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An Impact Analysis of Farmer Field Schools on Hog Productivity: Evidence from China

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Abstract: In recent decades, pigs and pork have been the central elements of Chinese agricultural systems, food security, and diet. China's rapid income growth has induced a significant change in food consumption patterns, and hog production has received utmost attention from both, the Chinese government and the public. While the impact of Farmer Field Schools (FFS) on crop cultivation has been widely studied, few studies have examined the impact of FFS on hog production. This study uses data collected from 222 hog farmers in Beijing to examine the impact of FFS on the productivity of hog production, focusing on its three main indicators: feed conversion ratio and the mortality of sows and piglets. We found that farms that participated in FFS programs significantly improved the feed conversion ratio of hog production, particularly in small scale hog farms. On average, FFS reduced the feed conversion ratio for herd sizes of 1000, 500, and 200 by 6.8%, 10.7%, and 14.0%, respectively. We did not find evidence that farms that participated in FFS programs had a significant impact on minimizing the mortality of sows and piglets. This study suggests that the knowledge training model of the FFS program could also work in fields other than crop cultivation. Furthermore, we suggest that more attention could be paid to extension services diffusing knowledge of vaccination and disinfection in hog FFS programs.

Keywords: farmer field schools; hog production; feed conversion ratio; sow mortality; piglet mortality

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1. Introduction

Pork has been a primary meat source for Chinese consumers for thousands of years [1]. Similar to major grain foods (e.g., rice, wheat, and maize), pork has been considered a "national food" [2]. In 2019, hog farmers and companies in China produced 42.6 million metric tons of pork from domestic swine, which accounted for 41.7% of the world's total production. Moreover, China's domestic pork consumption accounted for 44.4% of the world's total consumption [3]. However, recent evidence shows that hog production growth in China has stagnated since 2015 [4]. The ongoing epidemic of the African Swine Fever (ASF) virus has led to widespread deaths of hogs, although official ASF reported cases (by the Ministry of Agriculture and Rural Affairs of China) have significantly declined in China since the beginning of 2020 [5]. In addition, due to the COVID-19 outbreak, China has restricted and/or suspended pork product imports since early 2020 [6]. As the world's largest pork consuming country, ensuring hog production and supply is one of the most important concerns of the Chinese government and its domestic suppliers.

In the past few decades, there have been three main and distinct scales and forms of hog production in China: so-called backyard farms (annual hog production less than 5 heads), which accounted for over 92% of the total hog holders in the 1997 Agricultural Census; specialized household farms (annual hog production from 10 to 500 heads); and large-scale commercial farms (annual hog production from 500 to 50,000 heads) [1,7]. Currently, specialized household farms are the primary holders and producers in China's hog production sector [1,8]. In 2012, over 50% of total hog production in China was produced by specialized household farms [9]. This is because they have significant advantages over backyard farms in hog production [10]. Ensuring these massive and relatively intermediate-scale hog farms produce high-quality and safe pork is a top policy priority for Chinese central and local governments [11].

Farmer Field Schools (FFS) were developed by the Food and Agriculture Organization (FAO) in the late 1980s as an educational tool to facilitate farmers (e.g., paddy rice farmers) in Asian countries understanding complicated systems and adapting their decisions to integrated pest management (IPM) [12–15]. This was largely a response to alleviate negative side effects (i.e., input-intensive crop production) caused by Green Revolution technologies [16–18]. Later, the FFS were promoted as an educational tool in rural development and spread to over 90 countries and regions in Asia, Africa, and Latin America [19–21]. A recent systematic review of the published studies of the FFS concluded that FFS positively affect intermediate outcomes (agricultural knowledge and practices), as well as final outcomes (e.g., reduced use of pesticides and yield gain) [22–25].

Although FFS methods have been applied for use in crops other than rice [23,25–27], as well as for topics other than IPM [28–30], previous studies on the impact of FFS have mainly focused on its effects on technology extension in pest management [25,31,32], adoption of rice varieties [30], and sustainable agricultural practices [26]. In the last decade, more FFS have been targeted for livestock farmers. Some FFS supported various types of livestock, while others were focused more narrowly, for example, on poultry and cattle [26,33]. Waddington et al. [33] (p. 220) stated that "over a third of the projects collected in our portfolio supported some form of livestock farming, mainly poultry, cattle, sheep, and/or goats." However, few projects have supported hog production. There are few evidence-based studies that detail the impact of FFS on hog production.

Therefore, this study primarily aimed to provide a rigorous assessment of the impact of FFS on hog production in China. To the best of our knowledge, this is the first analytical study to focus on the effects of FFS programs on hog production. Unlike previous studies on smallholder livestock farms, we paid attention to intermediate-scale farms, which have been the mainstream hog producers in China since the 2000s [7]. The empirical analysis was based on detailed survey data collected from 222 hog household farms in 2012 in rural Beijing, China.

2. Materials and Methods

2.1. Farmer Field Schools in Beijing, China

The first FAO-supported Farmer Field Schools (FFS) program for rice farmers was launched in 1993 in China and was then nationally diffused [19,26]. By the end of 2003, there were over 30,000 FFS established for rice and cotton farmers in China [34]. The FFS program was first introduced to vegetable farmers in Beijing in 2005 and then extended to other fields [18,30]. In the same year, funded by the local government, the first FFS targeted for livestock (sheep) farms was set up in Changping District, Beijing [34]. FFS rapidly spread to aquaculture farmers in 2007 and hog breeding farmers in 2009 [35].

Hog breeding FFS programs account for the largest proportion of livestock in Beijing [35]. There were nine suburban counties engaged in hog breeding in rural Beijing at the end of 2012 [35]. The hog breeding FFS was conducted by the Beijing Municipal Bureau of Agriculture and Rural Affairs in 2009, which mainly focused on hog breeding knowledge and skills training. Hog breeding FFS training provides knowledge about how to feed hogs, including knowledge of feedstuff, knowledge about viruses (e.g., what kind of virus breakout in different seasons), the suitable temperature for hog breeding, knowledge about disinfectants (e.g., the same kinds of disinfectants cannot be used for a long time), and knowledge about vaccines.

