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Loss Prevention for Hog Farmers

Insurance, On-farm Biosecurity Practices, and Vaccination

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Contents

List of Tables

List of Figures

ABSTRACT

Using agricultural household survey data and claim records from insurers for the year 2009, this paper analyzes hog producers' choice of means of loss prevention and identifies the relationships among biosecurity practices, vaccination, and hog insurance. By combining one probit and two structural equations, we adopt three-stage estimations on a mixed-process model to obtain the results.

The findings indicate that biosecurity practices provide the basic infrastructure for operating pig farms and complement both the usage of quality vaccines and the uptake of hog insurance. In addition, there is a strong relationship of substitution between quality of vaccine and demand for hog insurance. Hog farmers that implement better biosecurity practices are more likely to seek high-quality vaccines or buy into hog insurance schemes but not both. For those households with hog insurance, better biosecurity status, better management practices, and higher-quality vaccine significantly help to reduce loss ratios. However, we also find a moral hazard effect in that higher premium expenditure by the insured households might induce larger loss ratios.

Keywords: biosecurity, loss prevention, vaccine, hog insurance

1. INTRODUCTION

Hog production is one of the major activities in the agricultural sector and the main income source of many farmers in China. In August 2010, China had 442 million hogs, which accounted for half of the pork supply in the world. There were 72.4 million hog producers in China, and more than 56 percent of hogs were on small farms, with fewer than 100 hogs. Hog epidemics have been common in recent years and have caused significant losses for farmers in China. Common swine diseases in China are listed in Table 1.1. To help farmers mitigate loss, pilot hog insurance has been made available in China since 2007. Hog insurance is important because China is now a member of the World Trade Organization (WTO), which permits insurance as an exception to its rules on subsidies in the agricultural sector. In June 2009, 153 million hogs and 97 million sows were insured in China (China Insurance Regulatory Commission 2009). Reimbursements have been paid for losses of 7 million hogs and 5 million sows from August 2007 to June 2009. Hog insurance is increasingly critical in China to stabilize hog production and the pork market.

Although hog insurance provides a useful risk-mitigating tool, the fundamental task to reduce production risk for hog producers is to prevent loss through disease control. To control disease, appropriate on-farm biosecurity practices have become increasingly common, though with considerable variation across farms. In addition, vaccination provides an alternative method for loss prevention. A higher-quality vaccine is more effective for reducing the probability of disease occurrence. The purpose of this paper is to analyze hog producers' choice of means of loss prevention and to identify the relationships among biosecurity practices, vaccination, and hog insurance. Although loss reduction is the final target for all of the risk-mitigating tools, the tools represent different concepts. For example, hog insurance is an ex post instrument to recover the loss incurred but does not prevent loss in advance. Alternatively, biosecurity practices and vaccination are used to reduce the probability of disease ex ante. Therefore, risk management on pig farms can be explained in terms of two concepts developed by Ehrlich and Becker (1972), self-protection and market insurance. *Self-protection* refers to loss prevention through reducing the probability of loss and is consistent with the function of biosecurity practices and vaccination. *Market insurance* refers to loss reduction after a risk event occurs and is equivalent to hog insurance. Ehrlich and Becker (1972) showed that market insurance and self-protection are complements. Based on their argument, we may expect that biosecurity practices and vaccination complement hog insurance. Based on detailed data from a survey in De-Ching County, Zhejiang Province, this paper examines the relationships among on-farm biosecurity measures, vaccination, and hog insurance for hog producers. We first analyze how hog producers select their risk prevention tools conditional on the availability of hog insurance. In particular, we focus on the formation of biosecurity practices for various sizes of pig farms and explore the characteristics of farms that choose different levels of biosecurity practices. Then we test whether biosecurity practices and quality of vaccine on the one hand and hog insurance on the other are complements. We also investigate the associations between loss ratio and various risk-mitigating and loss-mitigating tools.

Table 1.1—Common swine diseases in China

Epidemic Disease	Chronic Disease	Parasitic Disease	Zoonosos
Porcine Reproductive and Respiratory Syndrome (PRRS virus)	Atrophic Rhinitis (Toxogenic P. multocida Type D)	Ascaris lumbricoides (ALB)	Foot and mouth disease (Aphthovirus)
Post-weaning multi-systemic wasting syndrome （PMWS ）	Enzootic Pneumonia (Mycoplasma hyopneumoniae)	Trichuris trichura	Shistosomaiasis
Porcine respiratory disease complex （PRDC ）	Porcine Pleuropneumonia (Actinobacillus pleuropneumoniae)		Pseudorabies (Herpes virus)
Poricine dermatitis nephropathy syndrome (PDNS)	Sarcoptes scabiei virus		Japanese encephalitis (Japanese encephalitis virus)
Post-weaning multi-systemic wasting syndrome（PMWS ）			Streptococcus meningitis (Strep. suis Type II)
			Swine influenza

Source: Re-tabulated from He, Guoe, Chen, and Chen (2011).

