market is relatively loose and difficult to grasp. Therefore, we focused on the concentration of sellers in swine industry in this study. The concentration rate is an index for measuring market share distribution of certain market or industry enterprises, and is an indicator of market competition or oligarch. Methods for measuring market concentration rate are mainly absolute method and relative method[3]. The former includes industry concentration rate (CRn), Hannah-Kay Index (HKI) and entropy index (EI); the latter includes Herfindahl-Hirschman Index (HHI), Lorenz Curve, and Gini coefficient. Absolute method mainly reflects concentration rate of leading enterprises but neglects other information in the concentration rate curve. Relative method better reflects scale difference of market enterprises, but fails to give consideration of concentration rate of leading enterprises.

3.1 Development trend of the swine industry Market activities of the swine industry are made up of large and small swine enterprises. As subject of market behavior, concentration rate of enterprises directly relates with market structure situation of the industry. In this study, we divided swine farms into 50-99 heads, 100-499 heads, 500-2999 heads, 3000-9999 heads, 10000-49999 heads, and more than 50000 heads. However, the scale of swine farms with more than 100 heads is increasing, but the percentage is relatively low and difficult to show in the curve, we finally divided swine farms into two scales: below 100 heads and more than 100 heads. In terms of the proportion of different scale of swine farms to the total swine farms, the percentage of small swine farms with annual slaughter below 100 heads dropped from 79.9% in 1998 to 61.7% in 2012. With expansion of the scale, the percentage was increasing, the percentage of swine farms with annual slaughter above 100 rose from 20.1% to 38.3%, as shown in Fig. 1. In terms of the proportion of annual slaughter of different scale of swine farms to total annual slaughter of swine farms, the percentage of swine farms with annual slaughter below 100 to total annual slaughter of swine farms declined from 39.4% in 1998 to 19.8% in 2010. With the expansion of the scale, the percentage of swine farms with annual slaughter above 100 rose from 60.6% to 80.2%, as shown in Fig. 2. (The data of annual slaughter of different scale were collected only before 2010, so the data hereinafter were before 2010.)



Data source: arranged according to *China Animal Industry Yearbook* (1998-2013)

Fig. 1 Number of swine farms with annual slaughter below and above 100 heads



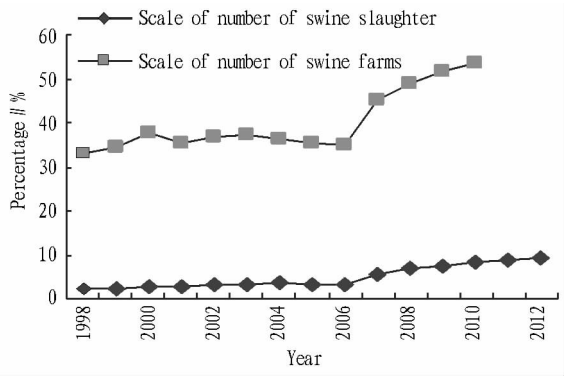
Data source: arranged according to *China Animal Industry Yearbook* (1998-2011)

Fig. 2 Annual slaughter of swine farms in the whole China

From Fig. 1 and Fig. 2, we can see that both the number of swine farms and annual slaughter declined with increasing expansion of swine farms. To a certain extent, this indicates China's swine breeding moves towards large-scale breeding.

3.2 Concentration rate of the swine industry The market concentration rate reflects concentration degree of certain market. Generally, it is expressed by the share of leading enterprises in the market. Common indicators include CR4, CR8, and HHI. However, due to high difficulty in collecting data of this industry, we employed the scale of number of swine slaughter and the scale of number of swine farms to analyze the market concentration rate of China's swine industry. The scale of number of swine slaughter (%) = number of annual slaughter above 500 heads / total annual slaughter * 100; the scale of number of swine farms (%) = number of swine farms with annual slaughter above 500 heads / total swine farms * 100, as shown in Fig. 3.

