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Feed Conversion Ratio, Profitability and Farm Size in China's Pig Industry

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Abstract.

The paper is based on a survey we have designed to document the feeding practices in China's hog industry. We estimate the live weight FCR to be 2.99, in which commercialized farms (>500 head/year) are the most efficient with FCR of 2.73, followed by specialized farms (50-499 head/year) of 2.90, and the main inefficiency in feeding comes from backyard (<10 head/year) and small household farms (10-49 head/year), with FCRs to be 3.03 and 3.99.The FCRs and the farm size have a clear inverse relationship, but the correlation between profit and farm size is not significant, suggesting further structural change toward larger operations will be slow. In addition, managerial variables have significant impacts on FCRs: participating training in disease control and using compound feed in the grower/finisher phase can lower the FCR significantly.

Keywords: Feed conversion ratio, farm size

JEL codes: C83, Q12, L110

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1 Introduction

The pig industry in China, like much of the agricultural sector, has changed drastically in recent years. Between 2001 and 2010, the total number of hog farms fell by 53%, and the average size of farm increased from 5.3 to 15.1 market hog per year (MOA, 2002-2011). In the meantime, the proportion of total market hog produced from small farms (<50 head/year, as a percentage of the total Chinese production) fell from 77% to 36%. This change was coupled with an increase in production by commercialized hog operations (>500 head/year) from 8% to 35%. With rapid consolidation throughout the industry comes increased pressure for farms to become more efficient to survive in the industry.

The feed conversion ratio (FCR) has long been recognized as an important indicator of profitability (Edwards et al. 1989). It is a critical measurement, providing essential information on the cost of production. The financial rewards of improved FCR can be significant given that feed cost consists of two thirds of the total cost. Despite the rapid adjustment in the pig industry, little is known about the recent development in FCR. Improvements in the FCR had been documented (Zhang 1998; Wang et al. 1999; Li 2002; DPPC 2008) (Wang et al. 1999), but the results were outdated. And farmers themselves do not have a clear idea on their own FCR either. Only 259 (63%) of 408 producers who were asked the FCR for finisher pigs provided a response during our survey in 2013.

Pork producers and policy makers require accurate estimates of FCR and better understanding of factors that can influence it. Our study is designed to fill in this gap between the rapid change of the pig industry and the lack of documentation for the development. To our knowledge, this is by far the only nationwide survey to study the pig industry. The goal of the paper is to examine FCRs during the grower/finisher phase in China, explore the relationship between FCR, profitability and farm sizes, and identify management and other variables that are associated with FCRs.

To meet these goals, our paper is organized as follows. In section 2, we introduce the design of our survey and present descriptive statistics of FCRs and household characteristics. In section 3, we estimate correlations between FCR, profitability, farm size and managerial variables. In section 4, limitations of the study are discussed. Section 5 concludes the paper.

2 Data

2.1 Sampling and the survey

Our survey is a unique study designed specifically to document the current situation of Chinese pig industry, organized by the Center for Chinese Agricultural Policy, in collaboration with the U.S. Grains Council and Asian Agribusiness Consulting. Key information included details in feeding, inventories history, marketing practices, health and disease control, technical assistance, waste management and farm investments. The survey is a longitudinal study that was carried out first in July 2011 and again in July 2013 following a multi-phase clustering sampling strategy. Five provinces, *Sichuan, Hubei, Shandong, Guangdong,* and *Jilin*, were selected on the basis of their geographical location, each representing one main agricultural region.[2] The geographical locations of these provinces are shown in Figure 1.

{Insert Figure 1 here}

Three counties were selected from each one of the five provinces. Within each province, all counties were first ranked by the annual market hogs and then divided into three strata, and we select one county from each stratum. We also made sure that one selected county is near the biggest city in the province, one near a prefecture-level city, and one in a more remote area. Then three townships were chosen from each county, based on the same consideration (concentration of hog production and geographic location). Then within each township, we

[2] Provinces included in each agricultural region were: 1) Southwest: *Sichuan*, Chongqing, Guizhou, Yunnan, Xizang; 2) Central and northwest: *Hubei*, Hunan, Henan, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang; 3) East and north: *Shandong*, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia; 4) South: *Guangdong*, Guangxi, Hainan; 5) Northeast: Liaoning, *Jilin*, Heilongjiang.

randomly select three villages while accounting for geographic location, one near the township city and two more remote. Finally we choose at least three hog producers and three non-hog producers from each village. Since most hog farms are small operations, we tried to pick at least one large producer in each village to ensure the representativeness of the selection. If the village has no large farms, we pick two medium-sized farms and one small farm. The sample selection process will over-represent large farms, and thus we construct sampling weights to correct for the herd size distribution.[3] In total, there are 398 valid households in 2010 and 408 from 2012 available for our analyses.

The production structures are expressed in farm sizes. In the Chinese context, there are three characteristic farm types: backyard producers, specialized farms, and commercial farms. Due to different approaches, these three types are defined differently among authors (Jörin & Rieder 2006). Chinese official statistics define small farms as those producing <30 head/year (NDRC 2013) or <50 head/year (MOA 2013). For our purpose, we define four types of pig farms: backyard farms (1-9 head/year), small household farms (10-49 head/year), specialized farms (50-499 head/year), and commercial farms (>500 head/year). We define producers with 1-9 head/year to be a separate group because raising only a few hogs in the backyard is a sideline work which requires the household to have other sources of income besides raising hogs, but larger farms can potentially be the sole source of income and require specialized management and often times with hired workers.