2. LITERATURE

Extensive literature has been devoted to the study of biosecurity status and risk management for hogs (Amass and Clark 1999; Amass 2005; Barcelo and Marco 1998; Boklund, Mortensen, and Houe 2003/04; Boklund et al. 2004; Julio Pinto and Santiago Urcelay 2003). In particular, Amass and Clark (1999) divided the factors influencing biosecurity of hogs into four categories: pathogen transmission among hogs, other methods of pathogen spread, pathogen survival, and cleaning and disinfection. This categorization forms the cornerstone of the questionnaire used in our study. Julio Pinto and Santiago Urcelay (2003) classified biosecurity measures in Chile into various categories by different functions: location and isolation, internal risks, movable risks, and nonmovable risks. Ribbens and colleagues (2008) conducted a similar survey Belgium and identified four different clusters corresponding to low or high biosecurity status. To diversify risk in livestock production, Meuwissen and others (2006) considered the design of livestock insurance. They pointed to a need for appropriate incentives in the insurance contract to induce farmers to manage their own risk and thus reduce economic loss from livestock epidemics, since the level of risk control might minimize the occurrence and extent of disease. They noted four issues: risk prevention, rapid disclosure, compliance with movement standstill, and preventing deliberate infection. Among these, risk prevention can be encouraged through adoption of risk classification, deductible, and proportional reimbursement in the insurance contract. Coinsurance through a localized mutual fund reduces the problem of asymmetric information and decreases the transaction costs.

Other studies in China have also discussed the biosecurity issue for pig farms. For example, Yu (2008) explored biosecurity measures in terms of farm location and layout, and risk management procedures such as sterilization, monitoring, vaccination, and preventive medicine. Yu found the government's role in adopting related regulations to be important. Wang (2010) examined the causes of hog disease in China and identified several major sources, including high density of hogs on farms, inappropriate location and layout, fever transmission from breeding swine, and lack of biosecurity practices. The related research in China mainly relies on experience and data accumulation, while analyses using cross-sectional data are rare. Our study attempts to fill this gap.

3. DATA AND METHODOLOGY

The data of this study are from a survey conducted in De-Ching County of Zhejiang Province in 2009. Hog producers are usually categorized into two classes in China: small farms, with 1–99 hogs, and large farms, with 100 or more. Large farms account for 68 percent of hog production in Zhejiang Province. For our initial samples, therefore, we selected those agricultural households with herds of 100 hogs or more. Thus designated, the hog producer sizes vary greatly, from 100 to 7956. As a result, the sample covers extensive to intensive production, and thus very different types of farming systems. To address this issue, we excluded very large producers by assigning a maximum farm size at 1500 hogs. Of the 531 households in the survey, 290 observations remained after incomplete responses were eliminated. The questionnaire included demographic information (age and schooling of owner), background of pig herds (the current numbers of sows and hogs, the reproductive rate of sows), financial management (hog insurance, loans, and hog production as income share), and biosecurity practices, with the latter being the main focus. As the critical issue in the process of hog production, biosecurity consists of three major elements: segregation, cleaning, and disinfection (Food and Agriculture Organization 2010). Each element can be evaluated in terms of several measures related to risk that may cause disease transmission and in turn create economic loss. Based on the criteria discussed by Julio Pinto and Santiago Urcelay (2003) and by Ribbens and colleagues (2008), and taking into account the appropriateness for China, we selected 20 measures of biosecurity to be used in the questionnaire for this study. The detailed variable definitions and summary statistics are listed in Table 3.1.

