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Farmers' Willingness to Pay for a Porcine Reproductive and Respiratory Syndrome (PRRS) Vaccine in Thua Thien Hue Province, Vietnam

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Abstract

Vietnam is a major pork producing country, but the livelihood of pig farmers is threatened by the pig disease Porcine reproductive and respiratory syndrome (PRRS). Although vaccination is the most practical method of choice for PRRS control, the vaccination percentage is very low in Vietnam. To help inform PRRS vaccine development and policy, our research employed the choice experiment method to assess pig farmers' attitudes toward and willingness to pay (WTP) for a PRRS vaccine. The results found a high positive WTP value for the PRRS vaccination program in Vietnam. This study provides insight into the possibility of increasing the PRRS vaccination percentages.

Keywords: pork disease, willingness to pay, vaccine, Vietnam

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Introduction

Porcine reproductive and respiratory syndrome (PRRS) is a highly contagious, economically devastating disease in pig production. Since 2006, China's pig-farming sector has been damaged by PRRS, resulting in huge economic losses in the Chinese pig industry (An et al. 2010). This disease quickly spread from China to Vietnam during the Beijing Olympic Games in 2008 (Zhang and Kono 2012). Total deaths of PRRS-infected pigs exceeded 300,000, and 26 of 60 provinces were affected during 2008 (Zhang et al. 2014). PRRS has already become an endemic pig disease in Vietnam (OIE 2015).

Vietnam is a major pork producing country in Asia, producing 3.2 million tons in 2013 (FAOSTAT 2015). Pig production is of great importance in Vietnam, and accounts for 75.45% of total livestock production (FAOSTAT 2015). Approximately 80% of pig production is small-scale, and pig production is the major source of income for those small-scale farms (Lemke et al. 2008). Therefore, PRRS outbreaks severely damage the livelihood of pig farmers (Zhang and Kono 2012).

To control PRRS in Vietnam, a stamping out (SO; culling all infected pigs) control strategy was applied in Vietnam during the outbreak period, and the government provided a culling subsidy to encourage pig farmers to cull infected pigs. Zhang et al. (2013b) clarified that the current SO strategy is epidemiologically effective and economically efficient. However, an epidemiological and economic modeling study by Zhang et al. (2014) demonstrated that SO combined with vaccination is more economically efficient than SO alone.

The primary problem of PRRS vaccination in Vietnam is that the vaccination percentage[1] on farms is very low. Only a small portion of large commercial pig farms apply the PRRS vaccine. Furthermore, the PRRS vaccine is available only as a costly imported vaccine (it costs 40,000 Vietnamese dongs (VND) per dose; 1 U.S. dollar = 21,090 VND), and that vaccine was developed from a cultured PRRS virus in China. Unfortunately, the efficacy of "Made in China" vaccine is limited, so a government project for the development of a PRRS vaccine is being carried out in Vietnam.[2] In addition, another problem with PRRS vaccination is that, although certification of classical swine fever (CSF) and foot-and-mouth disease (FMD) vaccination are currently required to sell pigs in Vietnam, no certification of PRRS vaccination is required to sell pigs. Furthermore, the government provides a culling subsidy for all culled pigs, but PRRS vaccination is not a condition for the subsidy. Therefore, there is no incentive for farmers to adopt PRRS vaccination.

To successfully disseminate PRRS vaccination in Vietnam, it is essential to investigate the pig farmers' preferences for key attributes in the design of a PRRS vaccination program. However, to the best of our knowledge, there has been no such study to date. The purpose of the present study was to use field research to assess the pig farmers' preferences for PRRS vaccination in Vietnam using a choice experiment (CE) approach, and clarify the incentives for farmers to

[1]The vaccination percentage in this study is % of farms.
[2]Personal communication with Nguyen Van Hung (Director of Thua Thien Hue Department of Animal Health, Vietnam), during the field survey of this study between February 25th and March 4th, 2013.

vaccinate their pigs. The findings of this study will help to inform vaccine policy for disseminating PRRS vaccination in Vietnam.