Fig. 3 indicates that China's swine scale degree is constantly increasing, especially after 2007, the number of slaughter rose



Data source: arranged according to *China Animal Industry Yearbook* (1998-2013)

Fig. 3 Changes in the scale of number of swine slaughter and the scale of number of swine farms

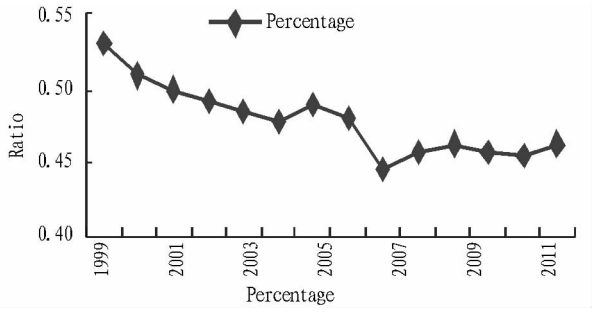
greatly. Although the number of large-scale swine farms was rising, the rising amplitude was much lower than the number of slaughter of large-scale swine farms, indicating the breeding efficiency of large-scale breeding is higher than small breeding.

4 Analysis on market performance of China's swine industry

Market performance mainly refers to resource allocation efficiency and benefit allocation situation resulted from certain market structure and market behavior. Using swine market performance of Sun Shimin *et al*. (2014) we evaluated the market performance of China's swine industry from the industry competitive power, breeding performance, breeding risk, and environmental pollution.

4.1 Industry position Industry position is a general indicator reflecting market performance. According related data of China Animal Industry Yearbook, we applied the proportion of number of swine slaughter to total slaughter of the animal husbandry (excluding livestock and poultry) and the proportion of pork production to meat production of the whole country to analyze changes in China's swine industry position. (i) Changes in swine slaughter. From Fig. 3, we can see that since the 21st century, the proportion of number of swine slaughter to total slaughter of the animal husbandry basically keeps 45%-55%. It declined in the beginning, but rose later. It can be divided into three stages: 1999-2004: this proportion declined from 55% to 47% because other livestock products replaced swine market; 2005-2007: this proportion lingered around 45%-49%, firstly rose then declined, because a series of subsidy policies were issued; 2008-2013: this proportion was in 45.6%-46.2%, indicating swine industry is always a major sector of animal husbandry, so its fundamental position should be kept.

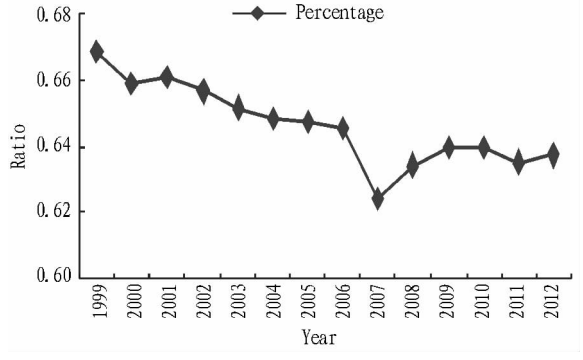
(ii) Changes in pork production. According to Fig. 4, the proportion of pork production to total meat production shows a decline trend. In 1999-2007, the proportion of pork production to total meat production dropped from 66% to 62%, basically it stably declined and dropped to the valley, mainly because the price fluctuation in 2007 influenced the pork production. In 2009-2012,



Data source: arranged according to China Animal Industry Yearbook (1998-2012)

Fig. 4 Changes in the proportion of number of swine slaughter to total slaughter of the animal husbandry (excluding poultry and livestock) in 1999-2012

this proportion suffered slight fluctuation, pork market developed in twists and turns, but the overall development momentum is not considerable. The above indicates that primary situation of China's swine breeding is facing challenges and gradually losing superior position of industry development.