Table 3.1—Biosecurity factor definitions and summary statistics

Biosecurity measure	Definition	Mean	SD
1. Disposal of carcasses	= 1 if households use incinerator or deep burial, 0 otherwise	1.00	0.06
2. Visitors prohibited	= 1 if no visitors allowed to the farm, 0 otherwise	0.97	0.17
3. Visits to other farms prohibited	= 1 if workers are not allowed to visit other farms, 0 otherwise	0.94	0.23
4. Quarantine of new pigs on arrival	= 1 if quarantine is enforced for new pig arrivals, 0 otherwise	0.94	0.24
5. Slurry disposal	= 1 if manure or septic tank is used, 0 otherwise (direct emissions)	0.87	0.34
6. Individualized veterinary equipment	= 1 if individualized veterinary equipment is available, 0 otherwise	0.85	0.36
7. No other animals raised	= 1 if households raise no other animals on the farm, 0 otherwise	0.83	0.37
8. Excreta management	= 1 if excreta management procedures are adopted, 0 otherwise	0.82	0.38
9. New hogs raised separately	= 1 if households raise new hogs separately, 0 otherwise	0.80	0.40
10. All-in/all-out management	= 1 if all-in/all-out management is adopted, 0 otherwise	0.78	0.42
11. Wheel bath for trucks at the entrance	= 1 if wheel bath is provided for trucks at the entrance, 0 otherwise	0.75	0.44
12. Disease records	= 1 for households that keep disease records, 0 otherwise	0.68	0.47
13. Labor exclusively in maternity	= 1 if labor takes place exclusively in maternity, 0 otherwise	0.63	0.48
14. Equipment not shared	= 1 if equipment (shovels, brushes, and the like) is not shared among sections, 0 otherwise	0.61	0.49

Table 3.1—Continued

Biosecurity measure	Definition	Mean	SD
15. UV lamp and disinfection baths for staff	= 1 if UV lamp and disinfection baths are provided for staff, 0 otherwise	0.59	0.49
16. Keeping of pigs at workers' homes banned	= 1 for households that raise no hogs at workers' homes, 0 otherwise	0.49	0.50
17. Vaccination certificate	= 1 for households with certificate of vaccination, 0 otherwise	0.49	0.50
18. Mobility between sections prohibited	= 1 if workers are not allowed to move between sections of the farm, 0 otherwise	0.41	0.49
19. Sterilizing of trolleys and vehicles	= 1 if sterilizing of trolleys and vehicles is practiced, 0 otherwise	0.27	0.45
20. Kitchen waste prohibited as hog feed	= 1 if kitchen waste is not allowed to be used as hog feed, 0 otherwise	0.06	0.25

Source: Hog producer survey, De-Ching County, Zhejiang Province, China, 2009.

In addition to the measures mentioned above, other biosecurity practices that are commonly used in Western countries are extermination of insects, birds, and rodents; not allowing the slaughter of hogs on-farm; providing showers with change of clothing for visitors; and others. These are not included in the questionnaire because no pig farms in the sample were using these techniques in the pretest period. As shown in Table 3.1, all farms were disposing of carcasses properly (mean = 1), visitors were mostly prohibited, and workers were segregated from other pig herds. More than 50 percent of households were using 15 of the 20 measures. It is worth noting that only 49 percent of respondents possessed vaccination certificates, which are important for disease control. In addition, it was rare not to feed hogs with kitchen waste (6 percent).

Other variables used in the analysis are as follows:

Age:	age of pig farm owner
Schooling:	number of years of education of pig farm owner
Experience:	the experience in years of hog production of pig farm owner
Number of hogs:	the number of hogs on the pig farm at the time of the survey
Ratio of income:	the ratio of revenue from selling hogs to the total income of hog producer
Loan:	a dummy variable that equals 1 if the hog producer has a loan from a financial institution, 0 otherwise
Vaccine:	the average cost of vaccine for one hog in CNY
Sow vaccine:	the average cost of vaccine for one sow in CNY
Insurance:	a dummy variable that equals 1 if the hog producer buys hog insurance, 0 otherwise
Biosecurity score:	the number of biosecurity practices adopted by the hog producer

Table 3.2 presents the summary statistics. On average, the head of household was 45 years old with 7.16 years of education, which is relatively low but common in agricultural villages. The average years of experience in hog production was 8.28 with a maximum of 30 years. On average, there were less than 440 hogs per farm. Revenue from selling hogs, on average, accounted for 77.17 percent of the producer's total income, and some farms were fully specialized in hog production. Thirty eight percent of pig farms had obtained bank loan. The average unit cost of hog vaccine was 6.76 CNY. To pursue higher quality, farmers paid up to 30 CNY per hog for vaccine. The vaccine cost was much higher for sows, with an average of 22.15 and a maximum of 150 CNY. Only 33 percent of pig farms purchased hog insurance.