Material and Methods

In 2008, there were 1,077 PRRS outbreaks in Vietnam, infecting 300,906 pigs (Zhang and Kono 2012). The number of outbreaks decreased in 2009, but became widespread again in 2010. PRRS outbreaks were severe in the North Central Coast area of Vietnam in 2008. Thua Thien Hue (Hue) Province is located in the North Central Coast area (Figure 1), and the government-directed system for animal disease control in Hue Province is considered to be outstanding in Vietnam (Zhang et al. 2013b). Therefore, we selected Hue Province as our study area.[3]

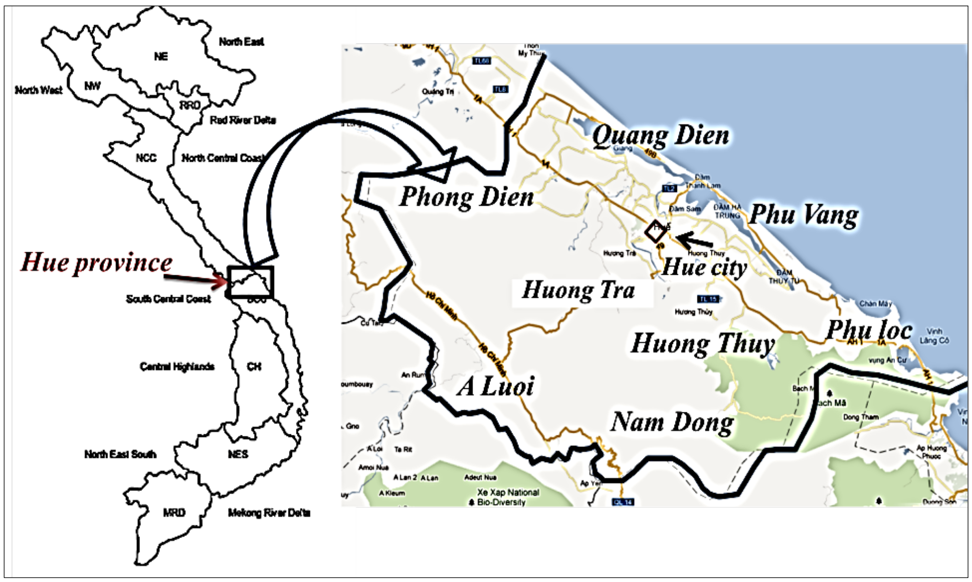

Figure 1. Location of Hue Province
Source. Veterinary office in Hue Province

A survey was conducted in villages by staff members of the Hue University of Agriculture and Forestry to collect data using an interview-based questionnaire between February 25th and March 4th, 2013. To clarify the difference in preferences for PRRS vaccination between PRRS-affected farmers (the PRRS infections occurred on their farms in 2008) and non-affected farmers, a total of 101 households were surveyed, of which 50 households had been infected by PRRS, and 51 households had not. Samples were selected randomly from a "farm list" provided by a local

3 Southeast Asia has a high pig density, and PRRS outbreaks occurred primarily in this area. Hue Province has a high pig density and PRRS was severe in this province. Hue province is located in the North Central Coast area, and this province is the only province in Vietnam where central slaughter houses have been controlled by government successfully, and all livestock is slaughtered in these centers. Many governmental officers from other provinces or other countries also visited Hue Province for educational purposes. The governmental direction system for animal disease control in Hue Province is considered to be outstanding in Vietnam. After the 2008 PRRS outbreak, the Hue government enhanced animal disease surveillance system in this area, and no further PRRS infection was officially reported (Zhang et al. 2013b). For these reasons, we chose Hue as our study area.

veterinary office. The sample collection area is Huong Tra district (the main pig farming area in Hue province; there are eight villages and over 800 pig farms in this district). The distances between samples were kept constant, to avoid samples close to each other and to spread the samples uniformly around Huong Tra district.

In order to ensure a balanced sampling, a set of criteria was developed by the authors and discussed with local veterinarians and an agricultural economic expert from Hue University. These criteria included a household concern with and interest in the PRRS vaccine. Other criteria were age, years of experience, and size of a pig farm.[4]

The PRRS vaccine examined in the present study is not yet available in the markets, because it is still being developed by the Vietnamese government project. Therefore, methods suited to measure the value of a commodity not yet available in the market needed to be applied.[5] Stated preference approaches have been widely used for this purpose. CE in particular has become increasingly popular (Louviere et al. 2000).

CE studies relating to livestock disease control are relatively few. Articles that report the use of CE for evaluating people's preferences in relation to livestock disease control include Otieno et al. (2011), who used CE to understand Kenyan farmers' preferences regarding the type of disease-free zones that would be readily acceptable to them, and Bennett and Balcombe (2012), who applied CE and contingent valuation (CV) to estimate farmers' willingness to pay (WTP) for a tuberculosis cattle vaccine.

Following the CE design process of Bennett and Balcombe (2012), the present research involved a number of stages prior to undertaking the survey, designed to ensure that the assumptions used were robust, scientifically realistic and well-grounded in terms of the level of understanding of Vietnamese pig farmers. These stages involved the identification of vaccine attributes, the initial questionnaire design, forming a focus group with pig farmers, further development and pretesting of the questionnaire, and a pilot survey.

