China's Hog Production Structure and Efficiency

by

Agapi Somwaru, USDA-ERS
Zhang Xiaohui, Ministry of Agriculture-RCRE, China
Francis Tuan, USDA-ERS

Corresponding author: Agapi Somwaru
ERS-USDA
1800 M Street, NW
Room S5224
Washington, DC 20036-5831
Tel (202)-694-5295
Fax (202) 694-5823
Email: agapi@ers.usda.gov

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Abstract

Over the last 20 years, China's demand for and supply of livestock products has increased dramatically. Although, China's livestock production has changed, with the share of pork production declining, pork production remains the core of the country's livestock industry. China's hog industry is adjusting to capture the benefits of specialization. This paper attempts to capture structural changes in China's hog production, its evolving trends, and economic efficiency. We estimate parametrically the overall efficiency and scale elasticity of 2500 surveyed hog farms in China. Our analysis indicates that the large commercialized farms are the most efficient but the middle size specialized farms with increasing returns to scale production technology are the most profitable.

Introduction

Over the last 20 years, China's demand for livestock products has increased remarkably due to rapid development of the national economy, rising living standards, and population growth. Many economists have documented the strong relationship between a country's economic development and increasing demand for livestock products with accompanying structural changes in the livestock sector (Taniguchi, 1995, Kurosaki, 1998, Benjamin, 1992, Skoufias, 1994). The hog industry still plays a dominant role in China's livestock sector despite the rapid expansion of poultry (Wailes et al., 1998, Tuan et al. 1998, and X. Zhang, 1999). In the last decade, however, hog production went through drastic structural changes with an increase in large, specialized farms and a decline in the overall number of farms. The purpose of this paper is to provide insights into China's hog production, structural changes, and economic efficiency.

Although, China's livestock production has changed, with the share of pork production declining, pork production remains the core of the country's livestock industry. In 2001, pork production accounted for 65.8 percent of China's total meat output and pork continues to be the most popular meat consumed by Chinese consumers. Pork production is also the most important enterprise among all livestock production activities in rural China. Continued income growth, urbanization, and rising meat demand will continue to shape and transform China's hog production and its need for feed inputs. To analyze these changes in China's hog industry, we utilize two unique data sets: first, China's Agricultural Census, conducted by the National Bureau of Statistics in 1996 and second, a 1999 comprehensive livestock survey conducted by the Research Center of Rural Economy (RCRE) in the Ministry of Agriculture (MOA). These data sets allow us to capture changes in hog production activities, analyze structural change, and measure the economic performance of the hog-raising sector. Understanding the factors affecting hog production at the micro-level is very important, because livestock production, with its linkages to rural economic growth, can be viewed as a means to improve farm household incomes. Knowledge of structural characteristics, adoption of practices, and new technologies for a more profitable hog industry, would be of great importance for farmers and China's entire hog sector.

During the period of transition to China's current market economy, the role of the market mechanism in guiding rural households' livestock raising activities has been crucial. Though production technologies applied by different rural households vary significantly, the hog industry is adjusting to capture the benefits of specialization in production as well as new opportunities offered by liberalized markets. Farmers adjust their operations to take advantage of economies of scale and to make the most effective use of scarce investment and available resources. As the dynamics of micro economic decisions change livestock

production, the number and size of hog operations are also adjusting in China. Some studies of various countries have recognized unprecedented changes in hog production and documented empirically these structural adjustments (Adams and He, 1995, Taniguchi, 1995, Chen et al., 2001, McBride and Key, 2003). This paper attempts to capture and document structural changes in China's hog production, its evolving trends, and economic efficiency. The rest of the paper is organized as follows. In the next section we present changes in livestock production and consumption over the last sixteen years. Then the structural changes in hog production are described. We discuss the methodology used for this analysis, data sources, and sampling characteristics. We then review the hog industry's structural and technical performance, followed by econometric results of hog farms' economic performance. Lastly, we conclude with a summary.

China's Livestock Production and Consumption in the Last Fifteen Years

In the last decade and a half, meat production in China not only experienced a dramatic increase in total quantity produced, but also underwent significant structural changes. Total meat production increased around 3.3 times in volume, reaching 63 million tons in 2001 as compared to 19 million tons in 1985. Pork still has the largest share of total meat output (66.1%), although this declined by 20 percent in the last 16 years while the share of poultry production has increased. Poultry now accounts for about 21 percent of total meat production in China (Table 2).

Likewise, China's total meat consumption has increased in volume and changed in composition. Between 1985 and 2001, poultry consumption rose nearly 3 times while pork consumption increased only by 1.48 times (figure 1). In other words, Chinese consumers are gradually shifting from favoring pork consumption to consuming more poultry and aquatic

products. Nevertheless, pork meat consumption is still predominant in total meat consumption for both rural and urban residents (figure 2). Changes in consumption can be traced to China' fast economic growth, rising per capita income, as well as urbanization. As urban residents' consumption of meat products continues its upward trend, rural households' income generated from raising livestock will also increase, boosting their standard of living.

Changes in Hog Production Structure in Rural China (1985-1996)

There are primarily three categories of hog operation in China: backyard hog farms, specialized hog operations, and commercialized hog production enterprises. We briefly present each category of hog operation and their technical and economic characteristics.