2.2 Feed conversion ratio (FCR)

We define FCR as the kg feed per kg live weight gain. This measure is criticized for ignoring the differences in dressing percentage, and thus it could be misleading if higher fiber diets are used (Patience 2013). However, the Chinese consume all parts of a pig including head,

[3] We have also conducted interviews with local cadres on the village, township and county levels, collecting data of herd size distributions on each level of administration. And for herd size distribution on the provincial and national levels, we use estimates from *China animal industry yearbook* (MOA 2013). Details see Appendix: Constructing weights.

feet, bones and offal as food, the FCR based on live weight thus is close to represent the real relationship between feed usage and output. We use the formula below:

$$FCR = \frac{X_{q_1 - q_0}}{q_1 - q_0} \tag{1}$$

where $X_{q_1-q_0}$ is the amount of total hog feed from weaning to market; q_0 is the starting weight; q_1 is the market live weight. If the household has self-bred piglets, we use the average weight at weaning, 7 kg, as the starting weight,[4] otherwise the purchase weight.

For our purpose to investigate the feeding practice, we divide the growing phase of hogs into four distinctive phases: 7-15 kg, 15-30 kg, 30-60 kg, and above 60 kg in the questionnaire. [5] In each phase, length of the feeding period and formulation of diets were documented. We recorded feed ingredients usage of the most recently market cohort of hogs to improve recall accuracy (farmers are far less likely to recall feeding practices of past cohorts). Multiplying the daily feed ration by the number of days spent in each growth phase and summing across phases yields the total amount of feed.

Feed ingredients are divided into four categories: commercial feed, energy feed, protein meal and pre-mix. Commercial feed include compound and concentrate feed directly bought from the market; Energy feed include corn, bran, green feed, food waste and other types of grains.; Protein meal include soybean meal (SBM), rapeseed meal (RSM), cottonseed meal (CSM), distillers dried grains with soluble (DDGS) and fish meal. Pre-mix feed include vitamin, minerals and other types of feed additives. Some diets contain too much water that can cause

[4] The weaning period is usually 21-35 days when piglets usually reach 7-8 kg (Li 2002).

[5] In the second round of survey in 2013, we divided the fourth feeding phase into two periods: 60-90 kg and above 90 kg. It is designed to capture the over-feeding behavior of hog farmers. To make feeding results comparable to the 2010 survey, we combine the last two feeding periods in 2013 survey together.

misleading results, and we thus multiply green feed by 0.2, food waste by 0.2, and DDGS by 0.3 to convert them into dry matter.[6]

{Insert Table 1 here}

{Insert Figure 2 here}

Table 1 further summarizes the FCRs by farm scales. The national mean FCR is 2.99, with the commercial farms being the most feed efficient with a FCR of 2.73. As farm size goes up, the FCRs, length of feeding period, amount of total feed (including commercial feed and other types of feed), starting and selling weight all declines. Smaller farms were more likely to purchase piglets which are usually heavier than the self-bred weaners. As shown in the Lowess curve (Figure 2), FCR declines as farm size increases. Larger farms are more efficient at converting feed to meat than smaller ones.

{Insert Figure 3 here}

Figure 3 compares FCR of major pork producing countries with China. The FCR of the backyard farms is 3.99, lower than Vietnam and Ukraine but considerably higher than the rest of the world. The small-household farms with FCR of 3.03 have reached the world average of feed efficiency, between Russia and Great Britain. Farms producing >50 head/year are quite efficient. The FCR of specialized farms is 2.90, slightly higher than the USA, and FCR of commercialized farms 2.73, just behind Brazil. In general, China's feed efficiency is quite high and the major inefficiency comes from the backyard farms.

2.3 Descriptive statistics

{Insert Table 2 here}

Table 2 summarizes the mean values for household characteristics by farm size in 2012. Farms with different herd sizes have distinctive features. Smaller farms on average have smaller

[6] Wang et al. (1999) used protein and fat contents to convert DDGS to corn equivalence and the conversion ratio is between 0.2 and 0.3, quite close to what we use here.

family, lower education, older farmers and longer years of experience in the hog industry. They also tend to have lower consumption per capita, lower agricultural productive assets, and are more likely to engage in off-farm employments while raising pigs. Besides, smaller farms have much bigger cultivated land area, more likely to rent in and less likely to rent out land, and are more financially constrained. The results are not surprising given that small hog farms do not entirely rely on selling hogs for a living, and thus have to diversity their employments between agricultural and off-farm jobs. As farm size increases, pig farms become more specialized.

{Insert Table 3 here}

Achieving superior feed efficiency requires attention to all aspects of pork production, including proper management, diet formulation, selecting genetics, and disease control, and all those factors are different with regard to farm size. Besides, different feeding phases have distinctive FCRs as well.

a) Management

Table 3 shows that smaller farms make far less durable investments, such as automatic feeder, than larger farms, and thus they are more vulnerable to feed loss, temperature and environmental changes that can reduce feed efficiency.[7] The choice of the feed will also affect feed efficiency. Smaller farms tend to purchase from local general stores of whatever commercial feed are available, while large-scale farms (>=500 head/year) are more likely to travel further to obtain feed from specialized feed companies whose feed are possibly of higher quality.[8] Besides feed quality, increasing the energy concentration in the diet can also improve the feed efficiency. Large commercial farms usually use compound feeds which have the highest

[7] A study carried out by a livestock consulting firm in Beijing showed that by feeding hogs from a trough, rather than by putting feed directly on the ground, increased feed to meat conversion ratio by 0.5 (CCAP & Bunge China Research 2011).

[8] China's Ministry of Agriculture has sought to test commercial feed to determine whether they are comprised of the ingredients listed on their labels (and for illegal additives) and has reported (verbally) that protein levels below the amount on the label are not uncommon for commercial feed, and smaller farmers may be disproportionately using these inferior feeds (MOA 2013).

energy concentration, and small or backyard farms mainly use other types of feeds and mix them with additives.

{Insert Figure 4 here}

Superior FCRs were linked to the use of compound feed which can satisfy all the nutritional needs. Pigs fed with compound feed grow faster and takes shorter days to reach the market weight. Figure 4 shows the diet usage by feeding phase. It is clear that the percentage of farms using compound feed declines as farm size goes down in every feeding phase, while the use of concentrate and other feeds go up.