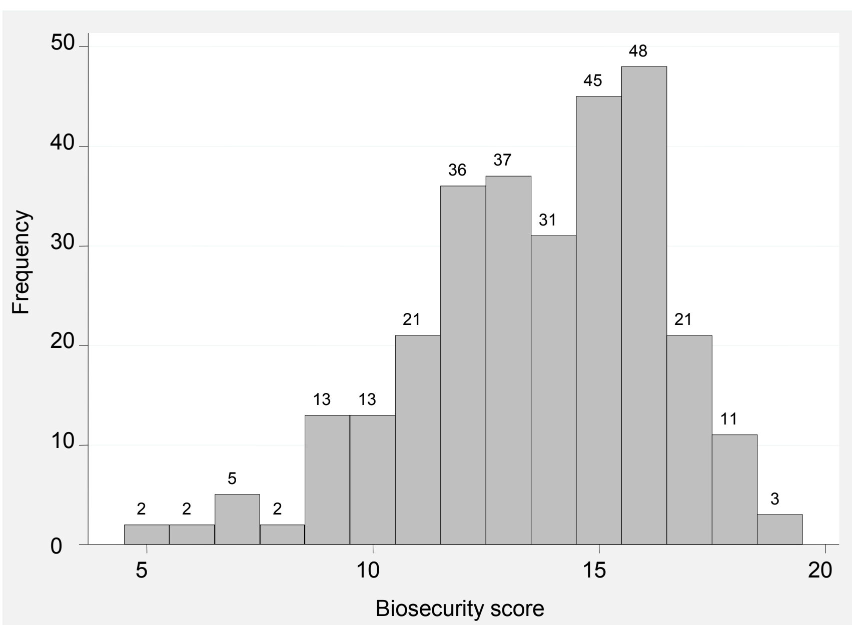
Table 3.2—Summary statistics

Variable	Mean	Std. dev.	Min.	Max.
Total sample *N* = 290				
Age	45.49	7.58	22	77
Schooling (years)	7.16	2.58	1	13
Experience (years)	8.28	4.50	1	30
Number of hogs	438.87	315.26	100	1,500
Ratio of income	77.17	19.78	10	100
Loan	0.38	0.36	0	1
Vaccine	6.76	6.41	0	30
Sow vaccine	22.15	18.16	0	150
Insurance	0.33	0.47	0	1
Biosecurity score	13.63	2.73	5	19

Source: Hog producer survey, De-Ching County, Zhejiang Province, China, 2009.

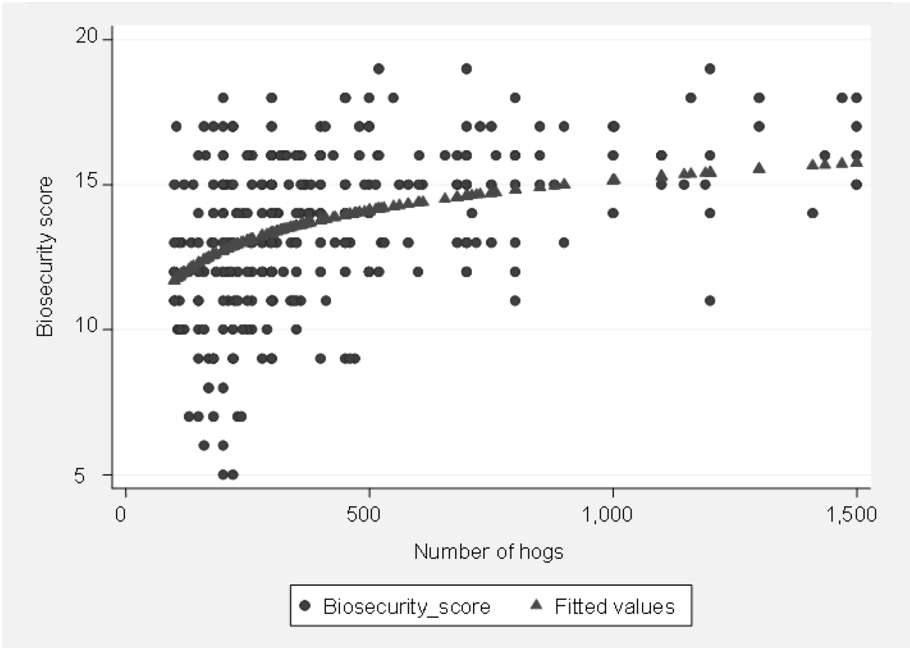
Based on the answers regarding biosecurity status, we established a biosecurity score for each household by counting the number of measures adopted. These scores ranged from 5 to 19. Figure 3.1 shows the distribution of biosecurity scores. A very small number of farms had a score of less than 10. Almost half the farms (47 percent) had scores of 15 or higher. Figure 3.2 demonstrates the relation between size of pig herd and biosecurity score, indicating that the scores increased with herd size in level-log form. This implies that for larger herds there tends to be more rigorous risk management.