Our survey began with the identification of policy-relevant PRRS control features through an in-depth interview with key officials of the Ministry of Agriculture and Rural Development (MARD) in Hanoi, and local veterinarians in Hue Province. We also held focus group discussions with local pig farmers, veterinarians, and economic experts from Hue University. Following the guidelines proposed by Bateman et al. (2002), the focus group discussions

[4]In the case of Hue and most other areas in Vietnam, some farmers raise pigs occasionally or seasonally. Those farms usually raise one or two pigs and sell them just before the Chinese new year season, or the flooding season (in Hue, there is a flood every year from June to August, and most farms sell all of their pigs before flooding season). Due to this reason, we selected the pig farms that raise pigs continuously and where pig farming is their main income source.

[5]The PRRS outbreak in Vietnam was caused by the newly emerged virulent strains of the PRRS pathogen virus (HP-PRRS virus). The PRRS vaccine, developed from other strains of PRRS pathogen virus in other countries might not be effective for controlling the PRRS outbreak in Vietnam. For this reason, the government project on PRRS vaccine development is being carried out in Vietnam (Field survey, 2012). Therefore, to calculate a pig farmer's willingness to pay for a PRRS vaccine (which is developed from HP-PRRS virus to control the PRRS outbreak in Vietnam), economic techniques for measuring the value of a commodity not yet available in the market had to be applied. This is why we chose stated preference approaches and the CE method.

included four small-scale pig farmers recruited from Huong Tra District, Hue Province, where there was a severe PRRS outbreak in 2008, two veterinarians from the Huong Tra District Veterinary Office, two economic experts from Hue University, and the director of the Animal Health Department of Hue Province. The focus group discussions were also used to explore important attributes that were identified and their inclusion in the CE. Following pre-testing of the questionnaire, three pilot surveys were undertaken before the main survey was commenced in order to test the survey method.[6]

Three attributes were ultimately selected for the CE design:

1. Vaccine administration (if the pigs are vaccinated, the farmer obtains a PRRS-vaccinated certification);
2. Culling subsidy (if a PRRS infection occurs on the farms, then the government provides compensation for those farms to cull infected pigs) [7]; and
3. The Price of vaccine (if pig farmers want to vaccinate their pigs, they have to pay the cost of the vaccine itself and the veterinary service charge) .[8]

Table 1. Attributes and levels for CE

Attribute	**Unit**	**Levels**
Vaccine administration	Dummy	Adopt=1, Not Adopt=0
Culling subsidy	%	25, 50, 75, 100
Price of vaccine	**(VND)**	30,000, 40,000, 50,000

The attribute of vaccine administration had 2 levels, the attribute of culling subsidy had 4 levels, and the attribute of price had 3 levels, generating 24 full-profile choice cards for respondents to fill out (Table 1). From these, 12 unrealistic choices were deleted (for example, the combination of ‘non-acceptance of vaccine administration’ with ‘price of vaccine and culling subsidy’). Because the total numbers of attributes and the choices generated are relatively small, we used all of the choices to create six CE questions in one questionnaire. The respondents were then presented with the full set of six pair choices (totaling 12 individual profiles choice cards, an example of one pair of choices appears in Table 2). Following Bennett and Balcombe (2012), for each question, the choice ③ is fixed and is always “No vaccination” and “Compensation 0%”). Prior to answering the survey, the respondents were provided with an explanation of the

[6]The first pretest survey was conducted in September, 2012. The farmers were confused when answering the original questionnaire, e.g., they believed that vaccinated pigs must have certification, and did not understand why there was an alternative under which vaccinated pigs were not required to have certification. We also found it very difficult to explain the CE question if the attributes were more than four. The second pretest survey was conducted in March, 2013, and the CE design was again modified slightly. The final pretest survey was conducted just before the main survey began.

[7]According to Ministry of Agriculture and Rural Development (MARD) regulation No. 80/2008/QD-BNN, in 2008, PRRS-infected farms were paid a subsidy of 25,000VND per kg of infected pig, which was approximately 70% of the market value of pigs at that time. Based on this information, we set the attribute of “Compensation” at four levels: 25%, 50%, 75% and 100%.

[8]According to an interview with the director of the Animal Health Department of Hue Province, the government permitted PRRS vaccines made by Guangdong Dahuanong Animal Health Product Co. Ltd., in China. The vaccine costs 40,000 VND per dose, including the veterinary service charge. Based on this information, we set the attribute of “Price of vaccine” at three levels: 30,000, 40,000 and 50,000 VND per dose per pig.

hypotheses in the CE question (Table 3). The questionnaire used in this study can be found, in the online version, at: http://wenku.baidu.com/view/f435d764a6c30c2259019e8b.html.