Table 3 compares FCRs by managerial variables. Farms with favorable managerial traits have higher feed efficiency, such as having automatic feeder, attending training in disease control and using compound feed in grower/finisher phase. Other traits, such as having farrowing facility, raising sows, buying feeding from specialized company, also are associated with lower average FCR but not statistically significantly different from the other group. Empirical analyses are needed to further investigate the correlations between FCR and managerial factors, controlling for other variables.

b) Genetics

Genetic selection that focused on increased growth and reduced fat is an important factor that contributed to the improved feed efficiency (Honeyman 1996). In 2012, 50% of the participants raise non-hybrid pigs, being either some sort of the Chinese varieties, imported varieties such as Duroc, Landrace, Large white, Yorkshire or others) ; 28% of the participants raise two-way cross; 14% raise three-way cross; and the rest 8% didn't know.[9]

[9] The cross breeds could either be the mix of all foreign varieties (*wai san yuan*), or some foreign varieties with at least one Chinese local variety (*nei san yuan*).

Table 3 indicates that the three-way cross are the most efficiency, with mean FCR to be 3.53. Non-hybrid and two-way cross are less efficient, and those who don't know the breed of their pigs are the least efficient.

c) Feeding phases

{Insert Table 4 here}

FCRs not only differ by farm size, but also by feeding phases. On the one hand, feeding is more efficient in earlier phases than in later ones since heavier hogs require more feed due to higher metabolic requirements for maintenance, and this is true regardless of farm size. On the other hand, larger farms had shorter feeding days and higher daily gain in body weight comparing to smaller farms, particularly in the finishing phase (>60 kg).

3 Empirical evidence

3.1 FCR, farm size and managerial variables

{Insert Table 5a, 5b here}

Panel regressions in Table 4a and 4b provide further evidence for the inverse relationship between FCR and farm sizes. Table 4a uses farm scales as regressors and Table 4b uses the number of annual market hogs and its squared term. Columns 1 and 2 present original results and columns 3 and 4 the weighted results. As expected, FCR declines as farm size goes up. Table 4b also shows that as farm sizes go up, the decrease in FCR becomes slower, and after about 7400 head/year the FCR will pick up again. It is not surprising because FCR cannot decline indefinitely with farm size. As the farm gets more crowded with pigs, it puts more pressure on management, technology and disease control, and thus the feed efficiency will go up again after an optimal level of farm size. There is evidence that an inverted U-shaped relationship between technical efficiency and farm size exists for dairy farms (Hansson 2008) and manufacturing firms (Aggrey et al. 2010). For pig farms, our results suggest there is also a nonlinear relationship between technical efficiency and farm size.

Managerial variables turn out to have significant impacts on FCR. Farms can achieve superior FCR by attending trainings in disease control and by using compound feed in grower/finisher phase, and those results are robust. Having automatic feeder have some impact on FCR, but the result is not significant after controlling for the province and breed dummies.

3.2 FCR, profitability and farm size

No matter how important the FCR is, the ultimate goal of a farm is to maximize profit or to minimize losses when the markets are down. Maximizing feed efficiency is not equivalent to maximizing profit. As farm sizes go down, they become less technically efficient, but they may not be less economically efficient. And if that's true, further structural change toward larger operations will be slow. Small farms have to consider the tradeoff between technically less efficient production versus the costs required to improve efficiency and the benefits from such improvements (Heady & Dillon 1961). The costs to improve facilities can be sizeable, and much of it is long-term investments that can be risky in a highly volatile market. In our survey, about 12% of the pig farmers in 2010 had quitted by 2012, among which 50% were backyard farms. Given that smaller farms are also older and less educated, they may prefer to keep a smaller capital footprint to negotiate the volatility in the market. Farmers can also easily improve FCR by using compound feed, but the increased feed cost may not improve profit.

{Insert Table 6 here}

The main inputs of hog production are feedstuffs, labor and piglets, whose prices determine the profitability of an operation. Table 6 shows the situation of the cost and profit per hog in 2012.

The gross income is the summation of monthly income of the year, and the selling price per kg of live weight is equal to the gross income divided by the average market weight. Production costs included feed costs (58%), labor cost (15%) and other costs (27%, mainly the expense on purchasing the piglet).

Feed costs included the cost of feed purchased off the farm as well as the value of feed produced on the farm. Our surveys have collected prices of the commercial feeds (compound, concentrate and premix feed), and farm produced feed was valued by using the six-month average of the local prices prior to the last market cohort (MOA 2013) .

Labor costs included wages paid to hired labor, as well as the value of unpaid family labor. Unpaid labor was valued at the prevailing wage for livestock labor in the selected provinces (NDRC 2013).

The net profit in Table 6 is the economic profit per hog, calculated as the reported cash profit per hog in the questionnaire subtracted by the value of unpaid family labor. The other cost is calculated by subtracting gross income by the sum of feed cost, labor cost and economic profit, which mainly includes the cost of purchasing piglet and other operating costs which included items such as feed processing, water, fuel, medical, death damage, technical support, tools and materials, maintenance, and miscellaneous expenses.

As displayed in Table 6, smaller farmers incur lower expense on feed than bigger farms, and their selling price is also higher. However, they also have much higher labor costs and other costs, and the combined result is that smaller farms have a lower economic profit (higher loss) than bigger farms.

{Insert Table 7a, 7b here}

Table 7a and 7b further investigates the relationship between FCR, profit and farm size in 2012. The dependent variable is FCR for columns (1) to (4), and profit for columns (5) to (8). Although the inverse relationship between FCR and farm size is clear, the correlation between profit and farm size are less profound. As farms become larger they are more profitable, but the coefficients are less significant than in the FCR regressions. The optimal size to reach the maximum feed efficiency 7606 head/year (table 5b), while the optimal size to obtain the maximum economic profit is 7201 head/year (table 7b). In other words, the difference in profit is

not as significant as difference in feed efficiency, and thus further structural change toward larger operations will be slow.