Figure 3.1—Frequency distribution of biosecurity scores



Source: Hog producer survey, De-Ching County, Zhejiang Province, China, 2009.

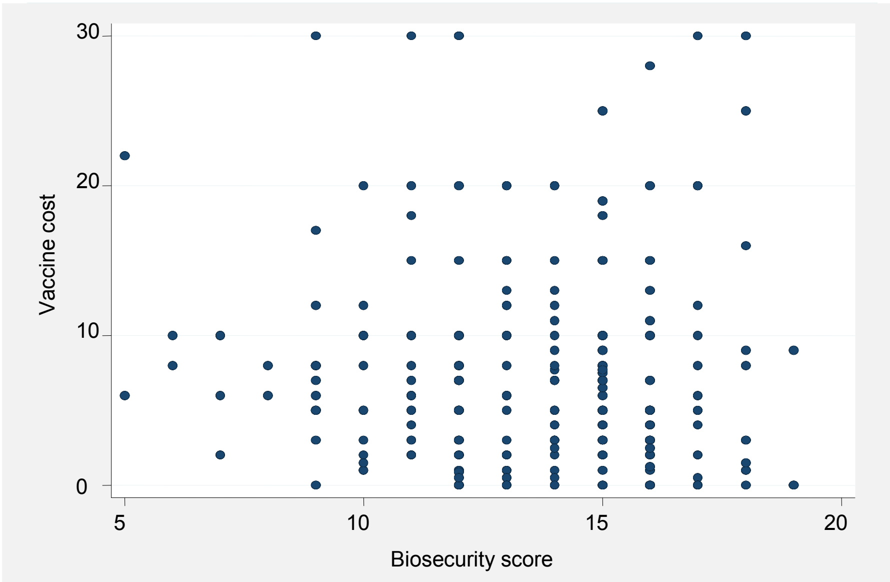
Figure 3.2—Relation between size of hog herd and biosecurity score



Source: Hog producer survey, De-Ching County, Zhejiang Province, China, 2009.

Intuitively, one would expect biosecurity practices and the unit cost of vaccine to be closely related to each other because both have the same function of loss prevention. We plot the correlation between these two measures in Figure 3.3. Surprisingly, there is no clear pattern, indicating that the choice of vaccine quality has nothing to do with the producer's biosecurity score. There are two possible reasons for this situation. First, biosecurity practices should be set up in the very beginning of the hog production process as standard procedures implemented over the long term. In contrast, the choice of vaccine and hog insurance are short-term decisions and might be adjusted frequently. Second, a simple correlation may not reveal the complex relations in which multiple variables are involved. Figure 3.3 displays the simple correlation to show that the decision about vaccine quality seems to be independent of biosecurity practices. A further exploration of this relation that takes the effect of multiple variables into account will be discussed later.

Figure 3.3—Randomization of selection of vaccine quality by biosecurity score



Source: Hog producer survey, De-Ching County, Zhejiang Province, China, 2009.

Based on Figure 3.3, it is interesting to examine whether vaccine quality (as measured by cost) and biosecurity score are connected with the purchase of hog insurance. We separated all samples into two groups by insurance status: with and without hog insurance. Table 3.3 displays summary statistics and mean test results. All of the key variables except age and loan are significantly different between groups with and without hog insurance. In particular, vaccine cost is significantly higher and biosecurity score is significantly lower, both at the one percent level, in the group without hog insurance. These initial findings suggest that high-quality vaccine and hog insurance are substitutes and that biosecurity score and hog insurance are complements. It is worth noting that producers with hog insurance have more years of education, a greater numbers of hogs, more years of experience in hog production, and a larger ratio of hog income to overall income.