Table 2. CE Questions Example

	Choice ①	Choice ②	Choice ③
Vaccination	Yes	Yes	No vaccination
Price of vaccine (VND)	30,000 per pig	40,000 per pig	
PRRS-free Certification	Yes	Yes	
Compensation	50%	75%	0%

The conceptual framework of CE is derived from Lancaster's theory of consumer choice (Lancaster 1966), which postulates that preferences for goods are a function of the attributes of the goods, rather than of the goods themselves. An analysis of CE data follows the behavioral framework of random utility theory (McFadden 1973), which describes discrete choices in a utility maximizing framework. We applied the random parameter logit (RPL) model in the present analysis.[9] The RPL provides a flexible and computationally practical method for analyzing the results from CE surveys. The specification and estimation of the RPL model follows Revelt and Train (1998), to which the reader is referred for details.

Table 3. Hypotheses in CE question

Hypothesis	**Explanation**
Vaccine efficacy 90%	This vaccine was developed in Vietnam. If pigs are vaccinated, over 90% of vaccinated pigs can be protected from PRRS infection (vaccination reduces the probability of infection).
Certification	Pigs can obtain PRRS-vaccinated certification after they are vaccinated.
Culling subsidy	If a PRRS outbreak occurs after the pigs are vaccinated, farmers can receive a culling subsidy from the government. If the pigs are not vaccinated, no subsidy will be paid, even if an outbreak occurs.
Culling subsidy	Dose per pig price. Veterinary service charge is included.

The indirect utility function of the individual i who chooses alternative (choice) j in alternative (choice) set C_i can be written in the form:

$$(1)\ U_{ij} = V_{ij} + \varepsilon_{ij}$$
$$\mathrm{i} = 1,2,3 \ldots\ldots\ldots \mathrm{n} \quad \mathrm{j} = 1,2,3 \quad \in C_i$$

The utility function of this model assumes that the observable component of utility V_{ij} is known

[9] Either the RPL or the latent class model could be used to investigate preference heterogeneity. There are no theoretical grounds for the choice of one over the other (Greene and Hensher 2003). We explored both approaches, but found the RPL to fit the sample data better.

for each individual *i* and choice j.[10] Without the covariates, with the exception of the error term ε_{ij}, and without considering the individual attributes, the observable deterministic component of the indirect utility function V_{ij} is:

$$(2)\ V_{ij} = \beta_1 Vaccine_{ij} + \beta_2 Culling\ Subsidy_{ij} + \beta_3 PRICE_{ij}$$

Where "Vaccine" is a dummy variable which 1=vaccinated and 0=not vaccinated (Table 1); "Culling subsidy" is the compensation amount of the market value of the culled pigs (Table 1; Note 7); "Price" is the vaccine value per dose (Table 1; Note 8). β_1, β_2, β_3 are the parameters should be estimated in the random parameter logit model. However, in this study, individual farms may vary in size and the farmers' understanding of and concern about PRRS outbreaks may differ (attitude statements in Figure 2). Therefore, they would have different preferences for the PRRS vaccination. To understand those differences, the new model (with interaction term) was created:

$$(3)\ V_{ij} = \beta_1 Vaccine_{ij} + \beta_2 Culling\ Subsidy_{ij} + \beta_3 PRICE_{ij} + \sum_{h=1}^{6} \lambda_h\, Vaccine_{ij} S_{h,i} + \sum_{h=1}^{6} \psi_h\, Culling\ Subsidy_{ij} S_{h,i}$$

In which $\sum_{h=1}^{6} S_h =$ (Number of pigs, attitude statement Q1, attitude statement Q2, attitude statement Q3, attitude statement Q4, attitude statement Q5,and the details interpretation of those variables are represented in Note 11)[11], and the $\sum_{h=1}^{6} \lambda_h$, $\sum_{h=1}^{6} \psi_h$ and $\sum_{h=1}^{3} \beta_h$ are the parameters which should be estimated in the random parameter logit model. The parameter β_1 and β_2 in equation (2) and (3) are random parameters, and the estimations of these two parameters will be decomposed by their means and standard deviation. Other parameters are fixed. The probability that individual *i* choses choice *j* is expressed by the standard logit formula:

$$(4)\ P_{(j|V_i)} = \frac{e^{V_{ij}}}{\sum_{q=1}^{j} e^{V_{iq}}}$$

The V_{ij} in equation (2) and (3) are the unobservable component of utility, and it transformed into probability P in equation (4).