2.2. Data Sources

During the period from October to November 2012, survey teams from the Beijing Institute of Technology, Beijing, China, conducted a survey of hog farms in five randomly selected counties. The survey aimed to gather information on farm household hog production activities. Extensive data were collected on the use of inputs and outputs of hog production. For fattening hogs, input and output data of hog farms before the latest selling/slaughter in 2012 were collected. Regarding sows and piglets, the information (e.g., mortality rate of sows and piglets) was collected from October 2011 to September 2012.

Since 2010, the Beijing Municipal Government has targeted the fostering of medium- and large-size hog production farms, as they are more market-oriented and productive. In addition, these groups of hog farms are usually specialized, and are more likely to adopt technology and facilities (e.g., nursery facilities); notably, they are more concerned about risks such as swine virus and market. Thus, the FFS programs, usually supported by the local government, may play a greater role in medium- and large-size hog farms.

After consulting with agricultural experts and government officials and based on the hog breeding name list of FFS and non-FFS farmers provided by each county, we stratified the sample based on the hog breeding scale and randomly chose 30 FFS farmers and 20 non-FFS farmers in each county. In each household, extensive information was collected on the input and output of hog breeding, as well as household characteristics. In total, we interviewed 237 households, of which 15 did not provide complete information on major variables in our analysis, such as feed input or sow deaths. Thus, these households were excluded from the sample, and 222 households remained. Of these households, 146 participated in the FFS programs.

Sampled farmers who participated in FFS programs were denoted as the FFS group, whereas those who did not were denoted as the non-FFS group. We classified both groups of farmers according to herd size (Table 1). On one hand, the sample size in the non-FFS group was too small when the herd size was larger than 1000. Selection bias arose when the sample was used. On the other hand, as mentioned in the Introduction, we were interested in intermediate hog farms (10 to 1000 heads per year). Thus, we kept observations with the herd size less than 1000. Finally, 169 households were used for analysis in this study, with 100 FFS members and 69 non-FFS members.

Table 1. Sample distribution among different herd sizes between Farmer Field Schools (FFS) and non-FFS farmers.

	10–199	200–499	500–999	1000–1999	>1999
FFS	37	36	27	21	25
Non-FFS	37	21	11	2	5

The extension of FFS programs in the hog breeding field in Beijing provided us with a suitable venue to examine the impact of FFS on hog productivity. The development of the hog breeding industry in Beijing was several years ahead of that in other regions of China. Most of the hog production in Beijing was produced by specialized household farms in 2012 [35], whereas approximately 50% of hog production was by specialized household farms in the whole of China. The data used for this study resulted in the first systematic data collection from specialized farms for hog production in China.

2.3. Analytical Framework of the Impact of Farmer Field Schools on Hog Production

Previous studies have argued that lack of knowledge was the primary reason for technology adoption and misuse (e.g., *N*-fertilizer) in agricultural production in China [36–38]. The public extension system in China had carried out traditional training programs to solve farmers' problems through knowledge training [37,39]. However, the poor performance of the public extension system has been criticized for that; on the one hand, the promoted technologies did not meet farmers' needs, and on the other hand, their training effect was always less effective because farmers were not adapted to formal and complex class training [37].

Unlike traditional top-down knowledge training, the FFS program was developed with a "bottom-up" approach and focused not only on traditional class training but also on participating in training, as well as neighbor-to-neighbor diffusion [19,24,40]. The influence mechanism of FFS on hog production delivers new knowledge to farmers in the following aspects (see Figure 1): First, practical problems are collected from farmers during the training, providing a prompt response that can better meet farmers' demands. Second, the FFS program uses classroom course training. Third, considering that farmers find it difficult to understand theories, FFS training focuses on implementation in fields through participation in training. Finally, even if farmers miss the above steps of training, they can learn from their neighbors because one of the most important parts of the FFS program is to encourage farmer-to-farmer diffusion. In addition to the steps mentioned above, the FFS program usually requires specific training during different periods of crop cultivation and/or livestock production. For instance, during the period of flowering, the FFS program provides information on what kinds of insects and disease farmers would face.

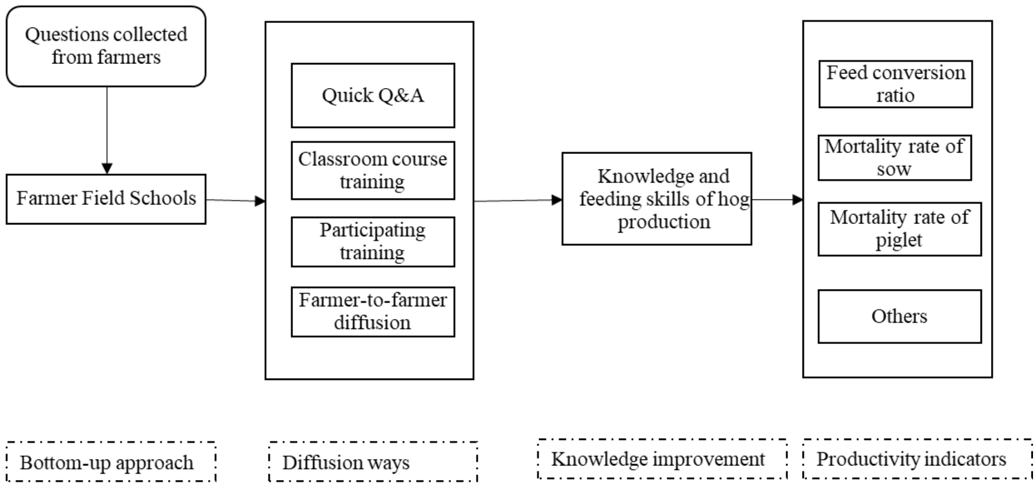

Figure 1. Influence mechanism of FFS on hog production.

Compared to crop cultivation, livestock production is a relatively highly specialized sub-sector. The demand to access information and knowledge of livestock breeding is more frequent and desirous than crop cultivation. For example, disease and virus resilience are the top concerns of hog breeding and pig farmers. Identifying viruses and the kind of veterinary services needed is usually less possible for and available to farmers. Unlike traditional training and visit extension services, the FFS programs first introduce knowledge of the common viruses in hog breeding through classroom-based courses or booklets, and then, facilitators help farmers understand and identify the specific virus to the local varieties. Groups of farmers meet regularly either in the organized classroom or in the field, for example, in a pigsty owned by one FFS member.