The first category, *backyard hog farms*, includes very small hog production activities in rural households. China's rural households, besides raising hogs, also are involved in raising small numbers of other animals, such as chickens and goats, as well as undertaking some crop production activities. Although their production scale is small, most hogs raised are sold in the local markets, providing an important source of cash income. These households often save some portion of the slaughtered hogs for home consumption. Usually, these small operations average 2-3 head of hogs per household per year. Rural households in this category use traditional feeding methods, such as table scraps, vegetables, green fodder, and unprocessed grains and oilseeds. Over the last 15 years, the number of backyard hog farms has gradually declined, but backyard hog operations still dominate in both the number of hog farms and share of total pork production in China.

The second category is the specialized rural hog production households or *specialized hog* farms. Family members are chiefly engaged in hog production. These operations on average produce over 30 hogs annually. Recently some larger operations have produced

several hundred head of hogs per year. The share of these operations in China's hog production is increasing, and their production capacity is beginning to dominate some of the rural markets in China due mostly to the government's marketing promotion policy. For example, the government is building more and more wholesale and retail markets in urban and rural areas, providing market information to the public through media, and reducing limitations on selling products by producers. Specialized hog farms can be, in particular, found in feed grain producing provinces or local areas that have brewery operations because of the availability of byproducts that can be used as high energy feed. In 1996, the output share of these operations increased to 14.6 percent of total pork output, compared with only 2.9 percent in 1985 (figure 3).

The last category, *commercialized hog production enterprises*, includes state or collectively owned hog farms, as well as privatly owned in the form of sole proprietorship or partnership, with share rent or contract arrangements with state farms or collectives. These operations are characterized by large capital investment and their size and production capacity considerably surpass those of the specialized hog farms. The breeding technologies, feeding methods, and disease prevention practices in this category are advanced and modern. Big and middle-sized hog production enterprises are mostly located near the suburbs of big- or middle-size cities. The operations presently account for 4.7 percent of total hog production in China.

Recent changes in the structure of hog production in China is clearly reflected in the decrease of meat output from backyard farms, at an average rate of 1.4 percent per year. This is the case because the number of backyard farms that raise hogs is decreasing annually, even though the slaughter per farm increased from 1-2 head to 3 head in recent years. Most rural households lack necessary capital to invest and improve their livestock operations. Further,

urbanization continues but its pace has slowed down considerably in the last few years. With a lack of urban job opportunities for the huge rural population, the majority of rural laborers are still confined to small-scaled cropping and livestock activities. Nevertheless, specialized hog farms, both in numbers and production, are expanding at an increasing rate.

Methodology for Analysis

Given the transition of the hog sector, our study attempts to assess the economic performance of China's hog production and its structural changes. Even though it is still dominated by many small operations, hog production in China has begun to shift and become more concentrated in large specialized operations. These changes have profound effects on the industry's performance, and measuring the impacts of these changes is therefore of great imterest. The method used to assess these changes is presented below.

Analysis of production structure and performance of hog production begins with the underlying production technology. This may be formalized by specifying a transformation function, $S(X_n, Y) = 0$, which minimizes the production frontier in terms of inputs X_n and output Y. Information on the production technology can be characterized via an input set, $F(Y,X_n)$, that represents the set of all inputs X_n that can produce Y.

An input distance function (denoted by superscript i) recognizes the least input use possible for producing the given output vector as defined by $F(Y, X_n)$ or the distance function implies input of resource use for production of a given output vector:

(1) $$D^i(Y, X_n) = \max\{\tau : (x/\tau) \in F(Y, X_n)\}$$

where D^i is the distance of unit i, Y is output, X_n are inputs such as labor, expenses for purchasing baby animals (feeder pigs), expenses for fine feed, expenses for beans, expenses for succulents and coarse fodder, expenses for additives, other feed expenses, other variable

expenses, indirect expenses, and marketing expenses. We use a programming method to estimate the input distance function and capture the distance from the frontier assuming a radial contraction of inputs to the frontier of hog operations. The ratio of estimated potential efficient input use compared to the actual observed use provides an estimate of technical efficiency. Further, scale economies can be measured by identifying variations in the input and output ratio at different scale levels when variable returns to scale are allowed.

Functional relationships of production or distance functions represent a foundation for data envelopment analysis (DEA) procedures and can be estimated using programming methods rather than econometric (parametric) techniques. Formally, an input-oriented programming problem may be written as:

$$(2) \qquad \min_{\theta,\lambda} = \theta_i, s.t. \sum_{j=1}^{J} \lambda_j Y_{mj} - Y_{mi} \geq 0, \theta_i X_{ni} - \sum_{j=1}^{J} \lambda_j X_{nj} \geq 0, \sum_{j=1}^{J} \lambda_j = 1,$$
$$m = 1,...,M, n = 1,...,N, j = 1,...,J$$

There are J observations and the non-negative weights, λ_j, determine the reference points on the frontier for unit i. For notational simplicity the unit index i is suppressed on the λ-weights. The input vector in (2) for unit i is adjusted by the efficiency score, θ_i, ($D^i = \theta_i$) and then compared with the reference point, $\sum_{j=1}^{J} \lambda_j x_{nj}$, on the frontier.

The Lagrangian of equation (2) is set up in such a way that the shadow prices of outputs and inputs, u_{mi} and v_{ni}, respectively, are non-negative:

$$(3) \qquad L = \theta_i - \sum_{m=1}^{M} u_{mi} (\sum_{j=1}^{J} \lambda_j y_{mj} - y_{mi}) - \sum_{n=1}^{N} v_{ni} (\theta_i x_{ni} - \sum_{j=1}^{J} \lambda_j x_{nj}) - u_i^{in} (\sum_{j=1}^{J} \lambda_j - 1)$$

where u_i^{in} is the shadow price of the equality constraint on the sum of the λ's. Since the value of the shadow price is unique for inefficient units, we utilize the radial projection approach for calculating scale elasticity values (see Forsund, F.R and L. Hjalmarsson (1979).