Results

The average age and level of education were similar between non-affected and affected farmers. However, the average pig numbers on the affected farms were smaller than those on non-affected farms (Table 4). According to an interview with a local veterinarian, some affected farms decreased the number of pigs being raised after a PRRS outbreak. After PRRS outbreak, some

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[10] The dependent variable in the model is the choice. If the Choice ① was chosen, then Choice ①=1, Choice ② and Choice ③=0; if the Choice ③ was chosen, then Choice ① and Choice ② =0, Choice ③ =1.

[11]When considering other farm related variables in the utility framework, it is unusual to include variables (such as "Farm size") in the utility framework directly. Therefore, following the similar analysis in the previous studies (Zhang *et al.*, 2013a; Kairu-Wanyoike *et al.*, 2014), we included farm related variables as interaction term ($\sum_{h=1}^{6} \lambda_h\, Vaccine_{ij} S_{h,i}$ and $\sum_{h=1}^{6} \psi_h\, Culling\ Subsidy_{ij} S_{h,i}$) in the utility framework. All variables of $\sum_{h=1}^{6} S_h$= are dummy variables. An example statement is: Number of pigs [Pig number > 8=1], attitude statement Q1 [Score > 3=1], attitude statement Q2 [Score > 3=1], attitude statement Q3 [Score > 3=1], attitude statement Q4 [Score > 3=1], attitude statement Q5 [Score > 3=1].

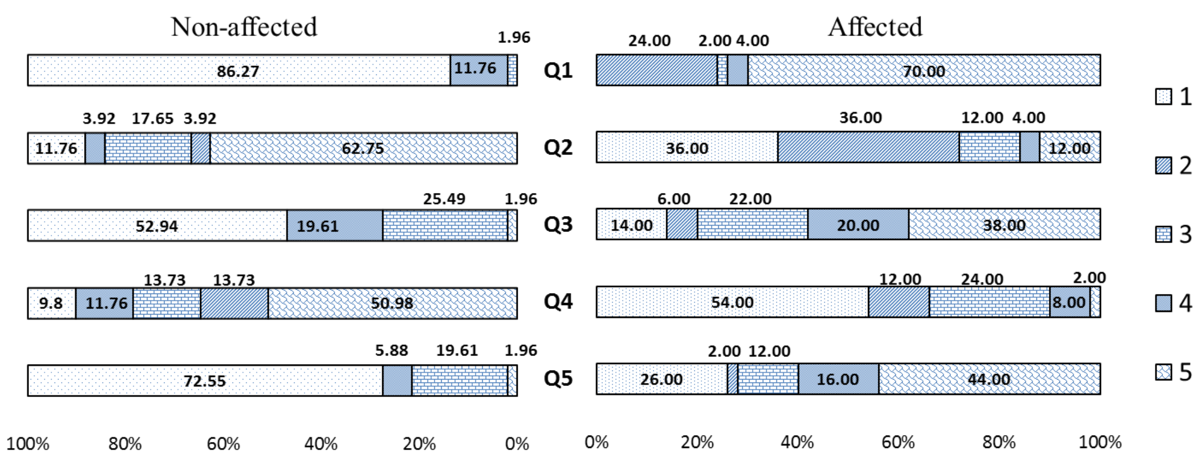
affected farmers felt it was risky to raise pigs, and they reduced pig number, so some of their family members changed their job from pig farming to working in urban area. Therefore, some of their family sizes were reduced (Table 4).

Table 4. Descriptive statistics about the data

	Average (Standard deviation)			
	Non-affected	Affected	*t*-test values	Pooled sample
Age (years)	53.55	56.46	-1.44	54.99
	(10.02)	(10.13)		(10.18)
Family number (People)	5.14	3.02	8.58***	4.09
	(1.37)	(1.10)		(1.63)
Pig farming Experiment (Year)	19.49	18.92	0.36	19.21
	(7.72)	(8.23)		(7.94)
Education (years)	8.71	8.28	0.85	8.50
	(2.16)	(2.79)		(2.50)
Pig numbers (head)	10.24	6.54	2.12**	8.41
	(9.85)	(7.31)		(8.88)
Sample size	51	50		101

Note. **significant difference (unpaired t-test; statistical significance level: 5%) between "Non-affected" and "Affected" samples.