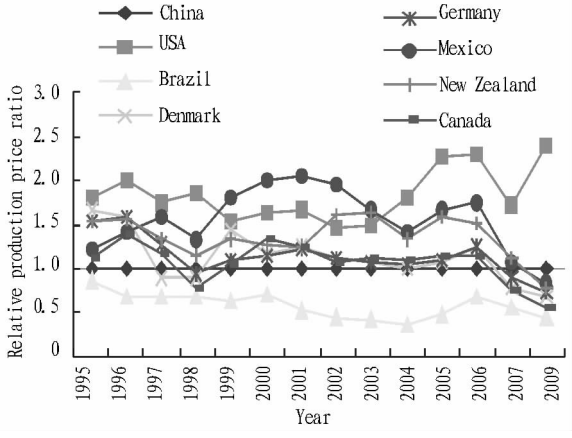
Data source: arranged according to *China Animal Industry Yearbook* (1998-2012)

Fig. 5 Changes in the proportion of pork production to meat production in 1999-2012

4.2 Industry competitive power Industry competitive power refers to competitive power of certain industry in a certain region or country relative to other regions or countries in terms of production efficiency, satisfaction of market demands, and sustained profitability. Analysis of industry competitive power generally focuses on cost and benefit. In this study, we also made analysis from these two aspects. We analyzed competitive power of swine industry with reference to related data of Qiao Juan (2011).

For competitive edge of pork production, common indicators are price and production. These indicators are key factors for measuring competitive edge. Finally, we quoted related indicators of pork trade data to measure competitiveness of China's swine industry at international market. (i) Pork price. Price is the exchange ratio of commodity and money. In other words, price is monetary manifestation of value. Price is an essential indicator in economics, it directly influences gross income and profit of products, so it is of utmost importance to understand the price. Knowing pork production price of China and other countries can rapidly

know whether China's pork price has competitiveness at international market, which is also an essential indicator for measuring China's competitive power. This is not the key point of our study. With reference to related price data of Qiao Juan (2011), we plotted price change curves of China and other major exporters, as shown in Fig. 5.

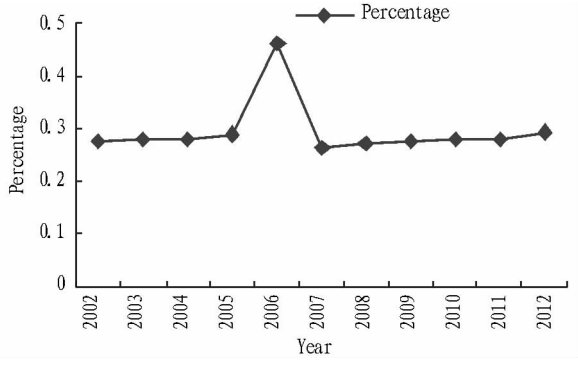


Data source: calculated according to data of FAS/USA, www.fas.usda.gov (taking price of China in the same period as basis).

Fig. 6 Comparison of pork production price between China and major exporters in 1995-2009

From Fig. 6, we can see that except Brazil, other pork exporters have price higher than China, indicating that China's pork production price is highly competitive; however, since 2007, pork price of many exporters gradually became lower than China's pork production price; by 2009, only the United States had pork price higher than China. Thus, China's pork production is losing certain competitive power, which influences China's international competitive level.

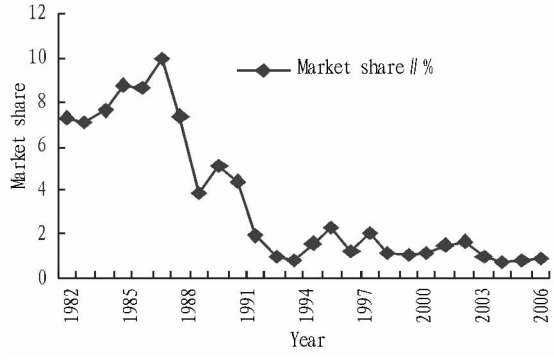
(ii) Swine output. The output is also an essential indicator for measuring the industry economic development, and it mainly refers to output level and production capacity of the industry. In this study, we used the proportion of China's annual pork output to total pork output of the world. It can clearly indicate changes in China's pork output at international market, as shown in Fig. 6.