Estimation of scale elasticities using non-parametric techniques, while straight forward for efficient points (i.e., points that satisfy F(Y,X) = 0) are ambiguous for inefficient points. Following Forsund et al. we use the *radial* projection approach and calculate for each farm the scale elasticity as follows:

$$(4)\quad \varepsilon(Y_{i,}E_iX_i) = \frac{E_i}{E_i - u_i^{in}}, i \in I$$

where E_i is the input-oriented efficiency score and u_i^{in} is the shadow price on the equality constraint $\sum_{j=1}^{J} \lambda_j = 1$. The farm exhibits increasing returns to scale if $u_i^{in} > 0$, constant returns to scale if u_i^{in}=0, and decreasing returns to scale if u_i^{in}<0.

Data Sources

China's 1996 national agricultural census provides us with a unique opportunity to comprehend the structure of hog production in China in its entirety. The census covers all Chinese persons and households in rural areas, non-household agricultural production units, township enterprises, as well as administrative organizations of all villages and towns. This was the first agricultural census conducted in China. We used the livestock data of this first agricultural census to put together a complete picture of the production structure of China's national hog industry, as well as its operations by size and by region.

Since the agricultural census lacks data on feed use and other important economic characteristics of hog production, we supplement our study with a livestock survey conducted by RCRE. The 1999 RCRE detailed household survey was conducted in the most important

hog producing areas in China. This was an extensive survey of more than 2500 farm households aimed to capture an accurate picture of hog production efficiency, costs, and feed use by size and types of operations in China.

Characteristics of the Sampling Areas

The 1999 RCRE livestock survey covered fifteen provinces, accounting for 65 percent of the country's hog output. The sample size in each province varies depending on the number of hog production enterprises. The distribution of the sample size by province and size of hog operation is reported in Table 1 below.

The provinces included in the 1999 survey are: Sichuan, Hunan, Hubei, Shandong, Henan, Hebei, Jiangsu, Jiangxi, Anhui, Guangxi, Liaoning, Beijing, Heilongjiang, Yunnan and Shanxi. The sample size of the survey is 2,558 households. Agricultural output per farm is measured as farm income or the main product output in jin (weight) times the price (yuan per jin). For the variable inputs, labor expenditures are the number of persons times the number of working days times wage rate (yuan per day) or annual per-farm expenditures on labor is used. Cost of purchased animals is the price of baby animals (or feeder pigs) purchased times the animal weight annually per farm. Cost of fine feed includes annual expenditures on mixed feed, grain feed, bran, and oilseed cakes per farm. Cost of bean dregs feed includes annual expenditures on lees and bean dregs annually per farm. Cost of succulents and coarse fodder includes expenditures on rice chaff, millet bran, fodder, and succulents annually per farm. Cost of additives includes annual expenditures on additives. Other expenditures include annual cost of leftovers, such as leftovers from restaurants, per farm. Indirect cost includes annual depreciation of fixed assets, expenditures on repairs, and miscellaneous fixed expenses per farm. Marketing cost includes annual expenditures on

contract fees, costs of marketing, taxes and other fees per farm. Other variable expenses include costs of feed processing, fuel, irrigation, and electricity, the cost of veterinary fees, and the cost of other direct fees annually per farm.

Hog Production: Structural and Technical Performance

According to China's first ever agricultural census conducted in 1996, there were 119 million hog producers in the 31 provinces and municipalities that produced a total of 345 million hogs. On average, each producer raised 2.9 hogs that year.

Despite hog production in each of the 31 provinces and municipalities in China, in general, hog production is concentrated in the central, eastern, and southwest provinces (see map with the top ten hog production provinces). The top ten hog producing provinces accounted for 65 percent of total hog production. Of the ten, the largest two hog producing provinces, Sichuan and Hunan, contributed 25% of China's total. The biggest private feed company in China, namely the Hope Feed Company, is located in Sichuan province. According to the census, around 85-90 percent of rural households in Sichuan and Hunan raised hogs. However, the number of hog farms is declining rapidly in some coastal provinces, such as Zhejiang, Jiangsu, and Guangdong, due to the growth of non-farm industries (Figure 4). Nevertheless, Guangdong province remains in the third place in terms of slaughtered hogs in 1996, because the size of hog operations grew rather rapidly during the last 15 years., even as the number of hogs declined.

Figures 5 and 6 present the distribution of hog farms and production by size of operations. In 1996, most hog farm operations in China were small and produced one to five slaughtered hogs annually; these accounted for 92.6 percent of the total farms (figure 5). However, these farms produced 59.4 percent of total hog production (figure 6). Farms with

hogs ranging from 6 to 30 head account for 7.1 percent of total farms and 24.7 percent of total production. Farms with more than 30 head account for 0.3 percent of total hog farms but 15.6 percent of total production (figures 5 and 6). This indicates that large production units take advantage of the economies of scale in their operations. Based on gross accounting, our survey clearly indicates that feeding cost efficiency increases with the size of hog operations (table 3). For hog operations under 5 head (small size), the average profit per farm for raising hogs is 79 yuan or 40 yuan per head of animals slaughtered. For hog operations with 6-10 head, average profit per operation is 332 yuan (42.3 yuan per head), or three times larger than the profit of the smaller hog operations. For operations with more than 500 head, average profit amounts to 99,171 yuan or 40 yean per head animals slaughtered (table 3).