4 Discussion

Although our results found statistically significant associations between herd size, management practices and FCRs, this does not necessarily mean that these factors were the cause of differences in FCRs. The relationship found in the paper could be beneficial to producers and researchers for further investigation of the feed efficiency. However, we should be aware of some of the limitations of the study.

One limitation of the study is that not all relevant information with FCR in the grower/finisher-production phase was collected. We made assumptions on the starting weights to be 7 kg if the piglets were self-bred, but in reality the starting weights could be vastly different between farms. The weaning weight of 7 kg is actually the optimal weight if the farm has the proper management skills, but for many small farms the length of weaning can take up to 60 days when piglets reach 15 kg (CCTV 2013). Therefore, our results may have underestimated the FCR small farms.

Second, the environmental factors can also affect FCRs, but our study was not able to collect the related data. The barn temperature is an important factor to influence FCR. If the temperature is too low, feed intake will increase (NRC 2012). If the temperature is too high, the pigs will have lower feed intake and also slower growth (Renaudeau et al. 2012).

Third, no information on the form of the feed was collected. Reducing particle size or pelleting the diet will affect digestibility of nutrients (Owsley 1981). For example, when the amount of corn used in feeding was recorded, it did specify whether it’s the corn cob or the kernels which will have different implications for FCR.

Another limitation of this study is that the situation of the culled breeding stock were not collected, which will affect the average FCR and profit of the farm. The selling prices for culled breeding stock are usually lower than those for market hogs, and low values for pigs weaned per sow cause a higher proportion of the total pork sold to come from culled breeding stock and a lower proportion to come from market hogs (Edwards et al. 1989). For farms that have sold the culled breeding stock, the actual FCR and profit should be the weighted average of income form hogs and culled breeding stock.

5 Conclusion

Although the FCR is considered to play a central role in determining a farm's profitability, there is a lack of research in what the actual situation was in China for the past decade. Even for pig farmers themselves, only 63% of respondents had a rough idea on what their FCR is. As the industry becomes more consolidated, more producers will need to pay closer attention to FCR and to factors that influence it on their operations.

The paper provides a snapshot of feeding practices in rural China for pig producers. The detailed estimates of hog feeding practices, including the types of feed and estimates of FCR, drawn from a multi-stage stratified sample of producers across regions, scale and proximity to market, are unique. We estimated the national live weight FCR to be 2.99. Commercialized farms (>500 head/year) had significantly higher feed efficiency than smaller operations, and with the mean FCR of 2.73 they are among the most efficient pig operations in the world (typically 2.7-3, see Figure 3). The main inefficiency comes from the backyard farms (<10 head/year), with the mean FCR to be 3.99.

Achieving superior feed efficiency requires attention to all aspects of pork production, including proper management, diet formulation, selecting genetics, and disease control. The empirical evidence indicates that superior FCRs were linked to larger farm size, younger farmers, shorter feeding days, the use of compound feed and attending trainings in disease control. Education has a significant impact on profit, but not on FCR. Besides, having access to the credit

market, the selection of superior pig breeds can also improve FCR. More research will be needed to examine the relationship between environmental variables (temperature, pig density) and the FCR on pig farms in China.

Findings in this paper are useful to guiding policy makers to determine what policies would be appropriate to improve the FCR. The policy intervention should target younger farmers involved in pig production, increase access to credit services, and provide training in disease control through extension services. Besides, trainings to improve farmers' ability in management are also important.