In most developing countries in Asia and Africa, agricultural extension services have developed around crop production and remain largely tied to the seasonal nature of cropping. Such a system is less useful for livestock production, with a longer time scale and a lack of synchronization of different animals and herds [41]. Over the past two decades, extension services have been well recognized in both crop cultivation and livestock breeding in countries such as India [42]. Thus, the experience of FFS programs in hog production in Beijing may provide a good extension and education example for developing countries in Asia, Africa, and elsewhere.

3. Specification of the Empirical Model

3.1. Feed Conversion Ratio and Mortality of Sow and Piglet

The feed conversion ratio (FCR) is an important indicator that measures hog production performance [43,44]. It provides a good indication of how efficient a feed or feeding strategy can be [45]. Improving the FCR is a major target in hog production because feed costs are the primary component of the total variable costs of hog production [44,46].

Following Wang et al. [9], FCR is defined as the amount of feed per amount of live weight gain. FCR is calculated as follows:

$$FCR = \frac{Feed\text{ given}}{Body\text{ weight gain}} \tag{1}$$

Feed given is the total feed intake offered to a fattening hog, since it was taken away from its mother sow until slaughter. Body weight gain is the total weight gain for the period of feed given in the numerator of Equation (1). In this study, we only focused on the FCR of fattening hogs; the FCR of sows and piglets was not included in the analysis.

Another important indicator of hog production performance is the mortality rate (MR) of sows and piglets. The MR is calculated as follows:

$$MR_{sow} = \frac{Number\text{ of dead sows}}{Number\text{ of sows breeding}} \tag{2}$$

$$MR_{piglet} = \frac{Number\text{ of dead piglets}}{Number\text{ of piglets bred}} \tag{3}$$

The mortality rate of sows and piglets is the number of dead sows and piglets in the year surveyed (from October 2011 to September 2012) divided by the number of sows and piglets bred in the same period. The period of piglets rearing refers to the period from when a piglet was born alive to the time it became a fattening pig.

3.2. Model Specification

To address the relationship between FFS and hog productivity, a quantitative model is specified as follows:

$$Y = f(FFS, Variety, Skillworker, County, HH, Z) \tag{4}$$

where Y is the hog productivity indicator. *FFS* is an indicator for farmers who have participated in Farmer Field Schools programs. *Variety* denotes hog variety. *Skill worker* is a binary variable representing whether the farmer employed a skilled worker during hog production. *County* is a dummy variable that captures the county-specific fixed effects. *HH* is a vector of household characteristics. Z includes the other control variables.

The regression model for the i-th household used for the empirical analysis is specified as follows:

$$y_{1i} = \beta_0 + \beta_1 FFS_i + \beta_2 Variety_i + \beta_3 Skillworker_i + \theta \bullet HH + County_i + \varepsilon_i \tag{5}$$

$$\begin{aligned} y_{2i} = \alpha_0 + \alpha_1 FFS_i + \alpha_2 Vaccine_{sow_i} + \alpha_3 Vaccine_{piglet_i} + \alpha_4 Disinfection_i \\ + \alpha_5 Variety_i + \alpha_6 Skillworker_i + \delta \bullet HH + County_i \\ + \mu_i \end{aligned} \tag{6}$$

where y_{1i} denotes the FCR in the i-th household. y_{2i} represents the mortality rate of sows or piglets in the i-th household. We estimated separate regressions for the FCR as well as the mortality rates of sows and piglets FFS_i is whether the i-th household participated in the FFS program, which was our main explanatory variable of interest. Negative coefficients of β_1 indicate that the farm households that participated in the FFS had decreased FCR, that is, improved feed efficiency and hog productivity. *Vaccine_sow* and *vaccine_piglet* are the number of times a sow or a piglet was vaccinated in the surveyed year, respectively. *Disinfection* is the number of times the piggery was disinfected in the surveyed year. *HH* is household characteristics that includes family size; assets per capita; family members; village leaders; and demographics of the household head, including age, education, and gender. The error terms ε and μ are assumed to be independently distributed. The ordinary least squares (OLS) method was used to estimate the empirical regression model. We used statistical software Stata 16 to conduct the analyses.

4. Results

4.1. Summary Statistics

One problem is that farmers may self-select to attend Farmer Field Schools (FFS) training, leading to the problem of self-selection. For example, younger farmers are more likely to attend FFS training because they lack feed experience. This can result in a negative selection effect [19]. To find evidence of possible self-selection behavior, we conducted a *t*-test statistical analysis and a chi-square test of household characteristics between FFS and non-FFS groups (Table 2) [19]. The results showed that farmers in the FFS group had significantly higher educational attainment than those in the non-FFS group, with approximately one-year differentiation between them. Regarding other household characteristics, there was an insignificant difference between the two groups in terms of family size, age of the household head, gender of household head, family member as a village leader, and the value of assets per capita. The above analysis shows that household characteristics were almost the same between the two groups of farmers.

Table 2. Comparison of household characteristics between FFS group and non-FFS group.

Characteristics	Mean ± SD		*p*-Value [a]
	FFS Group	Non-FFS Group	
Family size (No. of family members)	3.45 ± 1.17	3.33 ± 1.17	0.52
Age of household head (years)	49.04 ± 7.98	50.41 ± 8.55	0.29
Household head is male	0.92 ± 0.27	0.90 ± 0.30	0.63
Education of household head (years)	9.56 ± 2.35	8.74 ± 2.39	0.05
Family member as a village leader	0.08 ± 0.27	0.09 ± 0.28	0.87
Per capita fixed assets (10,000 Yuan [1])	24.60 ± 28.90	21.20 ± 25.82	0.43
Number of observations	100	69	

Source: Authors' survey [a] Chi-square for the binary variables and *t*-test for other variables. [1] Yuan is Chinese currency unit, 1 Yuan ≈ US$ 0.16 in 2012.

The average Feed Conversion Ratio (FCR) of all surveyed farms was 2.80 (Table 3). Approximately 59% of the farmers in our sample were FFS members. The mortality rates of sows and piglets were 5.2% and 13.0%, respectively. On average, farmers vaccinated sows nine times and piglets seven times. The number of times they were disinfected was 47.2, with variation ranging from 1 to 100. Approximately 84% of the hog varieties were imported, such as Duroc, Landrace, Large White, and Yorkshire. Only 9% of the farmers employed skilled workers to facilitate hog breeding.

