STUDY ON PRODUCTION EFFICIENCY AND IMPACTS OF NEW TECHNOLOGIES IN PIG FARM HOUSEHOLD: EVIDENCE FROM RED RIVER DELTA OF VIETNAM

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NGUYEN THI LY

2020

九州大学
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GRADUATE SCHOOL OF BIORESOURCE AND BIOENVIRONMENTAL SCIENCES
DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS
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STUDY ON PRODUCTION EFFICIENCY AND IMPACTS OF NEW TECHNOLOGIES IN PIG FARM HOUSEHOLD: EVIDENCE FROM RED RIVER DELTA OF VIETNAM

BY

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Nguyen Thi Ly

THESIS SUMMARY

Pig production is one of the most important sectors of livestock production in Vietnam. It brings job and income to Vietnamese farmer households who own mostly small scale. In this point, the government has built many strategies to develop this sector, especially focus on household level. Changing production scale of pig-producing household from scatter- small scale to commercial and large scale and applying new production technologies and management methods to increase production efficiency and to reduce pollution have been promoted. However, the achievement was limited for farmers at household level such low production efficiencies as well as low adoption rate in implementing new technologies. Against this background, this study aimed to measure production efficiency of household pig production and its determinant; and to assess the adoption and impacts of new technologies in pig management of households in Red River Delta of Vietnam.

This study used two data sets that were collected by face-to-face interviewed using questionnaire in two periods. The first period was from August to September in 2014. This survey was conducted in Tien Lu district, Hung Yen province with the total sample size was 161 farrow-to-finish households. The second period was in April 2018. Tien Lu and Khoai Chau were two of four districts promoting VietGAHP under LIFSAP support for household pig production in Hung Yen province. The second date set included 114 VietGAHP households and 116 conventional households. A VietGAHP household is defined as a pig household who registered as a member of their district's LIFSAP group. They were randomly chosen based on lists of VietGAHP groups. A conventional household (VietGAHP non-adopter) is a household pig producer as defined by MARD (2016) and one which was not registered as a member of VietGAHP groups. Data Envelopment Analysis (DEA) approach was used to estimate the level of efficiency scores in term of technical, allocative and cost efficiency, and Tobit model was used to determine the factors associating with these efficiency scores. Especially, the results of Tobit model were combined with those of three statistical tests (i.e., Spearman's correlation, Analysis of Variance (ANOVA), and the Kruskal–Wallis test) to identify the impacts of production scales on these efficiency score. In addition to, we used Logit and Probit model to identify factors associating with Biogas adoption in manure management and VietGAHP adoption. Last, we used the z-test to show the impacts of VietGAHP adoption in implementing its criteria.

Chapter 3 showed that overall technical efficiency in farrow-to-finish pig production of the household (TEcrs) was high (80.40%) but it fluctuated in a large range, from 52.57% to 100%. And the inefficiency of overall technical efficiency in pig production was mostly the product of less efficiency of pure technical efficiency (TEvrs) rather than scale efficiency (SE). The main factors that affect the overall technical efficiency in farrow-to-finish pig production in households were the live weight per fattened pig, breeding time, education, experience, number of family members joining in pig production, pig income, access to credit, and access to veterinary services. From above findings, it may be concluded that households should concentrate on improving their managerial skills rather than changing their scale in order to enhance their performance. In this regard, households could reduce their inputs and produce large quantities fattened pigs by utilizing breeding centers; also enhance their skills through training programs and by studying the best pig producers. Another option for inefficient households is to reduce their breeding time by taking better care of the sows before they become pregnant and by weaning their piglets earlier.

Chapter 4 highlighted the main factors affecting biogas adoption that were education of household heads, household head became a member of member of any agricultural cooperatives or farmer groups, large farm size, and household income. All of these have positive impacts on the willingness to adopt biogas, except for some farmers with very high education and some households with high income, who might seek more modern manure management technologies. The results suggest that educational and awareness programs on the merits of biogas digesters, particularly via farmer support channels, should be implemented. Furthermore, financial programs should be offered to farmers, especially to low-income households.