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Figures and tables

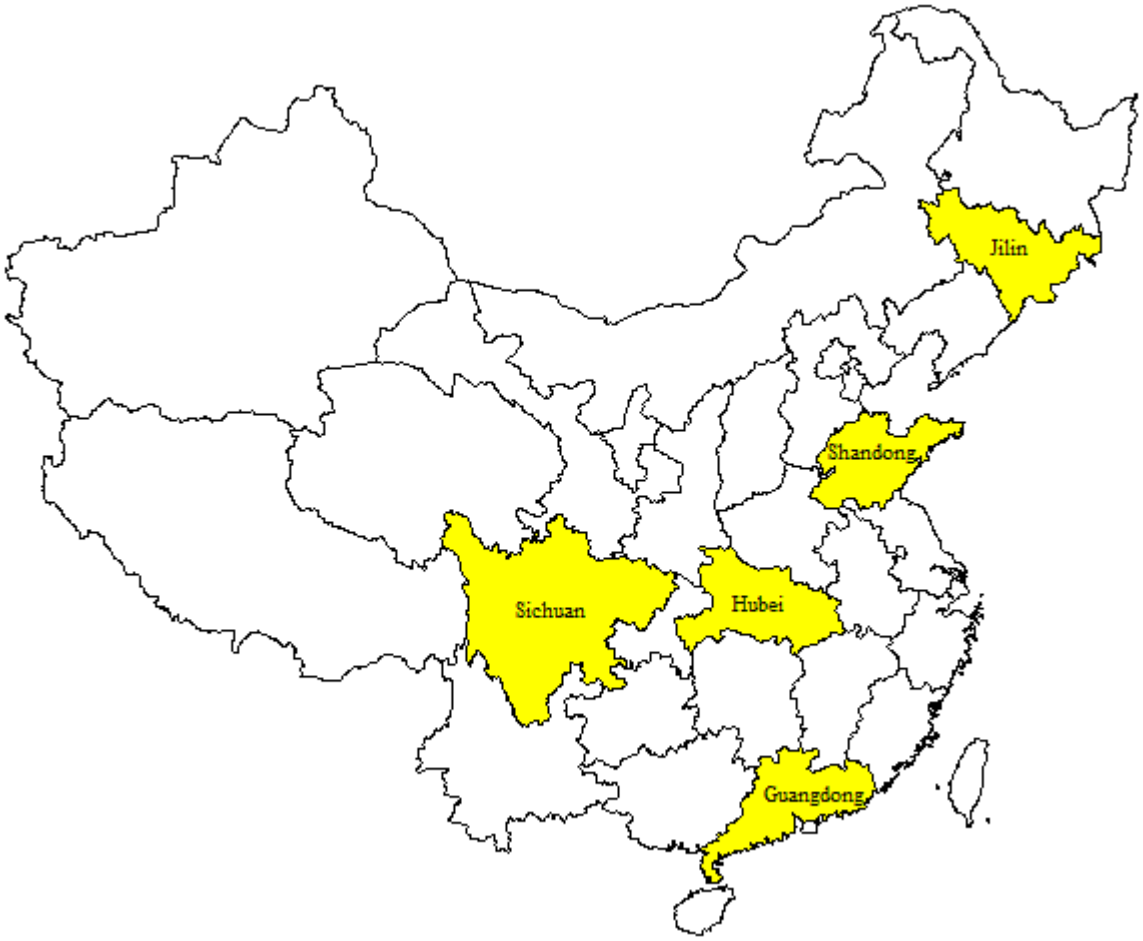

Figure 1. The Five Participating Provinces

Source: Author's survey.

Note: The five participating provinces are Jilin, Shandong, Sichuan, Hubei and Guangdong.

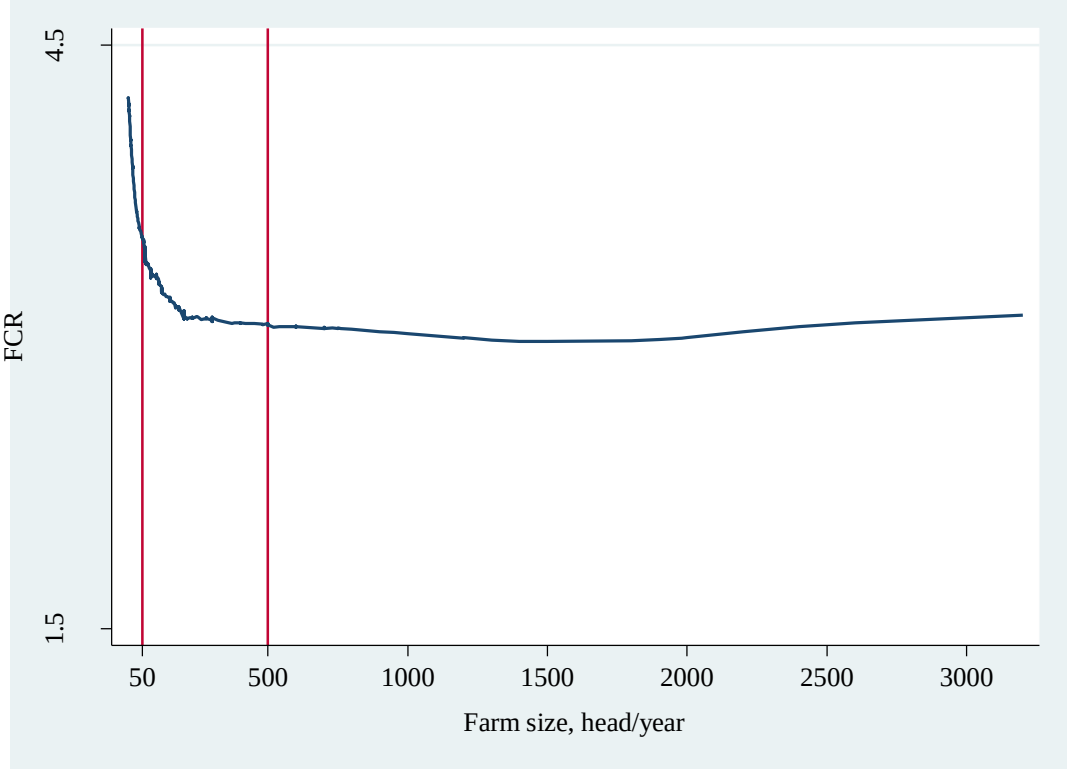

Figure 2. Lowess Curve of FCR and Farm Size in 2012

Source: Author's survey.

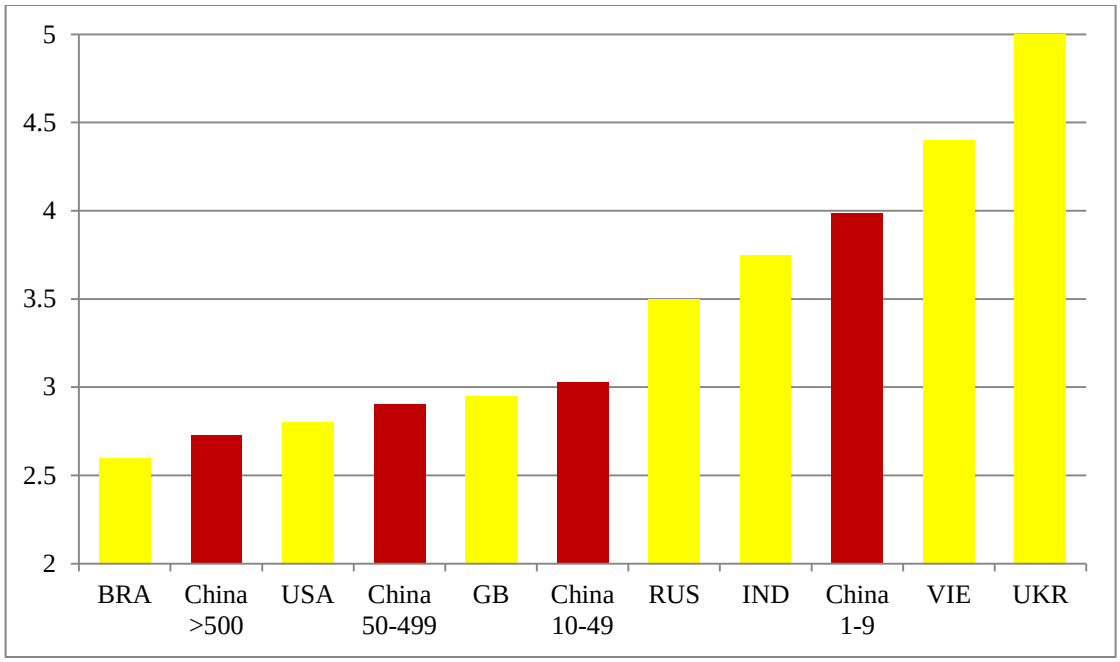

Figure 3. FCR of Major Pork Producing Countries in 2012

Source: Author's survey, Agricultural Market Information System (2014), Lankveld (2013), Dzung (2012), Grey (2012)

Notes:

a. FCRs from countries other than China are on the basis of live weight for the finishing herds.

b. Countries listed from left to right are: Brazil, China (>500 head/year), USA, China (50-499 head/year), Great Britain, China (10-49 head/year), Russia, India, Vietnam, China (1-9 head/year), and Ukraine.