To understand the pig farmers' understanding of and concern about PRRS outbreaks on their farms and in the whole country, attitude statement questions were also included on the questionnaire. The respondents were asked to score on a scale of 1-5 the extent to which they agreed or disagreed with each statement, where 1= strongly disagree and 5 = strongly agree. Farmers were provided a list and asked to check all that apply. Responses to those attitude questions are shown in Figure 2 below.



Q1: PRRS is a major risk for the pig farming industry in Vietnam
Q2: My farm has a high risk of PRRS outbreak
Q3: The PRRS vaccine can greatly reduce PRRS infection
Q4: I can prevent PRRS outbreaks by myself
Q5: Humans can be infected with the PRRS virus from infected pig

Figure 2. Frequencies of attitude statement questions
Note. The number on the bar chart means: percentage of those reporting 1 or 2, 3, and 4 or five.

Overall, these scores reflect the pig farmers' relatively low concern about the possibility of a PRRS outbreak on their farms. Interestingly, non-affected farmers thought that there is a higher risk of PRRS outbreak in Vietnam than affected farmers, and compared to the affected farmers, they also strongly believed that PRRS vaccine alone could prevent a PRRS outbreak. That is, before the PRRS outbreak in 2008, the PRRS vaccine was sold in Vietnam, which was made in China but was not effective for controlling this outbreak in Vietnam. Some farmers applied this vaccine to prevent an outbreak, but the outbreak still occurred. Therefore, affected farmers had less confidence in the effectiveness of the PRRS vaccine than non-affected farmers. On the other hand, most non-affected farmers (72.55%) strongly believed that statement Q5 ("Humans can be infected with the PRRS virus from infected pigs") is correct even though it is not true. This suggests that affected farmers are more knowledgeable about PRRS than non-affected farmers through the PRRS experience. Furthermore, non-affected farmers did not have the experience to understand how severely damaging a PRRS outbreak can be. Therefore, they incorrectly believed the vaccine had high efficacy to control PRRS, and they had relatively more confidence they could prevent PRRS outbreaks by themselves.[12]

Table 5. Reasons why farmers did not administer PRRS vaccination

	Non-affected		**Affected**		**Pooled sample**	
	No.	%	No.	%	No.	%
Price is too high	3	(5.88)	28	(56.00)	31	(31.00)
Pig pens are clean and disinfected, no need for vaccine	6	(11.76)	18	(36.00)	24	(24.00)
Difficult to obtain veterinary service	0	(0.00)	1	(2.00)	1	(1.00)
I think the PRRS vaccine is not effective	0	(0.00)	1	(2.00)	1	(1.00)
Did not know of PRRS vaccine	11	(21.57)	2	(4.00)	13	(13.00)
Farmers followed veterinarian's advice	12	(23.53)	24	(48.00)	36	(36.00)
I think vaccination is not important	0	(0.00)	4	(8.00)	4	(4.00)
PRRS never occurred in my farm	3	(5.88)	0	(0.00)	3	(3.00)
I am using imported PRRS vaccine (made in China)	0	(0.00)	18	(36.00)	18	(18.00)
No answer	1	(1.96)	6	(12.00)	7	(7.00)

Note. Respondents were allowed multiple answers

Table 5 shows reasons why farmers did not vaccinate their pigs.[13] For affected farmers, the main reason was the high price of vaccination, while some non-affected farmers simply did not know that there is a PRRS vaccine. Only a few of affected farms vaccinated their pigs, but no non-affected farms adopted PRRS vaccination (Table 5).

Table 6 gives the estimates of the mean and standard deviations of the parameters of the attribute variables. In the estimated results for the Non-affected and Affected groups, as well as those for the Pooled sample, all attribute coefficients were found to be significant. As expected, the price coefficient was negative; suggesting that a price increase would reduce the probability that pig farmers would choose vaccination. Furthermore, all attribute coefficients (except "vaccine administration" in the Affected group) had highly significant standard deviations, implying that

[12] In Figure 2, statement Q2 shows the low concern of non-affected farmers (2.0/5) of the possibility of PRRS outbreak; it is because they did not face this situation in the past. On the other hand, the affected farmers also show this low concern; it is because they got plenty of subsidies during the PRRS outbreak in 2008. According to Ministry of Agriculture and Rural Development (MARD) regulation No. 80/2008/QD-BNN, the stamping out (SO) control strategy was applied in Vietnam, and the government provided a culling subsidy (amounting to about 70% of the market value of all culled pigs) to encourage pig farms to cull infected pigs.