Table 3 indicates that rural households whose hog operations are in category 4 (raising 31 to 100 hogs) are the most profitable operations, based on their high ratio of profit to cost. Hog farms that have more than 30 head are considered s*pecialized hog farms* in China. These farms are characterized by their high adoption rate of new technologies in hog production. The source of specialized farms' efficiency primarily lies in economies of scale. Among the specialized hog farms, those middle size farms with 31-100 head (average slaughter number of 51 head) have advantages that allow them to be more efficient than bigger operations. That is because they depend mostly on their own labor and their need for hired labor is minimal. Second, they do not have to build large facilities, like the very large commercialized enterprises, to accommodate the hogs. Finally, the indirect cost, such as managing fees, for this kind of hog farm is low compared with other, larger operations.

In sum, the smallest size of hog operations are less profitable than the larger size, as the bigger operations can take advantage of economies of scale associated with their larger size, and specialized operations are more profitable than large commercialized operations.

Econometric Results

Using the survey data in conjunction with the agricultural census we employed the methods described in the previous section and constructed measures of efficiency and scale economies for our sample of farms in China. Our deterministic procedure estimates the best-practice production frontier from these data and compares individual farms to the estimated frontier. For this purpose, we use programming to estimate an input distance function. Our farm model, as stated previously, is based on one output and nine inputs.

The results are robust and presented in Table 4. We have constructed measures of efficiency or performance as well as scale elasticity for the entire sample, by class size and by province. The estimates, over the whole sample, by class size and by region, display some interesting differences. The overall efficiency estimate, using all 2558 hog farms, is 0.24, indicating low overall efficiency, but the scale elasticity shows increasing returns to scale (0.192). The most obvious differences are revealed by the measures of efficiency and scale elasticity by class size. As the size of operations increases from less than 5 head to more than 500 head, overall efficiency increases from 0.30 to 0.99, respectively, as expected because benefits of specialization and scale economies are likely. However, the estimates of scale elasticity reveal unexpected differences among the farms by size that support the gross accounting analysis presented in the previous section. As the size of farms increases from less than 5 to 100 head, hog farms exhibit increasing returns with scale elasticity averaging from 0.254, for the smallest size, to 0.506 for farms with 31 to 100 head of hogs. Scale elasticity, however, decreases as the size of farms increases further (specialized hog farms).

In sum, while overall efficiency increases with the increase in farm size, the "pure" economies of scale elasticity measure increases for backyard and specialized hog farms and decreases or exhibits constant returns for commercialized hog farm operations. Table 3

(based on accounting method) indicates the most profitable farms are those with 31 to 100 head, while Table 5 (capturing the major expense category by the size of hog operation) shows that feed cost accounts roughly for 70 percent of the total cost of hog production. Looking into feed categories more closely (table 6), we observe that the cost for fine feed accounts for the greatest expense (67%) for all sizes of hog operations, followed by residues from various feed sources such as sugar and starch (25%).

Since the cost of fine feed is so importance for China's hog operations, we examine this in depth. From table 7 below we observe that the share of raw grains is the largest in the total fine feed category (43.4%), followed by the commercially purchased mixed feed (33.6%), bran of various grain categories (14.1%), and oilseed cakes (8.9%). The smaller size operations use more raw grains than larger operations. On the other hand, larger operations use more bran of various grains as well as commercially purchased feed. Note that the most cost-efficient hog size category (31-100 head) uses more commercially purchased feed than any other category except the largest one (which has 500 heads and more). This explains why this size of operation exhibits larger scale elasticity than the backyard hog farms.

The average feed-meat conversion ratio is estimated at 3.18 for all farms in the survey. The middle size operations (6~10, 11~30, and 31~100 head) have a lower conversion ratio and better feed efficiency than all other operations including the smallest backyard hog farms and the largest-size hog operations.

All sizes of hog operations seem to depend on corn as the main feedgrain. In recent years, especially in south China, farmers used low-quality early rice to feed their hogs as the price of corn is much higher in this part of the country.

The spatial results, as shown in Table 4, capture regional disparities in both efficiency and scale measures. Anhui, Jiangsu, Hubei, Heilongjiang, and Yunnan provinces have the

highest performance regarding overall efficiency and increasing returns to scale. Hubei, Heilongjiang, and Yunnan provinces have primarily specialized and commercialized operations using commercially purchased feed and bran of various grains for feed. Anhui and Jiangsu have a fair amount of backyard farms but corn plays an important role as feed for their hog operations. Hebei, Hubei, and Jiangxi provinces have the highest scale economies as most of their hog operations are in the specialized category.

Summary and Conclusions

In summary, traditional small hog farms still dominate hog production activities in China, but their output share declined at a rate of 1.4 percent per year from 1985 to 1996. Meanwhile, operations of specialized hog farms are expanding at an increasing rate, in terms of both numbers and output.

After analyzing the feed efficiency and structure of production costs directly from survey data and estimating the overall efficiency and scale economies of hog farms in the sample, we can conclude that the middle size hog operations with 31 to 100 head are most profitable. The overall efficiency estimate, using all 2558 hog farms, is 0.24, indicating low overall efficiency. However, the scale elasticity (0.192) indicates increasing returns. As the size of operations increases from less than 5 head to more than 500 head, overall efficiency increases from 0.30 to 0.99, respectively. As the size of farms increases from less than 5 to 100 head, hog farms exhibit increasing returns. The scale elasticity ranges from 0.254, for the smallest size, to 0.506 for farms with 31 to 100 head of hogs.