Chapter 5 demonstrated that the factors positively contributing to VietGAHP adoption include male gender, farmer has been training in pig production issues by the extension staff, household income, and veterinary services, with the training factor as a substantial contributor. The factors presenting a challenge to this adoption included farm size, the number of family members participating in pig-raising, off-farm income, and biogas, with the last factor was an especially pivotal factor. Moreover, an expected result of the government's support was that VietGAHP adoption had a positive impact on 9 out 15 compulsory practices and 8 of 14 optional practices. These imply that to attain food safety and environmental protection goals through a public GAP program for pig production, traditional adoption

factors—including a male farmer status, training, household wealth, and veterinary services—remain key pillars on which government policies should focus.

In Chapter 6, we found that high efficiency scores of technical efficiency, allocative efficiency and cost efficiency among the Vietnamese pig-farming households were 89.2%, 84.6%, and 75.3%, respectively. Also we found that the cost inefficiency was caused by allocative inefficiency and technical inefficiency, respectively. Moreover, there were significantly higher allocative and cost efficiencies in larger production scale and adopting VietGAHP, which is consider as new management practices, brought the higher level of technical efficiency. Based on these findings, we suggest ways that the government could improve the current system to help even among household pig production who are the main agricultural producers in developing countries such as Vietnam, scale up their farms and adopt new management practices to improve their performance.

In overall, this study has pointed out five new findings as follow: 1) The level of overall technical efficiency in pig production was high but it fluctuated substantially among households; 2) Farmers' financial ability in term of household's income became the common factor effecting on the adoption of new technology. However, there was a conflict in adopting these new technologies because they had not yet supported each others; 3) The impact of new technologies such as VietGAHP has brought the substantial changes in implementing the difficult practices/criteria that were implemented by less than 50% of all farmers, especially for compulsory criteria; 4) Also, the other impact of VietGAHP adoption was that VietGAHP brought higher level of technical efficiency for households; 5) The larger production scale has been identified to improve the allocative efficiency and cost efficiency by exploring the advantages of economies of size.

Based on these findings, five practical implications may be formulated as follow: 1) Households should concentrate on improving their managerial skills rather than changing their scale in order to enhance their performance; 2) To encourage pig-producing households to adopt new technologies in the future, it is crucial to formulate a suitably formal credit system for household who were low income to access; 3) It can be introduced and encouraged pig-producing household who could not change their production scale in the future to adopt VietGAHP to improve their performances; 4) To increase the adoption rate of VietGAHP, traditional adoption factors—including training in pig production issue by the extension service and veterinary services—remain key pillars on which government policies should focus; 5) Scaling up the production scale was another way to improve the production

efficiency, the government should continue to deliver training and veterinary services to farmers.

Key words: biogas adoption, Data Envelopment Analysis, household pig production, impact of new technology, production scale, VietGAHP adoption, Vietnam

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CHAPTER I: INTRODUCTION

1.1 Background of the study

Pig production is one of the most important sectors of livestock production in Vietnam. According to the General Statistics Office of Vietnam (GSO) (GSO, 2013), the value of livestock constitutes 26.8% of the gross agricultural output, a ratio that has been growing overtime. It is predicted that by 2020, livestock production, of which pig production is the greatest component, will constitute over 42% of agricultural output. It is further thought that pig production will come to supply 63% of the country's total meat production by that same time (Vietnamese Prime Minister, 2008). It brings job and income to Vietnamese farmer households who own mostly small scale. Pig sector is one of the most important contributors to household income within the livestock sector (Epprecht, 2005).

However pig production had negatively impacted on the environment, including air, soil, and water pollution from waste, especially manure from pig production. Thus, the management of animal manure sources is one of the biggest challenges currently facing pig production in Vietnam. According to Vu et al. (2007), slurry, liquid manure, and solid manure are the three major manure types in pig farming while the four categories of pig manure management are non-treatment with direct disposal to fields or fishponds, composting, storage without treatment, and biogas production. Biogas production is perceived a good way to reduce some environmental problems in manure management, such as the spreading of pathogens and noxious odor emissions (Vu et al., 2007).