Table 3. Definition of variables and summary statistics.

Variables	Definition	Mean	S.D.	Min.	Max.
FCR	Feed conversion ratio	2.80	0.58	1.64	4.73
FFS	1 = farmer in FFS; 0 = no	0.59	0.49	0	1
Mortality_sow	Sow mortality rate (%)	5.15	9.54	0	62.5
Mortality_piglet	Piglet mortality rate (%)	13.0	9.68	0	50
Vaccine_sow	Times sows vaccinated	9.0	4.2	0	20
Vaccine_piglet	Times piglets vaccinated	6.7	2.4	2	20
Disinfection	Times pigsty disinfected	47.2	26.8	1	100
Hog variety	1 = Chinese breed; 0 = no	0.84	0.36	0	1
Skill worker	1 = Skilled workers employed; 0 = no	0.09	0.29	0	1
	Household Characteristics				
Family size	Number of members in household	3.40	1.17	1	6
Gender	1 = male; 0 = no	0.91	0.29	0	1
Age	Year old	49.6	8.22	25	85
Education	Years of education	9.22	2.61	0	16
Village leader	1 = village leader in the family; 0 = no	0.08	0.28	0	1
Passet	Fixed assets per capita (10 thousands)	23.2	27.7	0.03	150

Table 3. *Cont.*

Variables	Definition	Mean	S.D.	Min.	Max.
	County Dummies				
Daxing	Daxing County (1 = yes; 0 = no)	0.17	0.37	0	1
Fangshan	Fangshan County (1 = yes; 0 = no)	0.15	0.36	0	1
Pinggu	Pinggu County (1 = yes; 0 = no)	0.24	0.43	0	1
Shunyi	Shunyi County (1 = yes; 0 = no)	0.27	0.45	0	1
Tongzhou	Tongzhou County (1 = yes; 0 = no)	0.17	0.38	0	1

For household characteristics, sampled farmers had an average of 3.4 family members and about 232.1 thousand Yuan assets per capita. Approximately 91% of household heads were male. The average age of the household head was 49.6, and the education attainment of the farmers was about nine years. Furthermore, 8% of the households had a village leader in their families. The number of surveyed households in each county accounted for approximately 20% of the total sample size.

4.2. Feed Conversion Ratio and Mortality Rate of Sows and Piglets

Overall, FFS farmers had a lower FCR than the non-FFS group (2.74 vs. 2.89), with significance at the 10% testing level (p-value of t-test = 0.09) (Figure 2).

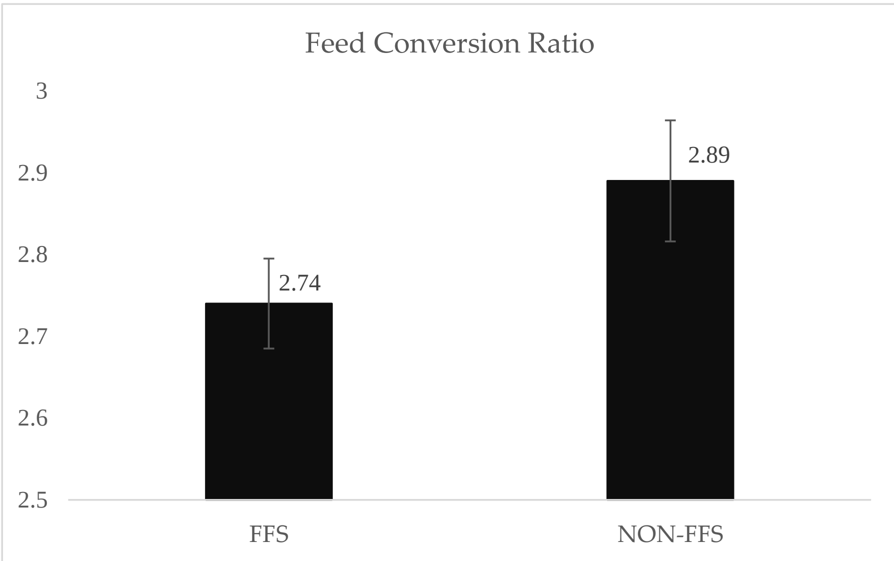

Figure 2. Feed conversion ratio between FFS and Non-FFS farmers.

From Figure 3, we can see that the mortality rate of sows in the FFS group (5.4%) was slightly higher than that in the non-FFS group (4.8%) but with an insignificant difference at the 10% testing level (p-value of t-test = 0.51). The mortality rate of piglets in the FFS group was also slightly higher than that in the non-FFS group (13.4% vs. 12.4%), but the difference was not significant (p = 0.69). The mortality rates of sows and piglets were quite similar between the FFS and non-FFS groups, indicating that FFS training had little impact on the mortality rates of sows and piglets.

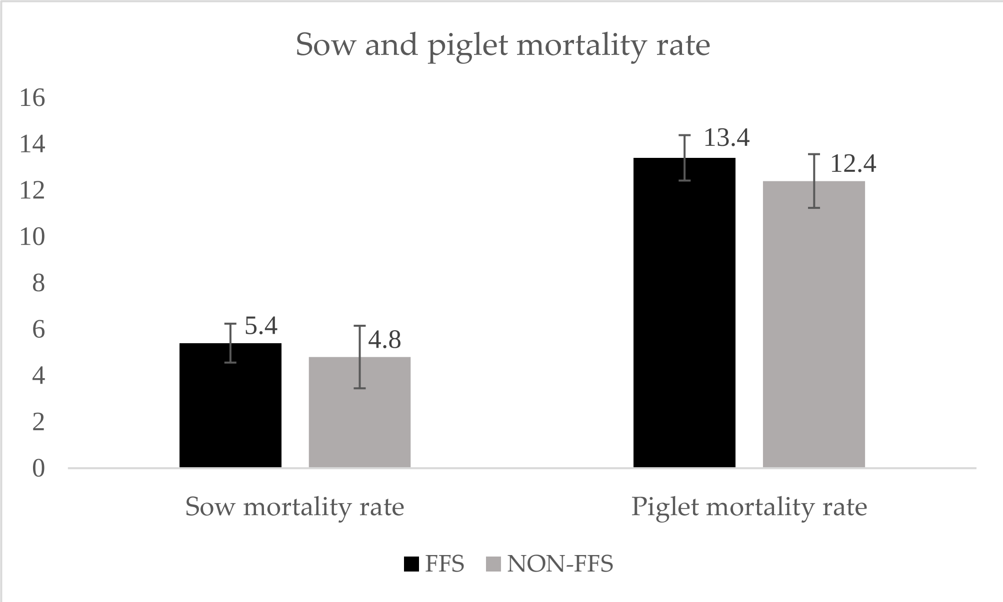

Figure 3. Sow and piglet mortality rate between FFS and non-FFS farmers.