Overall efficiency, measured by the efficiency scores θ_i, is the highest for the commercialized farms but their scale elasticity exhibits constant returns to scale. For the specialized farms the scale elasticity is increasing with lower efficiency scores than the commercialized operations. Based on the accounting method, indicates the most profitable

farms are those with 31 to 100 head while analysis of major expense category by the size of hog operation, shows that feed cost accounts roughly for 70 percent of the total cost of hog production. Looking into feed categories more closely, we observe that fine feed is the greatest expense (67%) for all size of hog operations, followed by residues from various feed sources such as sugar and starch (25%).

Our results suggest that larger hog farms are likely to prevail in China and, for the next 10 or 20 years, are more likely continue to replace the traditional backyard hog farms. The large commercialized farms although efficient their scale elasticity indicates that they operate either under decreasing returns or constant returns to scale. The spatial results, as shown in Table 4, capture regional disparities in both efficiency and scale measures.

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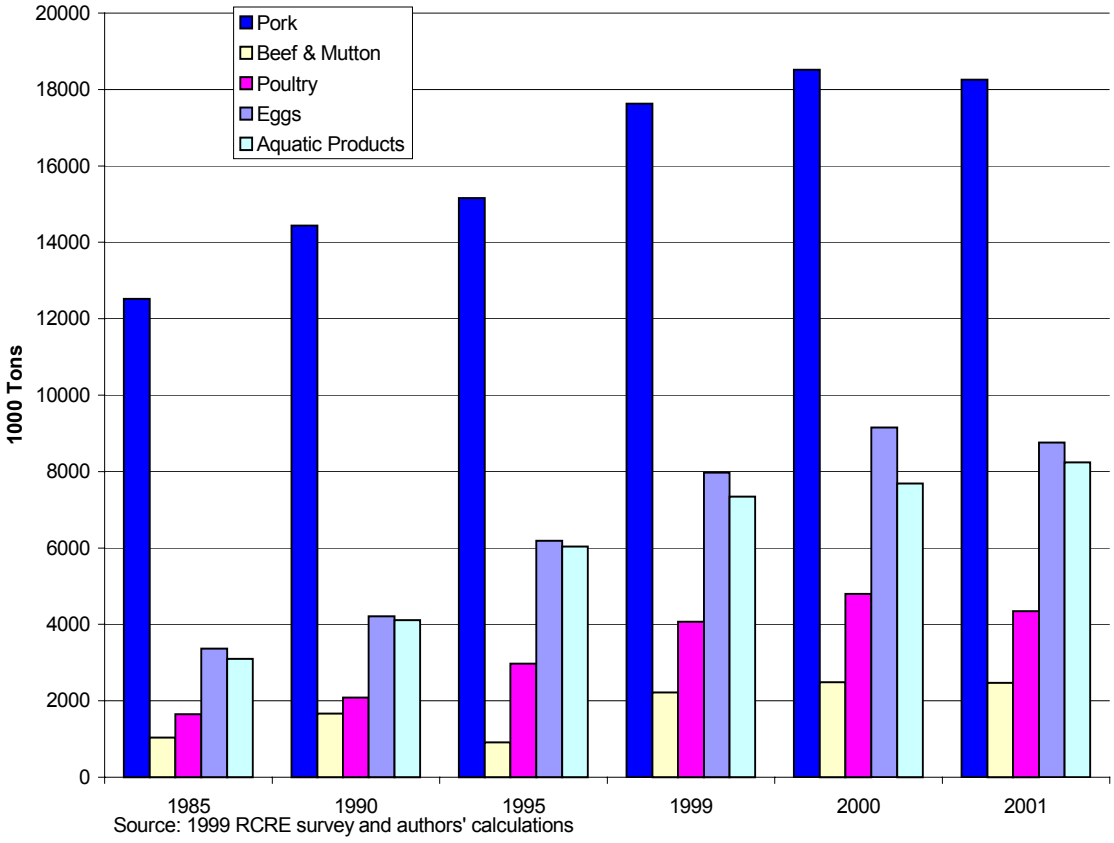
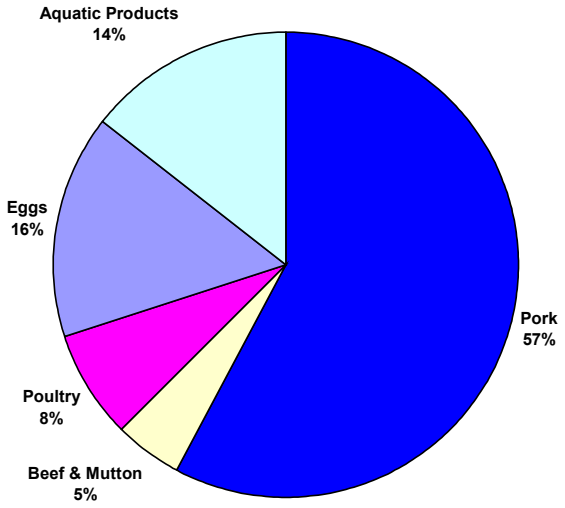
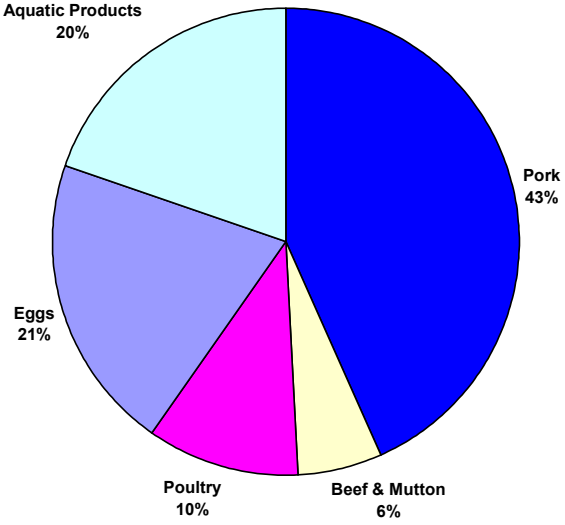
Figure 1. Livestock and Aquatic Products Total Consumption, 1985-2001