Data source: *China Rural Statistical Yearbook* and *Compilation of National Cost Benefit Data of Agricultural Products* (2002-2012).

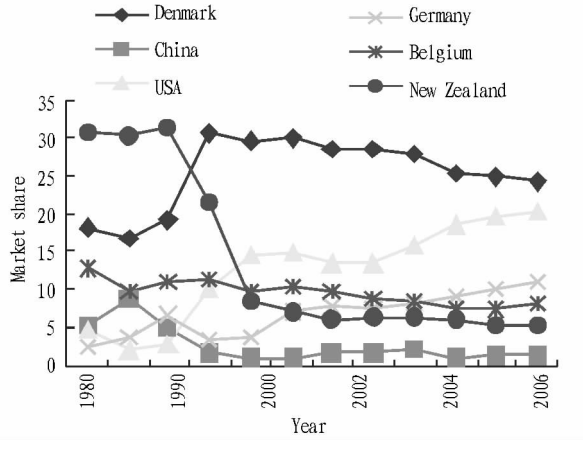
Fig. 7 The proportion of China's pork output to world pork output in 2002-2012

From Fig. 7, we can see that the proportion of China's pork output to world pork output always remains stable development. It underwent a great fluctuation in 2006-2007 mainly because China implemented some policies to support swine enterprises. But the policy effect is temporary. However, after this fluctuation, by now, the proportion of China's pork output has been stably rising. Fig. 7 reflects that China's pork output is relatively competitive at international market. (iii) Market share of China's pork industry. Market share refers to the proportion of sales volume (or sales amount) of an enterprise (or industry) to the same kind of products at the market. In this study, we took two steps to analyze market share of pork industry. The first step is to find out market share of China's pork to international market, and this indicator can clearly reflect the proportion of China's pork industry in the entire international market (as shown in Fig. 7). The second step is to find out market share of China's pork and other pork exporters, and this indicator is helpful for understanding the gap of China's pork market with other countries and clearly knowing China's existing market competitive level, as shown in Fig. 8.



Data source: calculated as per volume of export of FAO (www.fao.org).

Fig. 8 International market share of China's pork in 1982-2007



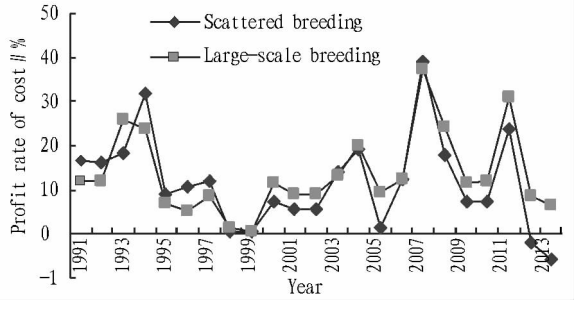
Data source: calculated as per volume of export of FAO (www.fao.org).

Fig. 9 Market share of China's pork and other major pork exporters in 1985-2007

From Fig. 8, we can see that international market share of

China's pork took on a decline trend. By 2005, it started to rise, but the overall market share was still relatively low; from Fig. 8, we can see that China's pork market share was obviously lower than other pork exporters. After 1995, China's pork market share suffered an extreme low market share. These two figures indicate China's pork market share is relatively low, reflecting China's pork industry is weak in competition at international market. To strengthen competitive power, China should take proper measures to increase the pork export volume.