4.3. Impact of Farmer Field Schools on Feed Conversion Ratio

Although the above descriptive analyses indicate that FFS training may have a positive impact on FCR, it does not provide information on conditional effects for given values of other variables that impact FCR. Table 4 presents the conditional effects of FFS on FCR for different hog production herd sizes. Column (1) reports an estimate of all those who participated in FFS programs on FCR under a herd size of 1000, whereas column (2) presents the results for a herd size of 500, and column (3) presents the results of relatively smaller-scale hog breeding farmers under a herd size of 200.

Table 4. Estimated impact of FFS on feed conversion ratio.

	(1)	**(2)**	**(3)** [a]
Variables	**Log (FCR) (Herd Size < 1000)**	**Log (FCR) (Herd Size < 500)**	**Log (FCR) (Herd Size < 200)**
FFS	−0.068 *	−0.107 ***	−0.140 ***
	(0.035)	(0.039)	(0.052)
Hog variety	−0.031	−0.042	0.043
	(0.045)	(0.055)	(0.084)
Skill worker	0.015	−0.070	–
	(0.063)	(0.116)	–
Household Characteristics			
Age	0.002	−0.0003	−0.001
	(0.002)	(0.002)	(0.003)
Education	0.007	0.002	−0.008
	(0.007)	(0.008)	(0.010)
Gender	0.043	0.050	0.097
	(0.059)	(0.062)	(0.090)
Family size	0.015	0.023	0.041
	(0.015)	(0.018)	(0.026)
Village leader	−0.025	−0.015	0.013
	(0.061)	(0.064)	(0.125)
Log(Passet) [b]	0.018	0.048 **	0.051

Table 4. *Cont.*

	(1)	(2)	(3) [a]
Variables	**Log (FCR) (Herd Size < 1000)**	**Log (FCR) (Herd Size < 500)**	**Log (FCR) (Herd Size < 200)**
	(0.015)	(0.020)	(0.032)
County Dummy			
Fangshan	0.072	0.162 *	0.059
	(0.064)	(0.088)	(0.144)
Pinggu	0.084	0.147 *	0.017
	(0.058)	(0.075)	(0.120)
Shunyi	0.091	0.114	0.043
	(0.057)	(0.075)	(0.118)
Tongzhou	0.075	0.138*	0.040
	(0.060)	(0.074)	(0.118)
Constant	0.699 ***	0.756 ***	0.813 ***
	(0.173)	(0.207)	(0.252)
Number of observations	169	131	74
R^2	0.061	0.112	0.213

Note: Standard errors are shown in parentheses; ***, **, and * indicate statistically significant differences at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses. [a] log(FCR) is the value of the natural logarithm of the FCR. The main reason for using a log-transformation is to impose a constant percentage effect of FFS on FCR. [b] log(Passet) is the value of the natural logarithm of the per capita fixed asset. The coefficient of the skilled worker is missing in column (3) because under the herd size of 200, no farmer employed a skilled worker.

Overall, farmers who participated in FFS programs had a significant and positive impact on FCR, while its effect varied depending on hog production herd size. When the herd size was less than 1000, those who participated in the FFS programs reduced the FCR by 6.8%. When the herd size decreased to less than 500, the impact of FFS on FCR increased to 10.7%. This effect was even larger for relatively small-scale hog breeding farmers under a herd size of 200. The reduction in FCR was 14.0% for small-scale farmers, which was twice as much as that of herd size under 1000. This implies that FFS have a positive impact on reducing the FCR of hog breeding, notably on relatively smaller-scale hog breeding farms.

In general, the larger herds hog farmers have, the more uncertainties and risks they face. Large-scale hog breeding farmers often make fuller preparations for production to avoid potential risks, such as disease outbreaks. We did not find significant effects on FCR regarding hog varieties and employment of skilled workers. We also did not find a significant effect of household characteristics on FCR.

4.4. Impact of Farmer Field Schools on Mortality Rate of Sows and Piglets

Columns (1) and (2) in Table 5 report the impact of FFS on sow and piglet mortality rates. The results show that FFS program participation had an insignificant impact on sow and piglet mortality rates. These results suggest that the knowledge acquired in the livestock FFS programs had not yet enabled farmers to adapt to their existing hog breeding technology to be more productive and reduce risks. However, these results should be interpreted with caution, because our study was based on a relatively small sample size in rural county areas of Beijing.

Table 5. Estimated impact of FFS on mortality rate of sow and piglet.

	(1)	(2)
Variables	**Sow Mortality Rate**	**Piglet Mortality Rate**
FFS	1.303	1.356
	(1.532)	(1.536)
Vaccine_sow	−0.334 *	
	(0.189)	
Vaccine_piglet		−0.603 *
		(0.330)
Disinfection	−0.009	−0.011
	(0.029)	(0.029)
Hog variety	−1.214	−0.867
	(1.993)	(2.003)
Skill worker	3.056	−3.112
	(2.799)	(2.850)
Household Characteristics		
Age	−0.006	−0.052
	(0.092)	(0.093)
Education	0.051	−0.236
	(0.319)	(0.321)
Gender	−1.232	−2.207
	(2.768)	(2.765)
Family size	−1.072	−0.148
	(0.666)	(0.673)
Village leader	−1.187	−4.084
	(2.728)	(2.760)
Passet	−0.048	−0.051
	(0.032)	(0.032)
County Dummy		
Fangshan	−0.812	−2.939
	(3.015)	(2.992)
Pinggu	−7.246 **	−2.418
	(2.797)	(2.815)
Shunyi	−7.566 ***	−2.190
	(2.763)	(2.780)
Tongzhou	−6.855 **	4.342
	(2.923)	(2.918)
Constant	19.45 **	27.51 ***
	(8.163)	(8.266)
Number of observations	167	167
R^2	0.142	0.155

Note: Standard errors are shown in parentheses. ***, **, and * indicate statistically significant differences at the 1%, 5%, and 10% levels. Because two of the farms had no sows and piglets, the sample size was reduced to 167 (Table 5).