Source: 1999 RCRE survey and authors' calculations

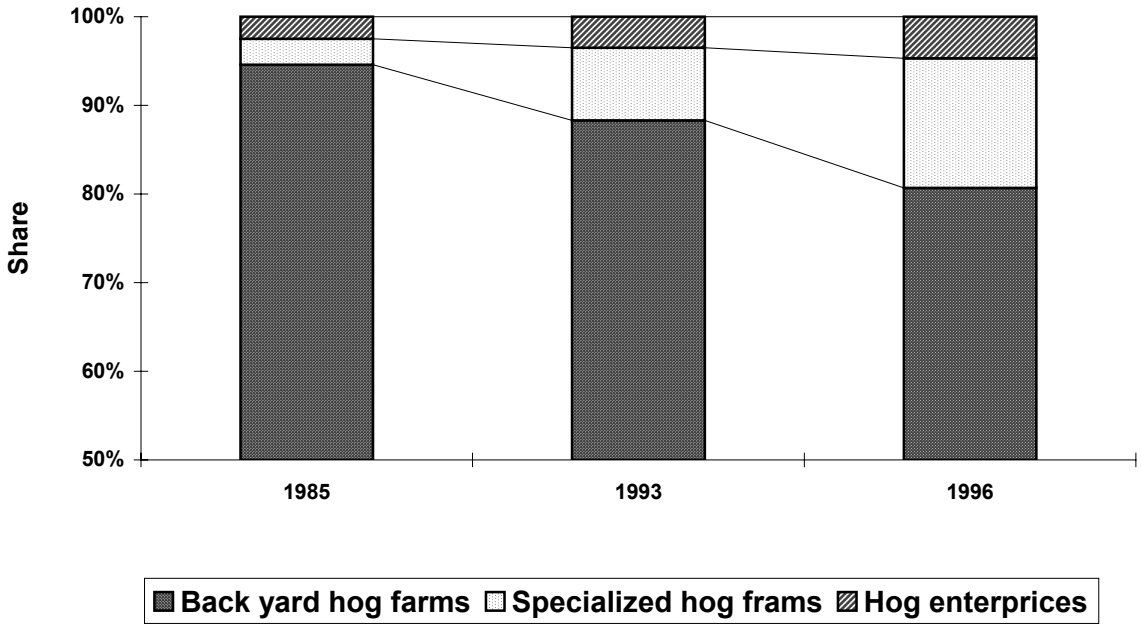
Figure 2. Composition of Total Consumption, 1985 and 2001





1986, 2001 China's Statistical Yearbooks

Figure 3. Shares of Hog Output by Type of Operation, 1985, 1993, and 1996



Source: China's Statistical Yearbooks.