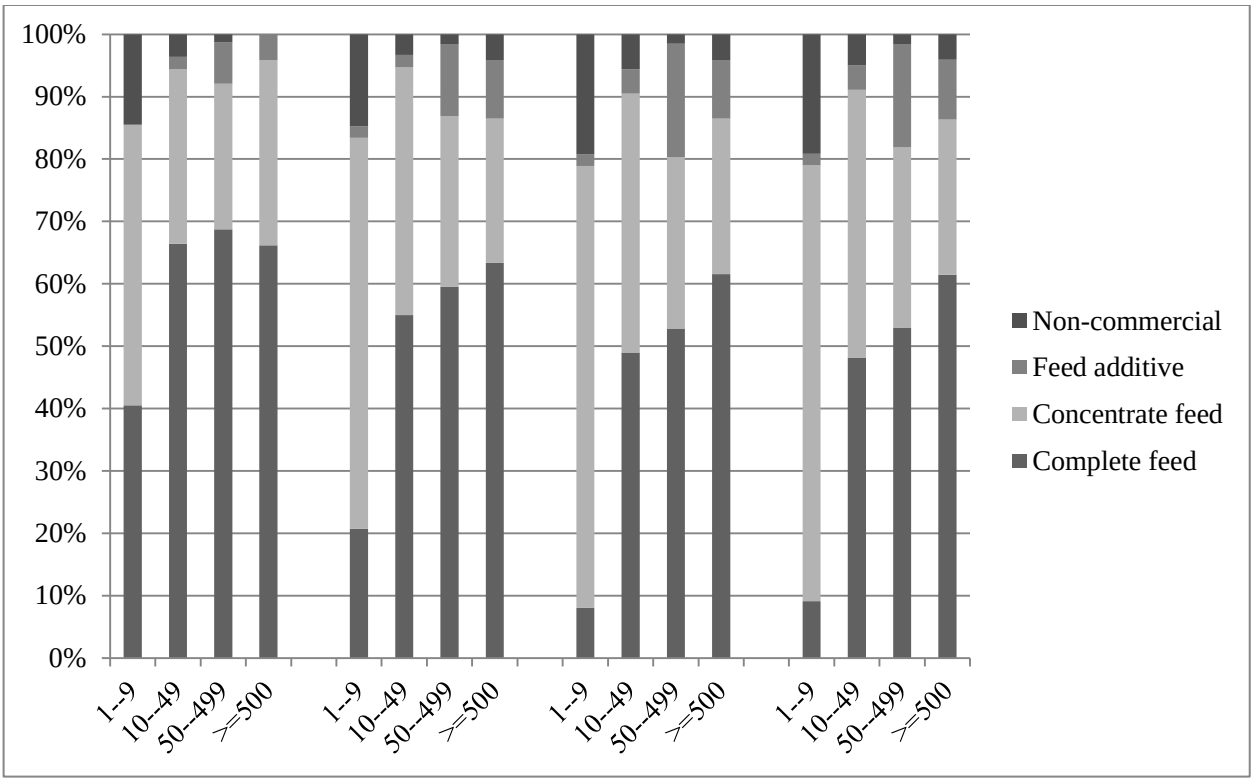

Figure 4. Types of Feed Used in Each Feeding Period by Farm Size

Source: Author's survey.

Table. Summary statistics of FCR in 2012

	Farm size (head/year)				
	1--9	10--49	50--499	>=500	Mean
FCR	3.99	3.03	2.90	2.73	2.99
Length of feeding period (days)	197.0	162.0	159.1	153.6	184.6
Total feed(kg) [a]	527.6	383.0	372.3	331.5	476.5
Starting weight (kg) [b]	7.6	7.0	7.1	7.0	7.4
Selling weight (kg) [c]	118.9	113.9	118.8	116.9	117.6

Source: Author's survey.

Notes:

a. FCR are weighted by sampling weights calculated based on shares of hogs of each sscale, and all other variables are weighted by household sampling weights.

b. "Total feed" is the total amount of commercial feed, energy feed, protein meal and non-commercial feed (dry matter) for pigs from weaning to finish.

c. The starting weight is the weighted average of purchased and self-bred piglets. We use the actual weight at purchase for purchased piglets and 7 kg for the self-bred piglets.

d. The finishing weight is the producer's average for the last cohort of hogs slaughtered.

Table. Summary statistics of households in 2012

	Farm size (head/year)			
	1--9	10--49	50--499	>=500
Household characteristics				
Household size	3.8	4.4	4.6	4.5
Education	6.0	6.6	7.8	8.3
Age	52.3	49.5	46.9	45.7
Years engaged in raising pigs	19.0	12.9	11.4	10.2
Ratio of family members raise pigs and work off-farm	9.3	12.4	8.5	6.5
Land cultivated (mu)	24.5	12.0	15.2	15.3
Durable consumption (yuan)	15636	31713	54404	174132
Agricultural productive assets (yuan)	1345	1097	1700	2531
Farm characteristics				
Bank credit availability (%)	0	1.9	6.9	18.1
Durable investments in last 3 years (yuan)	2766	6727	19370	182190
Have automatic feeder (%)	5.5	14.1	33.2	51.9
Have farrowing facility (%)	34.7	61.5	69.3	86.7
Attended training in disease control (%)	11.0	30.8	66.9	89.9
No. of market hogs (head/year)	4.4	25.1	167.2	1026.9
Raise sows (%)	68.2	95.1	94.0	95.9
No. of sow inventory (head/year)	1.2	5.1	18.6	83.6
Purchase feed from specialized feed company (%)	24.3	51.0	73.2	78.0
Use compound feed in grower/finisher phase (%)	10.4	50.2	59.5	57.4

Source: Author's survey.