An important finding is that the number of vaccinations had a significant effect on reducing sow and piglet mortality rates. On average, one more vaccine decreased the sow and piglet mortality rates by 0.3% and 0.6%, respectively. The average number of vaccines for sows and piglets was 5.15 and 13.03, respectively, which implies that the vaccine decreased sow and piglet mortality rate by 1.73% (0.335%*5.15) and 7.73% (0.593%*13.03), respectively. The effect of the vaccine on death reduction was relatively large in piglets. Piglets tend to be more vulnerable when facing diseases, and more often, vaccination largely reduces their risk.

5. Discussion

In this study, the estimated Feed Conversion Ratios for Farmer Field School (FFS) and non-FFS farms were 2.74 and 2.89, respectively. A national survey was conducted exploring the relationship between FCR, farm size, and profitability, in five provinces (these provinces are Sichuan, Hubei, Shandong, Guangdong, and Jilin and do not include Beijing) in China from 2011 to 2013 [9]. In this study, on average, the FCR of specialized farms was 2.90, while that for backyard farms and relatively smaller household farms was 3.03 and 3.99, respectively. The FCR of non-FFS farms is comparable in terms of specialized farms (2.89 vs. 2.90), while the FFS farms perform much better regardless of farm size as compared to the findings for this previous study [9]. A possible explanation for the relatively lower FCR in the counties we surveyed in Beijing is that the development of the hog breeding industry in Beijing was several years ahead from that of other regions of China.

The finding that participation in FFS can significantly reduce FCR in pig production may have implications. First, a lower FCR is likely to have a large impact on the feed (and/or food) market in China as well as other countries. In our surveyed hog farms, the ingredients of the feed for pig production were maize (64%), soybean (21%), wheat (13%), and others, which is consistent with China's feed ingredient for the pig industry [47]. According to the National Statistical Bureau of China [48] and the USDA [49], from 2013 to 2020, China imported over 84 million tons of soybean (mainly used for feed). It accounts for 90% of the demotic soybean supply [50] and approximately one-quarter of the world's soybean production [48,49]. For maize, China's annual imports accounted for approximately 0.4% of global production from 2013 to 2020 [48,49]. The reduction of FCR in pig production could largely reduce its dependence on the global soybean market. This may contribute to China's national goal of self-sufficiency in food production, which in turn decreases the pressure on the global grain market. Second, a better FCR may have an important environmental impact. For example, Brazil, together with the United States, is the largest supplier of soybean in China [51]. The reduction of soybean imports from Brazil may generate positive environmental impacts on the global scale, such as less pressure of deforestation in the Amazon area.

Another finding is that farmers who participated in FFS did not significantly reduce sow and piglet mortality. Our results are in contrast to those from an East Nusa Tenggara, Indonesia study, where farmers who participated in the breeding and fattening beef cattle FFS program significantly reduced calf mortality [52]. The different contents of knowledge and technology diffusion offered by the FFS in Indonesia versus China may explain the different results.

Future studies could be improved from our analysis. First, although pig production has developed rapidly in the past decade, specialized farms and backyard farms still dominate the swine industry in China [47,53]. Findings from our study may still provide important implications for current medium-size pig farms. Regarding the hog producers, farmers are still the main group within the hog industry in most developing countries. The hog production has changed very little in terms of producers and management practices over the past decade in China, and the results of our study could still be applied to the current medium-size hog farms in China and other developing countries. For future work, extensive data with broader regions and multiple years' observations (e.g., panel data) would provide more insights into the current state and trends of hog production and piglet rearing in China. Second, analyzing factors that influence other productivity indicators could improve understanding on how to better improve the productivity of China's hog industry. There are several parameters to measure the hog production performance. Apart from the indicators used in the study, the number of piglets a sow reared per year may also provide a broader view and indications to farmers on what to improve in terms of the critical elements of sow production so that they can give birth to and raise a greater number of healthy piglets. In addition, it also could provide insights into nutrition and proper hygienic conditions to improve piglet breeding.

6. Conclusions

As one of the most important agricultural extension tools, Farmer Field Schools (FFS) have been rapidly extended to fields other than crop cultivation, such as livestock breeding in China. However, few studies have examined the effects of FFS on hog production.

Using data collected from specialized household farms from five Beijing counties in 2012, we found that FFS programs significantly reduced the Feed Conversion Ratio (FCR) of hog breeding, particularly on relatively small-scale hog farms. On average, FFS program participants reduced FCR of hog breeding for herd sizes under 1000, 500, and 200 by 6.8%, 10.7%, and 14.0%, respectively.

Regarding the effects of FFS on sow and piglet mortality rates, we did not find any evidence that farmers who participated in FFS had a significant impact on reducing sow and piglet mortality rates. The number of vaccinations and disinfections considerably minimized the sow and piglet mortality rates. Although FFS programs in Beijing covered vaccine and disinfection training, such as what kind of virus would break out in different seasons and which kind of disinfectant could not be used repeatedly, more attention should be paid to the management of hog production, that is, the frequency and timing of vaccination and disinfection. Moreover, systematic data collected from a wider hog production region would allow for a more rigorous examination of the effects of FFS on hog productivity.

Considering these results, we concluded that the training model for FFS programs could also work in fields other than crop cultivation. Our findings may have important implications for intermediate-scale hog breeding in other regions of China and other developing countries. It is also suggested that more attention be paid to the frequency and timing of vaccinations and disinfections for hog farmers involved in FFS programs.