Fig. 4 Top ten hog production provinces

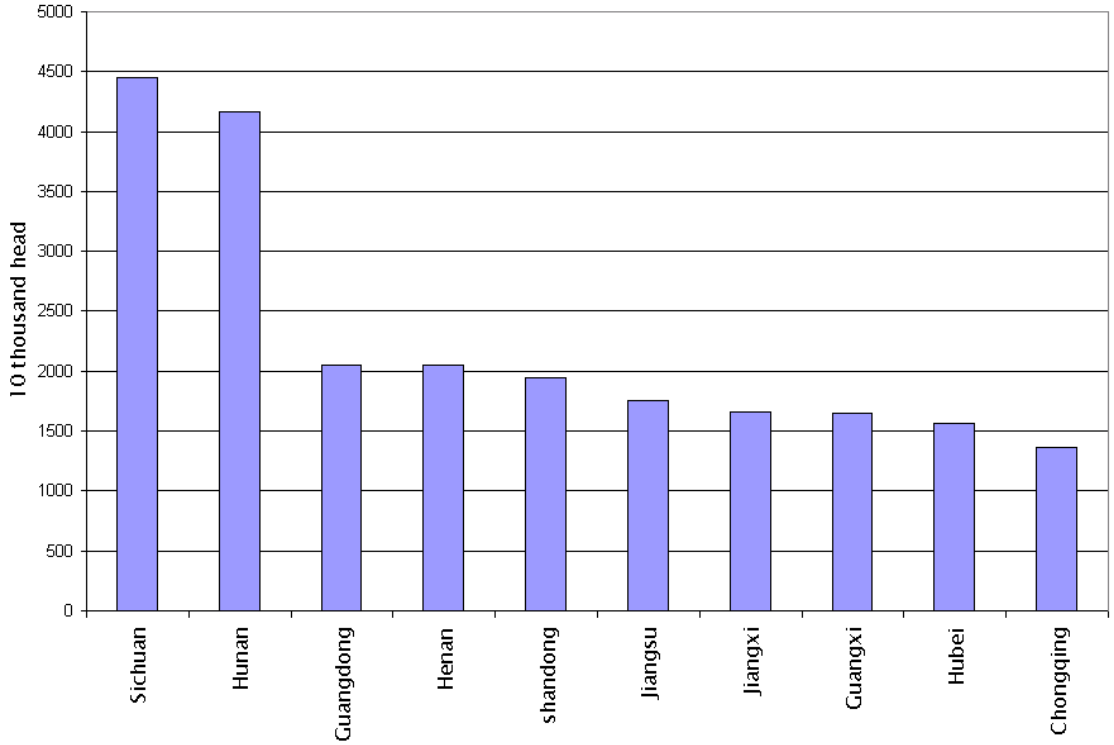
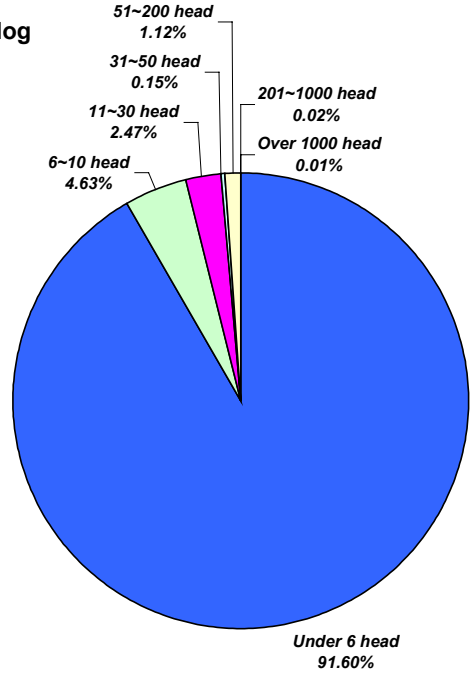
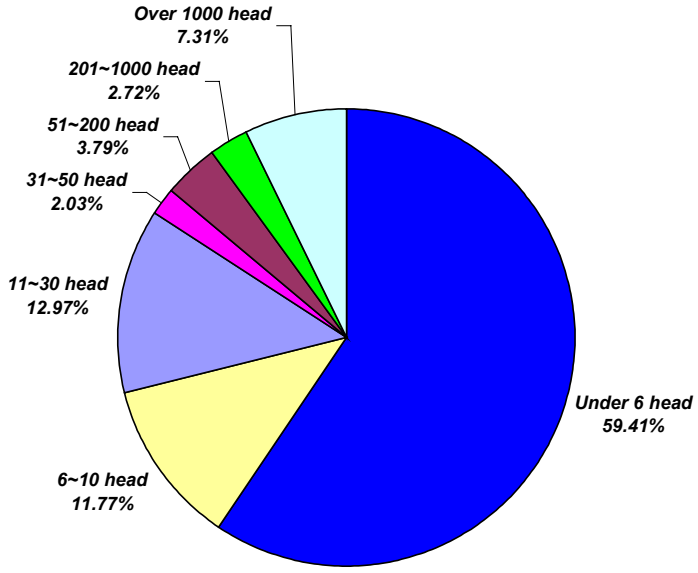


Figure 5. Distribution of Hog Farms by Size



Source: 1999 RCRE Survey; authors' calculations

Figure 6. Output (Animal Slaughtered) Shares of Hog Operation by Size



Regional Distribution of Hog Farms in China, 1999

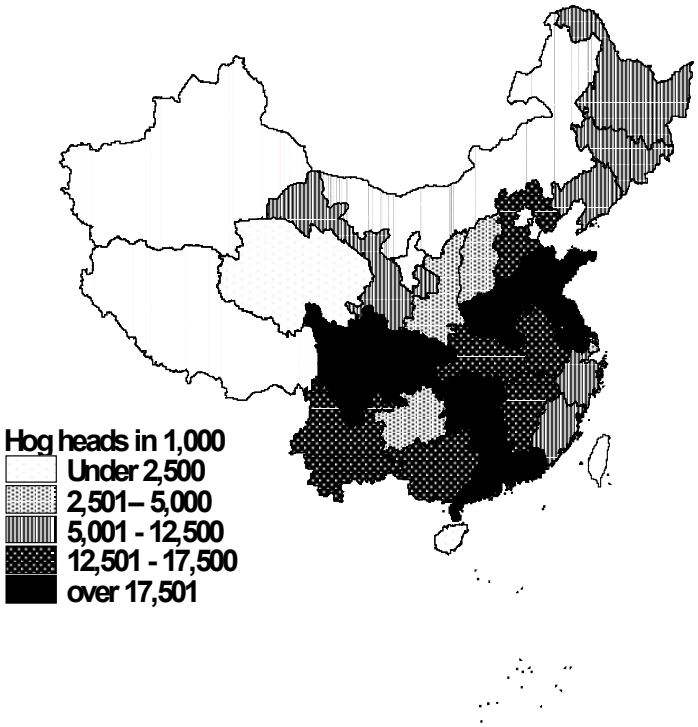


Table 1. Sample Distribution of Hog Operations by region

Item		<=5	6~10	11~30	31~100	101~500	>= 500
All farms							
Number	2558	1462	356	428	220	76	16
Percent	100	57.15	13.92	16.73	8.60	2.97	0.63
Top eight provinces	2090	1215	305	370	132	58	10
Liaoning	213	87	39	49	33	5	0
Jiangsu	181	83	25	51	17	5	0
Anhui	151	121	7	4	5	11	3
Jiangxi	242	117	45	50	21	8	1
Henan	330	273	16	17	11	11	2
Hunan	284	148	45	69	13	8	1
Guangxizhuangzu	288	114	71	88	12	3	0
Sichuan	401	272	57	42	20	7	3