Table 3.3—Summary statistics for groups with or without insurance

Variable	Without insurance				With insurance			
	(1) Mean	(2) SD	(3) Min	(4) Max	(5) Mean	(6) SD	(7) Min	(8) Max
Age	45.54	8.14	22	77	45.39	6.33	31	59
Schooling	6.87***	2.42	1	12	7.75	2.80	1	13
Number of hogs	381***	277	100	1,500	557	354	100	1,500
Years of experience	7.75***	4.19	1	22	9.36	4.92	3	30
Ratio of income	75.73*	20.17	10	100	80.07	18.73	18	100
Vaccine cost	7.36**	6.40	0	30	5.54	6.29	0	30
Sow Vaccine	23.91**	19.40	0	150	18.60	14.82	0	100
Loan	0.36	0.48	0	1	0.42	0.50	0	1
Biosecurity score	13.35**	2.85	5	19	14.21	2.37	7	19
Number of households (*N* = 290)	194 (67%)				96 (33%)			

Source: Authors' calculations from hog producer survey, De-Ching County, Zhejiang Province, China, 2009.
Notes: *, **, and *** represent significant difference from group with hog insurance in column (5) at 0.10, 0.05, and 0.01 levels, respectively.

4. EMPIRICAL MODEL AND ESTIMATION

To understand producers' decisions on biosecurity practices, quality of vaccine, and hog insurance, we set up a simultaneous three-equation model as follows:

$$P(INSURANCE \mid BIO\text{-}SCORE, VACCINE) = \mathbf{X\gamma} + \gamma_1\ BIO\text{-}SCORE + \gamma_2\ VACCINE, \quad (1)$$

$$BIO\text{-}SCORE = \mathbf{X\alpha} + \alpha_1\ VACCINE + \alpha_2\ INSURANCE + \varepsilon, \quad (2)$$

and

$$VACCINE = \mathbf{X\beta} + \beta_1\ BIO\text{-}SCORE + \beta_2\ INSURANCE + \nu. \quad (3)$$

Equation (1) describes the demand for hog insurance (*INSURANCE*) as a dichotomous variable that is determined by two endogenous variables, biosecurity score (*BIO-SCORE*) and vaccine cost (*VACCINE*), and a set of exogenous variables (X). The rationale is that when hog producers invest in better biosecurity practices or higher-quality vaccine, the possibility of loss is theoretically reduced. Consequently, the purchase of hog insurance is not absolutely necessary. In addition, biosecurity score and vaccine cost are not only mutually determined but also affected by the decision to insure, as described in equations (2) and (3).

Combining the above equations—one probit and two structural—we have a mixed-process model, which requires a three-stage estimation. In the first stage, we predict biosecurity score and vaccine cost in terms of all exogenous variables in the model. In the second stage, we estimate each equation by replacing those endogenous variables appearing in the right-hand side of the above equations with predicted ones. In the third stage, we run the seemingly unrelated regressions (SUR) to take into account the correlations among error terms in the model. However, the estimation method of a standard three-stage regression cannot meet the needs of our model because, by nature, a mixed-process model contains both dichotomous and continuous endogenous variables. In this study, we use the cmp procedures developed by Roodman (2009) in the environment of STATA software to solve the estimation problem. Table 4.1 presents the regression results. In model 1, the producers' biosecurity score has a significantly positive effect on the uptake of hog insurance, indicating a complementary relationship between these two variables. Vaccine cost is significantly negative at the 5 percent level, highlighting the relationship of substitution between vaccine quality and demand for hog insurance. After pursuing high-quality vaccine, which provides stronger disease prevention, there is less necessity to purchase hog insurance. In addition, the results indicate that the higher the number of hog production experience years, the higher the propensity to purchase hog insurance, which is also to be expected.

Table 4.1—Three-stage regressions of decisions on risk management tools in the hog production process

Dependent variable Explanatory variable	Model 1 With insurance or not	Model 2 Biosecurity score	Model 3 Vaccine cost
Biosecurity score	0.0597 ** (0.0304)		0.3354 *** (0.1282)
Vaccine cost	- 0.0295 ** (0.0129)	0.0988 *** (0.2337)	
Insurance		12.4870 *** (1.1213)	- 24.3193 *** (2.7205)
Age	- 0.0058 (0.0107)		
Schooling		0.1478 *** (0.0517)	
Experience (years)	0.0506 *** (0.0182)		
Ratio of income			0.0451 *** (.0156)
Loan		- 0.8174 *** (0.2757)	
Sow vaccine			0.1308 *** (0.0169)
Constant	- 1.2318 * (0.6618)	8.0922 *** (0.5852)	3.8396 *** (1.8259)
Observations: 290	Log-likelihood = -174.4764 Pseudo R2 = 0.0524	Adj R-square = 0.3227	Adj R-square = 0.3909

Source: Authors' calculations from hog producer survey, De-Ching County, Zhejiang Province, China, 2009.
Note: ** and *** represent significance at 0.05 and 0.01 levels, respectively.