4.3 Breeding benefits The profit rate of cost of swine breeding reflects cost benefit of swine breeding industry. It is a core indicator measuring cost-benefit situation. In this study, we divided swine breeding into large-scale breeding and scattered breeding and made data collection and analysis. Fig. 10 indicates that fluctuation of large-scale breeding and scattered breeding is basically consistent, but the profit rate of large-scale breeding is always higher than that of scattered breeding. The profit rate showed three peak values in 1994, 2007 and 2011 respectively, especially in 2007, the profit rate of scattered breeding reached 39.21%, and that of large-scale breeding reached 37.4%. Therefore, fluctuation of profit rate of cost reflects certain market risk in swine breeding. Besides, the difference in profit rate of cost between different scale of swine breeding is increasingly significant. From Fig. 10, we can see that such difference becomes more significant since 2011, and the profit rate of large-scale breeding is obviously higher than scattered breeding.



Data source: Compilation of National Cost Benefit Data of Agricultural Products (1991-2014).

Fig. 10 Changes in profit rate of cost of swine breeding in China in 1991-2014

5 Empirical analysis on the relation between market concentration rate and market performance of China's swine industry

5.1 Model design, and selection of variables and data Since the conclusion obtained from single equation model is sensitive to selection of models and form of functions, relative to single equation model, vector autoregression (VAR) model may have higher reliability. However, correct judgment of this model generally needs variables being steady, so we made stationarity test to make this model more reliable. The expression of VAR model is as follows:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + B_1 X_t + \cdots + B_r X_{t-r} + \varepsilon_t \quad (1)$$

where Y_t signifies vector of endogenous variable, X_t denotes vector of exogenous variable, $A_1, \cdots A_p$ and $B_1, \cdots, B_r$ are matrix of parameters to be estimated; endogenous variable and exogenous variable have p and r order lag term, ε_t is stochastic disturbance term. Taking VAR model as basis, we analyzed the relation between market concentration rate and market performance of China's swine industry using the unit root test, cointegration test, impulse response function, and variance decomposition model.

In this study, we made comparative analysis using single indicator. We used the profit rate of swine breeding cost (Y) to measure China's market performance level, and used the scale degree of swine slaughter (X_1) and scale degree of swine farms (X_2) to measure China's market concentration rate. The data in this study were selected from *China Animal Industry Yearbook* and *China Yearbook of Agricultural Price Survey*, to reduce data fluctuation and heteroscedasticity.

5.2 Unit root test Because nonstationarity series may have problem of spurious regression, we should firstly make stationarity test for time series. We used ADF unit root to test stationarity level of time series data.

From Table 1, we can see that *LNX*1, *LNX*2, *LNY* time series are non-stationary series at 5% level. After first order difference, we carried out ADF test. Results indicate that these three series are significant at 5% level, it rejects original hypothesis, indicating the series is stationary. Therefore, these three time series are first order integration I (1).

5.3 Cointegration test A common method for testing whether there exists cointegration between variables is Engel & Granger two step method, but in method processing, there is deviation in sample estimation. Therefore, we used JJ test method to conduct the cointegration test for *LNY*, *LNX*1 and *LNX*2. JJ test method is based on dynamic distribution lag model (VAR):

$$Y_t = \sum_{i-1}^{k} \alpha_i Y_{t-i} + \sum_{i-0}^{k} \beta X_{t-i} + \mu_i \quad (2)$$

Using this model to estimate long-term balance relation, we obtained an effective unbiased estimation. Firstly, we calculated Johanson statistics of regression equation, then made comparison with J value on the assumption of non cointegration and one cointegration and two cointegration. When J value of regression equation is higher than Johanson critical distribution value under assumption condition, it rejects precondition hypothesis; otherwise, it accepts the precondition hypothesis. Test results are listed in Table 2.

According to Table 2, at 5% level, there exists a cointegration between *LNY*, *LNX*1 and *LNX*2. In other words, there exists a long-term stable economic relation between profit rate of swine breeding cost, scale degree of swine breeding, and scale of swine farms. Granger stated that there exists a cointegration between weak variables, so these variables have Granger causal relation at least in one direction. Next, we will discuss the causal relation between profit rate of swine breeding cost, scale degree of swine breeding cost, and scale of swine farms.