[13] This is the answer to the question "Why you did not vaccinate your pigs?" in the questionnaire.

there are, indeed, heterogeneous preferences for these attributes. On the other hand, it also seems that affected farmers have relatively fewer heterogeneous preferences for vaccine administration than non-affected farmers, possibly because they have a relatively similar preference for PRRS vaccination after the experience of an outbreak on their farms. However, the result of "pooled sample with interactions" indicates the number of pigs in a farm has no significant impact on a farmer's preference for PRRS vaccine, and attitudes in Figure 2 are not strong drivers of choice.

Table 6. Random parameter logit estimates for PRRS vaccination

Coefficient (*t*-ratio) →		**Non-affected**	**Affected**	**Pooled sample**	**Pooled sample with interactions**
Vaccine administration	β_1	4.11 (2.13)**	5.09 (2.11)**	4.56 (3.34)***	3.23 (0.42)
Culling subsidy	β_2	2.34 (10.52)***	2.50 (16.54)***	2.41 (18.26)***	2.58 (12.02)***
Price	β_3	-0.000125 (-2.41)**	-0.000142 (-2.87)***	-0.000129 (-3.75)***	-0.000124 (-2.00)**
Vaccine × pig number	λ_1				2.35 (0.53)
Vaccine×attitude statement Q1	λ_2				-6.07 (-0.82)
Vaccine×attitude statement Q2	λ_3				21.91 (0.00)
Vaccine×attitude statement Q3	λ_4				1.91 (0.71)
Vaccine×attitude statement Q4	λ_5				1.67 (0.54)
Vaccine×attitude statement Q5	λ_6				0.71 (0.21)
Subsidy×pig number	ψ_1				3.90 (1.22)
Subsidy×attitude statement Q1	ψ_2				-0.95 (-0.23)
Subsidy×attitude statement Q2	ψ_3				7.57 (1.25)
Subsidy×attitude statement Q3	ψ_4				0.31 (0.15)
Subsidy×attitude statement Q4	ψ_5				0.17 (0.05)
Subsidy×attitude statement Q5	ψ_6				1.31 (0.34)
Standard deviation of parameter distributions (*t*-ratio)					
Sd Vaccine administration		2.28 (2.24)**	0.47 (0.81)	0.43 (1.79)*	1.71 (0.38)
Sd Culling subsidy		0.64 (2.77)***	0.81 (11.08)***	0.79 (9.75)***	1.21 (15.13)***
Log-likelihood		-87.07	-81.57	-177.45	-151.80
McFadden pseudo-R^2		0.74	0.75	0.74	0.77
n (respondents)		51	50	101	101
n (choices)		306	300	606	606

Note. Statistical significance levels: ***1%; **5%; *10%. The corresponding *t*-ratios are shown in parentheses.

Table 7 shows the results from the RPL model estimation of WTP for each of the vaccine attributes. The WTP results confirm that farmers have heterogeneous preferences for PRRS vaccination. The farmers' mean WTPs were 35,746 VND and 32,892 VND for vaccine administration in the Affected and Non-affected samples, respectively, and 176 VND and 187 VND for a 1% increase in the culling subsidy. [14]

Discussions

The results of the present CE study indicate that Vietnamese pig farmers show a high preference for the PRRS vaccine. However, their mean WTP is lower than the potential cost of the vaccine (40,000 VND/dose), which may be one of the reasons why the PRRS vaccination ratio remains low in Vietnam. To increase the vaccination ratio, one practical solution is government support for decreasing the vaccine price and/or for providing a culling subsidy to vaccinated farms to cull infected pigs.

Table 7. CE estimates of WTP for PRRS vaccination

	WTP (Standard error)		**Unit: VND**
	Vaccine administration	For 1% increase in culling subsidy	Sample size
Non-affected	32,892(8309)***	187(68)***	51
Affected	35,764(9759)***	176(55)***	50
Pooled sample	35,243(5101)***	187(44)***	101

Note. VND=Vietnamese Dong. Statistical significance level:***1%. The corresponding standard errors are shown in parentheses.

In addition, as mentioned in the introduction, there is no incentive for farmers to adopt PRRS vaccination because they can sell their pigs without certification of PRRS vaccination, and because all farmers are eligible to receive a culling subsidy, regardless of whether they adopt PRRS vaccination. The present CE results indicate that a PRRS-vaccinated certification to sell pigs and a culling subsidy only for vaccinated pigs are appropriate incentives for vaccination administration. The certification system for PRRS-vaccinated pigs is a priority for PRRS control.

Other research also reported the chaos of the pig meat market in PRRS epidemic areas in Vietnam. Pig farmers within epidemic areas have been rushing to slaughterhouses to sell as many pigs as they can. At markets in the Da Nang city, just near Hue province, farmers are freely selling pork to customers, even though the new PRRS infection was reported in this area. In the worst case, people dug up the PRRS-infected dead pigs to sell the meat and bones to restaurants (USDA, 2007). The certification system mentioned above will not only encourage farmers to vaccinate their pigs, but also can manage the pig market and protect the farmers who sincerely vaccinated their pigs.