Note: *Education and age refer to household members that work on the pig farm.

Table 3. FCR by managerial variables, breed and province in 2012

Categories	FCR	
Managerial variables	Yes	No
Have automatic feeder	3.34***	4.51
Have farrowing facility	4.11	4.62
Raise sows	4.34	4.57
Attended training in disease control	3.26***	4.70
Buy feed from specialized company	3.90	4.67
Use compound feed in grower/finisher phase	3.22***	4.78
Access to credit market	3.13***	4.41
Breed		
Non-hybrid	4.01	
Two-way cross	4.91	
Three-way cross	3.53	
Don't know	4.99	
Province		
Jilin	4.29	
Shandong	3.62	
Hubei	3.91	
Guangdong	3.29	
Sichuan	4.84	

Source: Author's survey.

Note: *** denotes the average is significantly different from the other group at the 1% level.

Table. FCR, Length of Feeding Period and Average Daily Gain by Phase

	1--9	10--49	50--499	>=500
FCR				
7-15 kg	1.81	1.62	1.42	1.23
15-30 kg	2.98	2.60	2.52	2.31
30-60 kg	3.20	2.79	2.67	2.72
>60 kg	4.51	3.11	3.00	2.70
Length of feeding period (days)				
7-15 kg	19	19	19	17
15-30 kg	32	31	31	28
30-60 kg	46	41	39	41
>60 kg	100	71	71	67
Average daily gain in body weight (kg/day)				
7-15 kg	0.40	0.44	0.45	0.48
15-30 kg	0.48	0.50	0.51	0.55
30-60 kg	0.67	0.76	0.79	0.75
>60 kg	0.66	0.81	0.87	0.88

Source: Author's survey.

Note: Estimates of FCRs are weighted by sampling weights calculated based on shares of hogs produced by farms of each scale, and all other variables are weighted by household sampling weights.

Table 5a. FCR and farm scales (pooled panel)

	Dependent variable: FCR					
	Original			Weighted		
	(1)	(2)	(3)	(4)	(5)	(6)
10--49 head/year	-0.349	-0.295	-0.279	-1.400***	-0.782**	-0.755**
	(0.255)	(0.222)	(0.222)	(0.388)	(0.328)	(0.325)
50--499 head/year	-0.727***	-0.504**	-0.474**	-1.688***	-1.012***	-0.973***
	(0.241)	(0.210)	(0.209)	(0.381)	(0.366)	(0.353)
>=500 head/year	-0.853***	-0.482**	-0.424*	-1.770***	-1.302***	-1.184***
	(0.254)	(0.229)	(0.228)	(0.413)	(0.430)	(0.417)
Education		0.004	0.005		0.101	0.089
		(0.019)	(0.019)		(0.080)	(0.065)
Age		0.007	0.007		0.060**	0.058*
		(0.006)	(0.006)		(0.029)	(0.031)
Feeding days		0.025***	0.025***		0.019***	0.020***
		(0.002)	(0.002)		(0.006)	(0.006)
Included province dummies	No	Yes	Yes	No	Yes	Yes
Included breed dummies	No	No	Yes	No	No	Yes

Table 5b. FCR and farm size (pooled panel)

	Original			Weighted		
	(7)	(8)	(9)	(10)	(11)	(12)
Farm Size/1000	-0.330***	-0.136*	-0.105	-3.446***	-2.088***	-1.871***
	(0.075)	(0.070)	(0.069)	(0.937)	(0.740)	(0.653)
(Farm Size/1000)^2	0.026***	0.011**	0.009*	0.233***	0.136***	0.123***
	(0.006)	(0.005)	(0.005)	(0.069)	(0.051)	(0.045)
Education		0.000	0.002		0.098	0.087
		(0.020)	(0.019)		(0.082)	(0.066)
Age		0.009	0.009		0.063**	0.061*
		(0.006)	(0.006)		(0.030)	(0.032)
Feeding days		0.025***	0.025***		0.021***	0.022***
		(0.002)	(0.002)		(0.006)	(0.005)
Included province dummies	No	Yes	Yes	No	Yes	Yes
Included breed dummies	No	No	Yes	No	No	Yes

Source: Author's survey.

Notes: Robust standard errors clustered by household in brackets: *** p<0.01, ** p<0.05, * p<0.1. These regressions also include a year dummy, a constant term, and individual fixed effects.

Table. Income, cost and profit per hog in 2012

Variable	1--9	10--49	50--499	>=500
Gross income (yuan)	1712	1384	1436	1361
Selling price (yuan/kg)	13.9	12.3	12.1	11.6
Selling weight (kg)	122	113	119	121
Total cost (yuan)	1960	1475	1533	1351
Feed cost (yuan)	1141	1026	1142	1039
Complete feed (yuan)	92	475	633	677
Concentrate feed (yuan)	315	197	141	83
Premix feed (yuan)	7	3	16	14
Other feed (yuan) [a]	726	351	352	265
Labor cost (yuan)	326	141	107	45
Value of unpaid family labor (yuan)	326	116	64	24
Days [b]	6.7	2.5	1.3	0.5
Wage (yuan/day)	48	45	47	48
Hired labor cost (yuan)	0	25	43	21
Days [b]		0.44	0.52	0.29
Wage (yuan/day) [c]		58.3	82.7	71.9
Other costs (yuan) [d]	493	307	284	267
Net profit (yuan)	-248	-90	-97	10

Source: Author's survey, NDRC (2013).