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References

1. Schneider, M. Feeding China's Pigs: Implications for the Environment, China's Smallholder Farmers and Food Security. Institute for Agriculture and Trade Policy. ISS Staff Group 4: Rural Development, Environment and Population. 2012. Available online: https://repub.eur.nl/pub/51021 (accessed on 31 August 2020).
2. Wang, J.; Watanabe, M. *Pork Production in China—A Survey and Analysis of the Industry at a Lewis Turning Point Institute of Developing Economies*; Japan External Trade Organization: Chiba, Japan, 2011.
3. US Department of Agriculture, Foreign Agricultural Service. Livestock and Poultry: World Markets and Trade. 2021. Available online: https://apps.fas.usda.gov/psdonline/circulars/livestock_poultry.pdf (accessed on 5 October 2021).
4. US Department of Agriculture, Foreign Agricultural Service. Livestock and Poultry: World Markets and Trade. 2016. Available online: https://downloads.usda.library.cornell.edu/usda-esmis/files/73666448x/0r967405p/9s1616627/livestock-poultry-ma-10-12-2016.pdf (accessed on 5 October 2021).
5. US Department of Agriculture, Foreign Agricultural Service. Livestock and Products Annual. 2016. Available online: https://Apps.Fas.Usda.Gov/Newgainapi/Api/Report/Downloadreportbyfilename?Filename=Livestock%20and%20products%20annual_Beijing_China%20-%20peoples%20republic%20of_08-15-2019 (accessed on 31 August 2020).
6. China Restricts Imports from Slaughterhouses with COVID-19. Available online: https://www.pig333.com/latest_swine_news/china-restricts-imports-from-slaughterhouses-with-covid-19_16429/ (accessed on 5 October 2021).
7. Qiao, F.; Huang, J.; Wang, D.; Liu, H.; Lohmar, B. China's Hog Production: From Backyard to Large-Scale. *China Econ. Rev.* **2016**, *38*, 199–208. [CrossRef]
8. Lander, B.; Schneider, M.; Brunson, K. A History of Pigs in China: From Curious Omnivores to Industrial Pork. *J. Asian Stud.* **2020**, *79*, 865–889. [CrossRef]
9. Wang, D.; Huang, J.; Lohmar, B. Feed Conversion Ratio, Profitability and Farm Size in China's Pig Industry. In Proceedings of the 29th International Conference of Agricultural Economists, Milan, Italy, 8–14 August 2015.

10. Xiao, H.; Wang, J.; Oxley, L.; Ma, H. The Evolution of Hog Production and Potential Sources for Future Growth in China. *Food Policy* **2012**, *37*, 366–377. [CrossRef]
11. Ji, C.; Jin, S.; Wang, H.; Ye, C. Estimating Effects of Cooperative Membership on Farmers' Safe Production Behaviors: Evidence from Pig Sector in China. *Food Policy* **2019**, *83*, 231–245. [CrossRef]
12. Kenmore, P.E. *Indonesia's Integrated Pest Management: A Model for Asia*; FAO Inter-Country Programme for Integrated Pest Control in Rice in South and Southeast Asia: Manila, Philippines, 1991.
13. Quizon, J.; Feder, G.; Murgai, R. Fiscal sustainability of agricultural extension: The case of the farmer field school approach. *J. Int. Agric. Ext. Educ.* **2001**, *8*, 13–24. [CrossRef]
14. Feder, G.; Savastano, S. The role of opinion leaders in the diffusion of new knowledge: The case of integrated pest management. *World Dev.* **2006**, *34*, 1287–1300. [CrossRef]
15. Anandajayasekeram, P.; Davis, K.E.; Workneh, S. Farmer field schools: An alternative to existing extension systems? Experience from Eastern and Southern Africa. *J. Int. Agric. Ext. Educ.* **2007**, *14*, 81–93. [CrossRef]
16. Gallagher, K.D.; Ooi, P.A.C.; Kenmore, P.E. Impact of Ipm Programs in Asian Agriculture. In *Integrated Pest Management: Dissemination and Impact*; Peshin, R., Dhawan, A.K., Eds.; Springer: Dordrecht, The Netherlands, 2009; Volume 2, pp. 347–358.
17. Kenmore, P. A Perspective on Ipm. *ILEIA Newsl.* **1997**, *13*, 8–9.
18. van den Berg, H.; Ketelaar, J.W.; Dicke, M.; Fredrix, M. Is the Farmer Field School Still Relevant? Case Studies from Malawi and Indonesia. *NJAS Wagening. J. Life Sci.* **2020**, *92*, 100329. [CrossRef]
19. Cai, J.; Shi, G.; Hu, R. An Impact Analysis of Farmer Field School in China. *Sustainability* **2016**, *8*, 137. [CrossRef]
20. Simpson, B.M.; Owens, M. Farmer field schools and the future of agricultural extension in Africa. *J. Int. Agric. Ext. Educ.* **2002**, *9*, 29–36. [CrossRef]
21. Röling, N.; Van De Fliert, E. Transforming extension for sustainable agriculture: The case of integrated pest management in rice in Indonesia. *Agric. Hum. Values.* **1994**, *11*, 96–108. [CrossRef]
22. Tripp, R.; Wijeratne, M.; Piyadasa, V.H. What should we expect from farmer field schools? A Sri Lanka case study. *World Dev.* **2005**, *33*, 1705–1720. [CrossRef]
23. Mauceri, M.; Alwang, J.; Norton, G.; Barrera, V. Effectiveness of integrated pest management dissemination techniques: A case study of potato farmers in Carchi, Ecuador. *J. Agric. Appl. Econ.* **2007**, *39*, 765–780. [CrossRef]
24. Feder, G.; Murgai, R.; Quizon, B.J. Sending Farmers Back to School: The Impact of Farmer Field Schools in Indonesia. *Rev. Agric. Econ.* **2004**, *26*, 45–62. [CrossRef]
25. Godtland, E.M.; Sadoulet, E.; de Janvry, A.; Murgai, R.; Ortiz, O. The Impact of Farmer Field Schools on Knowledge and Productivity: A Study of Potato Farmers in the Peruvian Andes. *Econ. Dev. Cult. Change.* **2004**, *53*, 63–92. [CrossRef]
26. Yang, P.; Liu, W.; Shan, X.; Li, P.; Zhou, J.; Lu, J.; Li, Y. Effects of training on acquisition of pest management knowledge and skills by small vegetable farmers. *Crop Protect.* **2008**, *27*, 1504–1510. [CrossRef]
27. Davis, K.; Nkonya, E.; Kato, E.; Mekonnen, D.A.; Odendo, M.; Miiro, R.; Nkuba, J. Impact of Farmer Field Schools on Agricultural Productivity and Poverty in East Africa. *World Dev.* **2012**, *40*, 402–413. [CrossRef]
28. Corales, A.M.; Santos, R.C.; Banayo, N.M.C.; Bueno, C.S.; Johnson, D.E.; Kato, Y. Dissemination Pathways for Drought-Tolerant Rice Cultivars: A Farmer-Participatory Evaluation in the Philippines. *World Dev. Perspect.* **2019**, *15*, 100131. [CrossRef]
29. Yorobe, J.; Rejesus, R.; Hammig, M. Insecticide use impacts of integrated pest management (IPM) farmer field schools: Evidence from onion farmers in the Philippines. *Agric. Syst.* **2011**, *104*, 580–587. [CrossRef]
30. Larsen, A.F.; Lilleør, H.B. Beyond the Field: The Impact of Farmer Field Schools on Food Security and Poverty Alleviation. *World Dev.* **2014**, *64*, 843–859. [CrossRef]
31. Friis-Hansen, E.; Duveskog, D. The empowerment route to well-being: An analysis of farmer field schools in East Africa. *World Dev.* **2012**, *40*, 414–427. [CrossRef]
32. Palis, F.G. The role of culture in farmer learning and technology adoption: A case study of farmer field schools among rice farmers in central Luzon, Philippines. *Agric. Hum. Values.* **2006**, *23*, 491–500. [CrossRef]
33. Waddington, H.; Snilstveit, B.; Hombrados, J.; Vojtkova, M.; Phillips, D.; Davies, P.; White, H. Farmer Field Schools for Improving Farming Practices and Farmer Outcomes: A Systematic Review. *Campbell Syst. Rev.* **2014**, *10*, i-335. [CrossRef]
34. Zhang, M.; Shi, S.; Wang, D. The Origin of the Farmer Field School and Its Development in China. *China Agric. Univ. J. Soc. Sci. Edition.* **2008**, *25*, 19–135. (In Chinese)
35. Xiao, C. Research on Creation and Impacts of Beijing Farmer Field School Model. Ph.D. Thesis, China Agricultural University, Beijing, China, 2012. (In Chinese).
36. Huang, J.; Hu, R.; Cao, J.; Rozelle, S. Training Programs and in-the-field Guidance to Reduce China's Overuse of Fertilizer without Hurting Profitability. *J. Soil Water Conserv.* **2008**, *63*, 165–167. [CrossRef]
37. Huang, J.; Huang, Z.; Jia, X.; Hu, R.; Xiang, C. Long-Term Reduction of Nitrogen Fertilizer Use through Knowledge Training in Rice Production in China. *Agric. Syst.* **2015**, *135*, 105–111. [CrossRef]
38. Jia, X.; Huang, J.; Xiang, C.; Powlson, D. Reducing Excessive Nitrogen Use in Chinese Wheat Production through Knowledge Training: What are the Implications for the Public Extension System? *Agroecol. Sustain. Food Syst.* **2015**, *39*, 189–208. [CrossRef]
39. Jia, X.; Huang, J.; Xiang, C.; Hou, L.; Zhang, F.; Chen, X. Farmer's Adoption of Improved Nitrogen Management Strategies in Maize Production in China: An Experimental Knowledge Training. *J. Integr. Agric.* **2013**, *12*, 364–373. [CrossRef]