Table 1 Results of ADF unit root test

Variable	Test type (C,T,K)	ADF statistics	ADF critical value -5%	*P* value	Conclusion
LNX1	(C,T,0)	-0.123492	-3.098896	0.9286	Not stationary
LNX2	(C,T,0)	-0.321089	-3.098896	0.8986	Not stationary
LNY	(C,T,0)	-2.589987	-3.098896	0.1178	Not stationary
△LNX1	(C,0,0)	-3.19806	-3.11991	0.0438	Stationary
△LNX2	(C,0,0)	-3.134337	-3.11991	0.0488	Stationary
△LNY	(C,0,0)	-5.565252	-3.11991	0.0008	Stationary

Note: △ signifies first order difference; C, T, K in test type denote intercept term, trend term, and lag term.

Table 2 Cointegration test results of LNY, LNX1 and LNX2

Cointegration vector	Johanson statistics			
	Null hypothesis	J statistic	5% level critical value	*P* value
LNY	rk(A) =0	39.46396	29.79707	0.0029
LNX1	rk(A) < =1	9.112041	15.49471	0.3551
LNX2	rk(A) < =2	1.666593	3.841466	0.1967

5.3 Impulse response The impulse response function is a standard deviation impulse for measuring stochastic disturbance term of an endogenous variable and it is influence on current value and future value of all endogenous variables in VAR model. Fig. 11 and Fig. 12 are impulse response of profit rate of swine breeding cost, scale of swine slaughter and scale of swine farms. In Fig. 11 and Fig. 12, LNY refers to logarithmic value of profit rate of swine breeding cost, LNX1 is logarithmic value of scale of swine slaughter, and LNX2 is logarithmic value of swine farms.

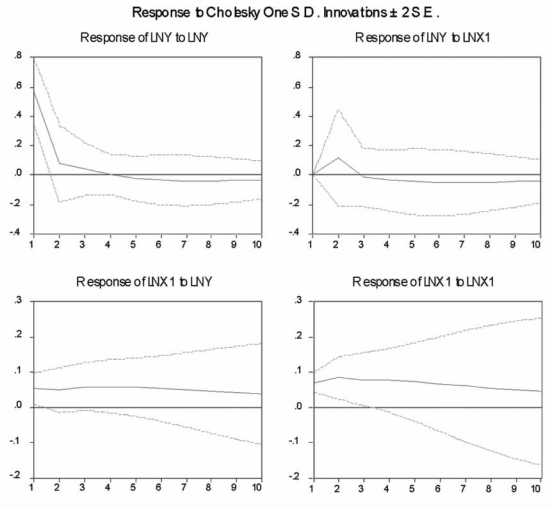


Fig. 11 Impulse response of profit rate of swine breeding and scale degree of swine slaughter

From Fig. 11, we can see that scale of swine slaughter exerted negative influence on profit rate of swine breeding cost at the early years. In the third period, the influence became stable and later it exerted positive influence. In practice, this is also explanatory. At early stage of large scale, input production cost was high and included fixed cost and variable cost. Because many fixed costs become sunk costs in later period, with expansion of breeding scale, the cost is gradually reducing, while the profit is increasing. From the third chart in Fig. 11, we can see that profit rate of China's swine breeding exerted positive influence on scale of swine production in both short term and long term. This indicates that with increase in the profit rate, the scale of swine slaughter becomes more and more, then the profit will become higher and higher, which will form a benign cycle.

From Fig. 12, we can see that at the early years, changes of China's swine breeding scale were negatively correlated with profit rate of swine breeding cost, but the relation became stable after it entered the third period. At the early period of large-scale breeding, large swine farmers were not clear of large-scale breeding methods. After production operation enters normal period, the previous cost is recovered and profit starts to increase. With rise of large swine farms, China's swine breeding profit is gradually increasing. From the third chart of Fig. 12, with rise of profit rate of China's swine breeding, large swine farms also rise because profit rise attracts more swine producers.