Notes:

a. “Other feed” includes corn, bran, DDGS, protein meal, food waste, green feed and other energy feed.

b. “Days” are standardized 8-hour days.

c. “Wage” of family labor is the prevailing wage per man-day by province obtained from NDRC (2013).

d. “Other costs” include cost of piglets and other operating costs (feed processing, water, fuel, medical, death damage, technical support, tools and materials, maintenance, and other indirect fees such as depreciation of fixed assets, insurance, management, finance, and sales). From estimates in NDRC (2013), the average of all other fees for the five participating provinces is 582 yuan/head, in which 519 (90%) is the cost of piglets.

Table 7a. Profit and farm scales (pooled panel)

	Dependent variable: profit per hog					
	Original			Weighted		
	(1)	(2)	(3)	(4)	(5)	(6)
10--49 head/year	453.28***	432.02***	420.32***	299.61***	179.08	176.60*
	(117.29)	(113.66)	(105.93)	(107.21)	(109.83)	(103.55)
50--499 head/year	497.85***	494.30***	481.98***	343.98***	240.01**	233.16**
	(114.14)	(113.04)	(101.82)	(106.44)	(110.66)	(107.05)
>=500 head/year	510.94***	532.23***	514.80***	383.61***	280.79**	225.96*
	(115.73)	(118.63)	(106.23)	(104.04)	(124.26)	(119.32)
Education		19.23***	19.66***		40.22*	42.86*
		(7.21)	(7.14)		(23.58)	(23.66)
Age		2.09	1.69		3.13	2.37
		(2.27)	(2.12)		(8.01)	(7.82)
Feeding days		0.45	0.10		0.17	-0.62
		(1.41)	(1.29)		(1.67)	(1.52)
Included province dummies	No	Yes	Yes	No	Yes	Yes
Included breed dummies	No	No	Yes	No	No	Yes

Table 7b. Profit and farm size (pooled panel)

	Original			Weighted		
	(7)	(8)	(9)	(10)	(11)	(12)
Farm Size/1000	123.36***	124.83***	114.09***	748.61***	511.17**	439.84**
	(26.37)	(26.22)	(25.18)	(238.10)	(202.54)	(181.95)
(Farm Size/1000)^2	-9.72***	-9.82***	-9.17***	-51.70***	-34.87**	-30.54**
	(1.85)	(1.88)	(1.79)	(16.80)	(13.92)	(12.58)
Education		22.11***	21.86***		40.76*	43.27*
		(7.75)	(7.50)		(23.06)	(23.02)
Age		0.32	0.16		2.54	1.79
		(2.40)	(2.24)		(7.83)	(7.65)
Feeding days		0.18	-0.17		-0.23	-1.03
		(1.50)	(1.36)		(1.58)	(1.44)
Included province dummies	No	Yes	Yes	No	Yes	Yes
Included breed dummies	No	No	Yes	No	No	Yes

Source: Author's survey.

Note: Robust standard errors clustered by household in brackets: *** p<0.01, ** p<0.05, * p<0.1. These regressions also include a year dummy, a constant term, and individual fixed effects.

Table 8. FCR and managerial variables (pooled panel)

	Dependent variable: FCR		
Use compound feed in grower/finisher phase	-0.487	-1.040***	-1.115***
	(0.564)	(0.391)	(0.399)
Have automatic feeder	-0.556**	-0.155	-0.090
	(0.249)	(0.222)	(0.228)
Attended training in disease control	-0.334	-0.115	-0.066
	(0.519)	(0.399)	(0.391)
Borrowed from bank	-1.197***	-0.956**	-0.923**
	(0.424)	(0.443)	(0.454)
Farm Size/1000	-0.666	-1.411*	-1.208*
	(0.696)	(0.787)	(0.677)
(Farm Size/1000)^2	0.049	0.091*	0.079*
	(0.046)	(0.052)	(0.045)
Education	0.102	0.108	0.096*
	(0.079)	(0.067)	(0.055)
Age	0.079**	0.060**	0.059*
	(0.033)	(0.029)	(0.031)
Feeding days	0.021***	0.018***	0.019***
	(0.006)	(0.006)	(0.006)
Province fixed effects	No	Yes	Yes
Breed fixed effects	No	No	Yes

Source: Author's survey.

Note: Robust standard errors clustered by household in brackets: *** p<0.01, ** p<0.05, * p<0.1. These regressions also include a year dummy, a constant term, and individual fixed effects.

Table 9. Summary statistics of variables used in regressions

Variable	Sample	Mean	Std. Dev.	Min	Max
FCR	806	3.27	1.44	0.31	11.84
Net profit (yuan)	789	-39.9	521.3	-6300	1553
Farm size (head/year)	806	323.5	961.1	1	15730
Years of education of main pig farmers	806	7.5	2.5	0	15
Age of main pig farmers	806	46.8	8.8	21	76
Total feeding days	806	151.7	29.8	37	313
Use compound feed in grower/finisher phase	806	0.46	0.50	0	1
Have automatic feeder	806	0.25	0.44	0	1
Attended training in disease control	806	0.51	0.50	0	1
Access to credit market	806	0.07	0.25	0	1
Farm scales in 2012 (head/year):					
1--9	806	0.13	0.33	0	1
10--49	806	0.25	0.43	0	1
50--499	806	0.46	0.50	0	1
>=500	806	0.16	0.37	0	1
Provinces:					
Jilin	806	0.20	0.40	0	1
Shandong	806	0.21	0.41	0	1
Hubei	806	0.21	0.41	0	1
Guangdong	806	0.20	0.40	0	1
Sichuan	806	0.18	0.38	0	1
Breed:					
Non-hybrid	806	0.36	0.48	0	1
Two-way cross	806	0.31	0.46	0	1
Three-way cross	806	0.24	0.43	0	1
Don't know	806	0.09	0.28	0	1

Source: Author's survey.