Table 2. China's Meat Output and Shares by Livestock Category

Item	1985		1993		1996		1999		2000		2001	
	1,000 tons	percent	1,000 tons	percent	1,000 tons	percent	1,000 tons	percent	1,000 tons	percent	1,000 tons	percent
Pork	16547	86.14	28544	75.14	40377	71.70	40060	68.15	40314	65.82	41845	66.07
Beef	467	2.43	2336	6.15	4949	8.79	5050	8.59	5328	8.70	5488	8.66
Mutton	593	3.09	1373	3.61	240	0.43	2510	4.27	2740	4.47	2927	4.62
Poultry	1602	8.34	5736	15.10	10746	19.08	11160	18.99	12870	21.01	13079	20.65
Total meat	19209	100.00	37989	100.00	56312	100.00	58780	100.00	61252	100.00	63339	100.00

Table 3. Balance Sheet of Production and Cost by Size of Hog Operation

Item		Gross income	Total cost	Direct cost	Purchasing animals	Feed	Employee Fee	Other Expenses	Indirect cost	Profit	Profit to cost ratio
<=5	per farm	1377.2	1270.7	1228.7	247.9	902.8	27.46	50.51	42.0	79.1	
	per head	692.1	638.5	617.4	124.6	453.6	13.8	25.38	21.1	39.7	6.1
6~10	per farm	3670.2	3302.6	3195.0	740.1	2292.8	35.23	126.9	107.6	332.4	
	per head	466.9	420.2	406.5	94.2	291.7	4.48	16.14	13.7	42.3	10.0
11~30	per farm	6476.1	5838.8	5644.6	1090.4	4280.8	80.64	192.72	194.2	556.6	
	per head	359.4	324.0	313.2	60.5	237.5	4.48	10.69	10.8	30.9	9.4
31~100	per farm	25926.3	22686.2	22131.7	4414.0	16728.3	409.98	579.41	554.6	2830.1	
	per head	505.9	442.7	431.8	86.1	326.4	8	11.3	10.8	55.2	12.3
101~500	per farm	93842.8	81923.5	77676.7	16002.3	56584.8	2722.11	2367.51	4246.8	9197.2	
	per head	465.5	406.4	385.3	79.4	280.7	13.5	11.75	21.1	45.6	10.9
>= 500	per farm	1174280.6	1026641.7	928825.1	116004.9	751214.3	48468.1	13137.8	97816.6	99171.1	
	per head	475.3	415.5	375.9	47.0	304.0	19.62	5.32	39.6	40.1	9.2

Table 4. Efficiency and Scale Estimation Results

Item		Efficiency	Scale elasticity
Distance function: All farms	2558	0.236	0.192
Distance function: by class size			
Less than 5 heads	1462	0.301	0.254
6-10 heads	356	0.449	0.420
11-30 heads	428	0.527	0.205
31-100 heads	220	0.607	0.506
101-500 heads	76	0.888	-0.042
Greater than 500 heads	16	0.994	0.013
	2558		
Hebei	141	0.524	0.433
Liaoning	213	0.457	0.303
Heilongjiang	50	0.840	0.051
Jiangsu	181	0.872	0.145
Anhui	151	0.878	0.194
Jiangxi	242	0.559	0.320
Shandong	79	0.686	-0.120
Henan	330	0.473	0.168
Hubei	40	0.840	0.362
Hunan	284	0.646	0.307
Guangxizhuangzu	288	0.562	0.252
Sichuan	401	0.405	0.160
Yunnan	118	0.808	0.070
Shaanxi	40	0.745	-0.217
	2558		

Table 5. Shares of Major Expense Categories by Size of Hog Operation

Item	All farms	<=5	6~10	11~30	31~100	101~500	>= 500
Hired labor	2.6	1.9	0.9	1.1	1.6	2.9	3.1
Purchasing animals	11.6	17.1	18.9	15.3	17.0	16.9	7.5
Feed	73.2	69.9	70.5	74.3	74.1	70.1	74.2
Other expenses	12.6	11.1	9.8	9.3	7.3	10.1	15.2
Total	100	100	100.1	100	100	100	100

Table 6. Share of Feed Cost by Size of Hog Operation

Item	All farms	<=5	6~10	11~30	31~100	101~500	>= 500
Fine feed	67.81	66.69	64.01	65.09	78.08	78.45	65.09
Cost of lees and bean dregs	24.90	13.92	20.85	22.90	15.06	10.80	22.90
Additivies	3.84	1.68	1.19	1.91	3.68	5.73	1.91
Succulence and coarse fodder	3.45	17.71	13.95	10.10	3.18	5.02	10.10
Other feed (leftovers)	0.62	0.72	1.74	1.42	1.25	0.85	1.42
Total	100	100	100	100	100	100	100

Table 7. Composition of Fine Feed by Size of Hog Operation

Item	All farms	<=5	6~10	11~30	31~100	101~500	>= 500
Raw grains	43.41	66.24	62.77	56.72	49.40	56.92	33.03
Purchased mixed feed	33.64	10.12	14.33	15.86	20.13	12.37	50.12
Wheat bran and broken rice	14.05	22.22	18.01	22.17	20.77	20.45	8.54
Oil cakes	8.90	1.42	4.89	5.25	9.70	10.26	8.31
Total fine feed	100.00	100.00	100.00	100.00	100.00	100.00	100.00