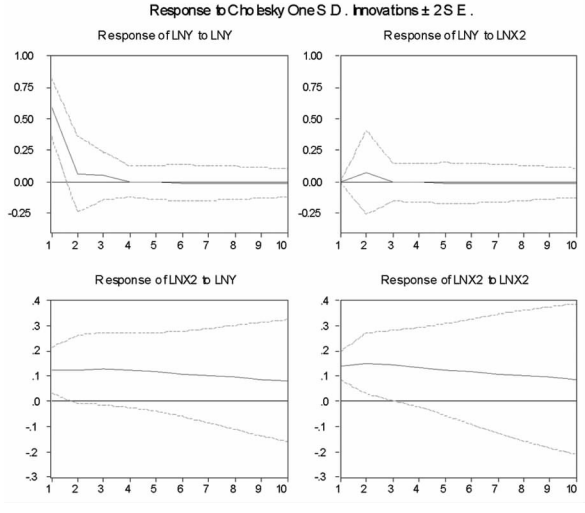


Fig. 12 Impulse response of profit rate of swine breeding and scale of swine farms

From the above two figures, for a long term, China's large scale breeding pulls the profit rate of swine breeding cost and the pulling action is becoming stable. This is consistent with conclusions of cointegration test.

5.5 Variance decomposition Variance decomposition is to analyze the contribution of each structural impact to changes of endogenous changes and further evaluate importance of different structural impact. From Table 3, we can see that the profit rate of

swine breeding cost is not only influenced from self change, but also influenced from expansion of scale swine slaughter and expansion of scale of swine farms. The profit rate of swine breeding cost was completely influenced from self changes in the first period. However, with lapse of time, the influence dropped to 69% in the 10th period. The influence of changes in scale of swine slaughter increases with the period, and finally rises to 26.4%. Besides, changes in large-scale swine farms start to rise gradually and later decline, finally become stable at 4.19%.

From the above analysis, the profit rate of swine breeding cost is influenced by itself, but also influenced by scale of swine breeding and scale of swine slaughter. On long terms, the contribution rate is 69.4%, 26.4%, and 4.19% respectively. The impact of scale swine breeding is much greater than impact of large-scale swine farms. In sum, swine breeding farms and number of breeding promote changes of swine productivity.

Table 3 Variance decomposition of swine market performance

Period	S. E.	LNY	LNX1	LNX2
1	0.565050	100	0	0
2	0.570555	98.11836	0.023668	1.857970
3	0.604031	88.11236	7.838507	4.049136
4	0.629515	81.67767	13.84522	4.477105
5	0.644003	78.04700	17.43032	4.522687
6	0.660017	74.73534	20.86799	4.396675
7	0.673419	72.23397	23.53963	4.226397
8	0.683331	70.71991	25.15353	4.126563
9	0.691032	69.86231	26.02365	4.114040
10	0.696633	69.42350	26.38767	4.188834

6 Conclusions and policy recommendations

From the above analysis, in recent 10 years, China's swine industry received considerable development, market concentration rate is greatly increased. Data show that swine enterprises with annual slaughter more than 500 heads develop rapidly, while enterprises with annual swine slaughter less than 500 heads are shrinking. With the aid of VAR model, we made analysis of market concentration rate and market performance of China's swine industry, and used impulse response function and variance decomposition. We came up with following conclusions. Firstly, with rise in market concentration of China's swine industry, the corresponding market performance is also rising. Secondly, the influence of scale of swine slaughter on market performance is greater than large-scale swine farms. Major defects of this study: (i) we only considered the influence of profit rate of swine breeding cost on market performance. In fact, market performance is influenced by many external factors. (ii) The data of market concentration rate were replaced with data of breeding scale because it is difficult to collect relevant data. Therefore, for swine breeding, China should issue powerful regulations to encourage large-scale swine breeding, and maximize economic benefits and market welfare considering external problems possibly brought by large-scale breeding.

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