Model 2 shows the results of determinants of biosecurity score. Both vaccine cost and hog insurance are significantly and positively related to biosecurity score at the one percent level. These results indicate that households deploy self-protection and market insurance strategies alongside biosecurity practices. It seems that bio-security practices are a standard approach to the hog production process and that hog producers, who are more likely to be risk averse, prefer to employ a secondary loss prevention procedure. In addition, the results indicate that the higher the education level, the higher the biosecurity score, which is also reasonable. Model 3 displays the estimation results for vaccine choice. Consistent with the findings in models 1 and 2, hog insurance is found to be negatively related to quality of vaccine at the one percent level while biosecurity score is positively related to quality of vaccine. This result confirms the indirect relationship between vaccine quality and hog insurance uptake, and the direct relationship between vaccine quality and biosecurity score. In addition, the higher the ratio of revenue from selling hogs to total income of hog producer, the better the vaccine quality. In sum, biosecurity practices seem to serve as the basic infrastructure utilized in the operation of pig farms while hog producers tend to adopt one additional risk management tool such as higher vaccine quality or hog insurance but not both.

5. TESTING MORAL HAZARD

To further examine whether hog insurance provides incentive for hog producers to be less careful in the process of hog production, we test the moral hazard effect in this section by estimating a loss equation. The dependent variable in the loss equation is the loss ratio of hog insurance *which is calculated as total loss divided by total premium.* We use it as the response variable and consider the variables directly related to loss. In particular, we take vaccine cost (*VACCINE*), biosecurity score (*BIO-SCORE*), and insurance premium (*PREMIUM*) as the key independent variables, together with other control variables (**X**). The model is

$$\text{Loss ratio} = \mathbf{X\beta} + \beta_1\ VACCINE + \beta_2\ BIO\text{-}SCORE + \beta_3\ PREMIUM + \varepsilon\ , \tag{4}$$

where β_1, β_2, and β_3 are the parameters of primary interest, and ε is an independent and normally distributed error term. Since not all households purchase hog insurance, we adopt Heckman's two-stage procedure to solve the sample selection problem. Before equation (4) is estimated, a probit (logit) regression is used to predict the probability of buying insurance, as follows:

$$\Pr(\text{buy hog insurance}) = \Phi(\mathbf{X\gamma})\ , \tag{5}$$

where Φ represents the standard normal cumulative distribution function and $\boldsymbol{\gamma}$ is a vector of model coefficients to be estimated. We include all available policy details in the predictor matrix $\mathbf{X}$: age, years of schooling, experience (in years) at raising hogs, expenditures on hog vaccine, number of hogs, ratio of revenue from selling hogs to total income, and whether a loan has been obtained from a bank. After applying Heckman's estimation, a lambda variable can be obtained from equation (5) and used as an additional control variable in equation (4), adjusting for the sample selection bias.

Table 5.1—Summary statistics by premium per unit of insurance

Unit premium (in CNY)	360 or 400	500
Number of households	23	73
N = 96 (ratio)	(24%)	(76%)
Farm size (number of hogs) mean	603	542
SD	350	356
Premium expenditure mean	4854.29	13,028.75
SD	2940.37	12,413.20
Biosecurity score mean	14.04	14.26
SD	1.82	2.53
Loss ratio (total loss/total premium) mean	.52	.78
SD	.80	.90

Source: Authors' calculations from hog producer survey, De-Ching County, Zhejiang Province, China, 2009.

Before running the regression, we compare the summary statistics of the pig farms choosing low (360 or 400 CNY) and those choosing high (500 CNY) unit premiums. As Table 5.1 shows, those farms with lower unit premiums have relatively larger size but pay less in total premiums on average. The biosecurity scores are similar between these two groups. However, farms choosing premiums of 500 CNY per unit have significantly higher loss ratios than those with premiums of 360 or 400 CNY per unit, indicating a moral hazard phenomenon.

Table 5.2 shows the Heckman two-stage regression results. In model 1, the probability of buying hog insurance is estimated in the first stage. Education level and hog-raising experience of households, as well as the scale of the farm, reveal a significantly positive tendency to purchase insurance. In contrast, households that spend a higher amount on vaccine for their hogs are less likely to buy insurance. The high quality of vaccine can substitute for insurance. Biosecurity score in particular plays no role in the demand for insurance, indicating that biosecurity practices seem to be the standard procedures in hog production. Financial status—revenue from hog production as a percentage of income and existence of a bank loan—does not affect the likelihood of buying insurance. In the second stage, loss ratios are examined for those households with hog insurance. As expected, better biosecurity status and management practices and the provision of high-quality vaccine significantly help to reduce loss ratios.