40. Van den Berg, H.; Jiggins, J. Investing in Farmers—The Impacts of Farmer Field Schools in Relation to Integrated Pest Management. *World Dev.* **2007**, *35*, 663–686. [CrossRef]
41. Morton, J.; Matthewmann, R.; Barton, D. Livestock Production Extension: Issues, Case Studies and Policy Options. Natural Resources Institute: Chatham, UK, 1997.
42. Mahesh, C.; Triveni, D.; Ravikumar, R.K.; Subrahmanyeswari, B. Livestock Technology Transfer Service in India: A Review. *Indian J. Anim. Sci.* **2010**, *80*, 1115–1125.
43. Agostini, P.S.; Fahey, A.G.; Manzanilla, E.G.; O'Doherty, J.V.; de Blas, C.; Gasa, J. Management Factors Affecting Mortality, Feed Intake and Feed Conversion Ratio of Grow-Finishing Pigs. *Animal* **2014**, *8*, 1312–1318. [CrossRef] [PubMed]
44. Losinger, W.C. Feed-Conversion Ratio of Finisher Pigs in the USA. *Prev. Vet. Med.* **1998**, *36*, 287–305. [CrossRef]
45. Edwards, W.M.; van der Sluis, G.T.; Stevermer, E.J. Determinants of Profitability in Farrow-to-Finish Swine Production. *Appl. Econ. Perspect. Policy* **1989**, *11*, 17–25. [CrossRef]
46. Henry, Y. Influence of Diet Composition on Feed Efficiency and Utilisation in Growing-Finishing Pigs. *World. Rev. Anim. Prod.* **1992**, *27*, 76–92.
47. Liu, X.; Cai, Z.; Yuan, Z. Environmental Burdens of Small-Scale Intensive Pig Production in China. *Sci. Total Environ.* **2021**, *770*, 144720. [CrossRef]
48. National Statistical Bureau of China. *The Statistical Yearbook*; China Statistical Press: Beijing, China, 2021.
49. US Department of Agriculture, Foreign Agricultural Service. 2020. Available online: https://www.fas.usda.gov/commodities/soybeans (accessed on 31 August 2020).
50. Ren, D.; Yang, H.; Zhou, L.; Yang, Y.; Liu, W.; Hao, X.; Pan, P. The Land-Water-Food-Environment Nexus in the Context of China's Soybean Import. *Adv. Water Resours.* **2021**, *151*, 103892. [CrossRef]
51. Gale, F.; Valdes, C.; Ash, M. *Interdependence of China, United States, and Brazil in Soybean Trade*; US Department of Agriculture; Economic Research Service (ERS): New York, NY, USA, 2019; pp. 1–48.
52. Ratnawaty, S.; Tiro, B.M. Farmer Field School of Beef Cattle Breeding and Fattening in East Nusa Tenggara. *Int. J. Agric. Innov. Res.* **2018**, *6*, 164–168.
53. Zhang, D.; Wang, X.; Zhou, Z. Impacts of Small-Scale Industrialized Swine Farming on Local Soil, Water and Crop Qualities in a Hilly Red Soil Region of Subtropical China. *Int. J. Environ. Res. Public Health* **2017**, *14*, 1524. [CrossRef]