[14] Based on McFadden (1973)'s random utility theory, The WTP for vaccine administration is calculated by $-\beta_1/\beta_3$; the WTP for 1% increase in culling subsidy is calculated by $-\beta_2/\beta_3$. In the case of "affected", the estimation of β_1 is not perfectly estimated (the estimated standard deviation of β_1 is not statistically significant). Therefore the estimation of WTP in the case of "affected" might be underestimated. This can be considered as a major reason that the estimation result of "pool" sample is so close to "affected" sample in Table 7.

The CE results also show a relatively high WTP for a 1% increase in the culling subsidy. Pig farmers agree that PRRS is a terrible disease, and they want to minimize their losses if an outbreak occurs after vaccination. Therefore, they set a high value on the culling subsidy paid by the government if infection occurs even after vaccination.

To disseminate the PRRS vaccination most efficiently, affected farmers and people who run relatively larger farms should be the first target for selling PRRS vaccine. The present results indicate that affected farmers show a much higher WTP for the PRRS vaccine and, due to their PRRS experience, are eager to administer the potentially highly effective PRRS vaccine. On the other hand, non-affected farmers value the culling subsidy more, and are more likely to avoid the uncertainty of PRRS infection after vaccination.[15] There is a close relationship between the poverty level and the pig production in Vietnam (Zhang and Kono 2013), because pig farms in Vietnam are usually small and might not be able to afford to vaccinate their pigs. Therefore, the PRRS vaccine may target relatively larger farms for selling their product.

According to our discussion with key individuals from Hanoi University of Agriculture, the cost of a vaccine produced in Vietnam may be higher than that of the imported vaccine if the production quantity is small. Strong government support is needed to increase quantity and to decrease the unit cost.

A similar study by Kairu-Wanyoike et al. (2013) indicated Kenyan dairy farmers prefer the bovine pleuropneumonia vaccine, which is vaccinated by the government. The extension study Kairu-Wanyoike et al. (2014) also indicated that farmers' WTP for bovine pleuropneumonia vaccination is higher than the market price, and abundant government compensation (subsidy) has to be provided to help farmers purchase vaccine. In the case of U.K. (Bennett and Balcombe, 2012), farmers preferred insurance combined with tuberculosis cattle vaccine, for recovering the financial loss from bovine tuberculosis if the disease occurred after they vaccinated their cattle. On the other hand, unlike Kenya and U.K., in the case of PRRS in Vietnam, PRRS is a highly contagious disease with a high mortality rate, and the government budget for animal disease control is limited, so the government support only for culling subsidy is appropriate in Vietnam.

To encourage vaccine producers to develop and produce a more effective deterrent to PRRS in Vietnam, only the certification we mention above is not sufficient. In addition, if the government can provide the culling subsidy only for the farms with the certification (who vaccinated their pigs), more farms would be likely to buy this vaccine. This will help vaccine producers develop an effective vaccine for the PRRS outbreak in Vietnam.

Additionally, most farmers either did not know that a PRRS vaccine exists or did not think they needed the vaccine. Furthermore, Vietnamese farmers tend to follow the advice of local veterinarians, most of whom do not have sufficient knowledge to encourage PRRS control (Table 5). Therefore, more explanation of PRRS vaccination to farmers by local veterinarians is

[15] According to the data shown in Figure 2 and Table 5, although non-affected farmers have relatively less knowledge about PRRS, they feel that PRRS is a big threat to the entire pig industry, but is less of a threat to their farms. This can be considered to be one of the reasons why some non-affected farmers were unfamiliar with the PRRS vaccine and why none of them adopted it (Table 5).

needed. To accomplish this, greater government attention is essential. To help disseminate the vaccine, as suggested by the results shown in Figure 2, we recommend a training seminar with an explanation of the PRRS vaccine, government support for vaccination, and instruction on the disease.

Another problem of PRRS vaccine diffusion in Vietnam is that the performance of veterinary services is restricted by poor existing infrastructure or a lack of infrastructure in some underdeveloped areas. For example, the attenuated live vaccine must be kept chilled, which may be difficult or costly where infrastructure is limited.

Further research is necessary to design an appropriate PRRS vaccination program, and to determine the costs and benefits of PRRS vaccination in Vietnam. Such research might also provide insight into the social impact of a PRRS vaccination program on pig production in Vietnam.

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