Table 5.2—Estimates of Heckman two-stage regression

	Model 1		Model 2	
	Coefficient		Coefficient	
Dependent variable: with insurance or not				
Age	0.0059		0.0054	
	(0.01125)		(0.0124)	
Schooling	0.0744	**	0.0770	**
	(0.0344)		(0.0341)	
Experience (years)	0.0349	**	0.0357	*
	(0.0193)		(0.0192)	
Vaccine cost	- 0.0321	**	- 0.0332	**
	(0.0144)		(0.0144)	
Biosecurity score	0.0222			
	(0.0373)			
Ln(no. of hogs)	0.3631	***	0.3960	***
	(0.1244)		(0.1058)	
Ratio of income	- 0.0003			
	(0.0045)			
Loan	0.1621		0.1482	
	(0.1766)		(0.1750)	
Constant	- 4.0176	***	- 3.9212	***
	(0.9083)		(0.8831)	
Dependent variable: loss ratio				
Age	- 0.0011		- 0.0001	
	(0.0112)		(0.0116)	
Schooling	0.0733	**	0.0854	***
	(0.0335)		(0.0330)	
Experience (years)	- 0.0017		- 0.0014	
	(0.0158)		(0.0168)	
Vaccine cost	- 0.0312	**	- 0.0358	**
	(0.0147)		(0.0146)	
Biosecurity score	- 0.0834	**	- 0.0874	**
	(0.0393)		(0.0358)	
Ln(no. of hogs insured)	- 0.4228			
	(0.3857)			
Ln(total premium)	0.5947	**		
	(0.3228)			
Ln(self-paid premium)			0.2553	***
			(0.0882)	
Mills	0.3177		0.4875	
lambda	(0.4096)		(0.3582)	
Constant	- 1.5821		- 1.2732	
	(1.4717)		(1.3826)	
Wald Chi-square	34.30		32.06	
Probability > Chi-square	0.0006		0.0004	

Source: Authors' calculations from hog producer survey, De-Ching County, Zhejiang Province, China, 2009.
Notes: Standard deviations are in parentheses. *, **, and *** represent 10 percent, 5 percent, and 1 percent significance levels.

However, we also find a moral hazard effect in that higher premium expenditure by the insured households might induce larger loss ratios. Education level also shows a significantly positive effect on loss ratio. More experience in hog production is associated with lower loss ratios, but this relationship is insignificant.

In model 2, we ignore the biosecurity factor and income share in the first stage and obtain results similar to those of model 1. In the second stage, the size of the pig herd and the total premium are replaced by the self-paid premium (which is the total premium minus the premium subsidy provided by government) of households, assuming that other variables remain the same. The results show that self-paid premium has a positive effect on the loss ratio that is significant at the one percent level, highlighting a moral hazard similar to that observed in model 1. Risk management variables such as vaccine quality (as measured by cost) and biosecurity practices reveal significantly negative coefficients.

6. CONCLUSION

Based on detailed survey data, this paper explores the biosecurity practices adopted by pig farms in De-Ching County, Zhejiang Province, China. We examine the relations among loss prevention procedures and market insurance for pig farms. We analyze whether risk management procedures are connected to loss ratio and to demand for high-quality vaccine and hog insurance. Our findings indicate that biosecurity status adopted by pig farms has a significant positive effect on the selection of high-quality vaccines and provides an incentive for buying insurance. In addition, the action of choosing a high-quality vaccine or purchasing hog insurance also has a significantly positive effect on biosecurity practices. However, the quality of vaccine demonstrates negative effect on the decision to purchase insurance. There is a trade-off between vaccine quality and hog insurance. Our findings contain some policy implications for pricing of hog insurance. Currently, the premiums of hog insurance are determined by the choice of deductible alone. Ehrlich and Becker (1972) argued that if insurance premiums are set up by taking into account self-protection (such as vaccination), market insurance and self-protection would be complements. In other words, the negative association between vaccine quality and hog insurance that we found might be reversed. In addition, if biosecurity practices are connected with insurance premiums, risk management can be improved. For those households with hog insurance, our major findings reveal that both biosecurity measures and quality of vaccine perform well in reducing loss ratio. Nevertheless, a higher insurance premium provides a higher incentive for loss claims. A limitation of the dataset is the lack of loss data for pig farms without insurance. A further study could be made to compare the connections between biosecurity practices and loss measures in the future.

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