In this regard the Vietnamese government has built many strategies to develop livestock sector including pig production, especially focus on household level. Changing production scale of pig-producing household from scatter-small scale to commercial and large scale and applying new production technologies and management methods to increase production efficiency and to reduce pollution have been promoted. Firstly, the Vietnamese government's strategy for the future of the pig sector through 2020 holds that production should be shifted from small-scale and family operations to large, intensive and commercial scale operations (Vietnamese Prime Minister, 2008). Then, Biogas technology was introduced in Vietnam in 2003 with the Biogas Program for the Animal Husbandry Sector in Vietnam (BPAHSV) encouraging construction of biogas digesters through cooperation between the Livestock Production Department of the Ministry of Agricultural and Rural Development and the Netherlands Development Organization (SNV) (BPAHSV, 2015b). To quality assurance and food safety pressures from international and domestic trading partners within the region,

as well as in response to sustainable environmental development, Vietnam developed its own GAP based on the GAP of Association of Southeast Asian Nations (ASEAN), (Premier and Ledger 2006). Specifically, the Vietnamese Good Animal Husbandry Practices (VietGAHP) publication describes GAPs for pig and other livestock (MARD 2008c, 2008d, 2008e, 2008f, 2011b, 2011c, 2015, 2016).

Currently, the total number of households raising pigs declined from around 4.1 million in 2011 to 3.44 million in 2016 (GSOV, 2018a). HH pig production supplied approximately 80% of Vietnamese pork and will continue to dominate the Vietnamese pig sector over the next decade (Lapar et al., 2011; Lapar, 2014; Tisdell, 2010). Also, in term of structural changes, the percentage of households keeping 1–5 pigs decreased significantly (down 10%), from 77.55% in 2011 to 67.55% in 2016; however, the percentage of households with more than five pigs increased in 2016 compared to 2011, with the greatest increase found among households with 20–49 pigs (up 4.09%). Moreover, current trends in Vietnamese pig-production industry notwithstanding, it is difficult to change immediately from a production characterized by small-scale farms to that of large-scale and commercial farms (Lapar, 2014; Tisdell, 2009). Thus, the question remains whether there is any advantage to having pig-farming households scale up their production to improve farm performance.

Against the above background, it is important to evaluate the overall production efficiency of pig-producing households and the adoption of new technologies as well as the impacts of these technologies to contribute to the development of this sector in the future.

1.2 Statements of problems

The change of structure among production scales of households was slow, and smallholder pig-farm households were still the main pork suppliers in Vietnam (VGSO, 2018a). The households studied lacked the resources to become large commercial farms; therefore, to remain competitive, it was imperative that they produce with maximum efficiency, changing their production scale to the extent possible to keep up with the market competition.

Although several studies have measured productive efficiency in pig farming, most of these ignored small-scale household operations in developing countries except for Mugera & Featherstone (2008) and Tian et al. (2015). However, these studies only estimated the single component of production efficiency was technical efficiency. The question remains whether there is any advantage to having pig-farming households scale up their production to improve their farm performance in term of technical, allocative and cost efficiencies. Furthermore, we

could find no past studies that provided an analysis of the effect of production scale on all relevant efficiencies in the context of Vietnamese household pig farming.

In addition to, while VietGAHP and Biogas adoption were promised as the another ways to improve the farmer' performance by enhancing the product quality and reducing pollution to the environment, the adoption rates were slow (GSOV, 2018a). However, changes in farmers' behavior could be observed after VietGAHP adoption (Lapar et al. 2017). Thus, some questions on farmers' engagement and participation in the program still remain, as some VietGAHP standards are strict and difficult for farmers to adopt, especially for farmers with limited abilities (Nguyen 2017). It is needed to measure the impact of VietGAHP adoption on its implementation as the first step to improve the farmers' behavior to achieve the final goal of producing VietGAHP products with safety and high quality.

1.3 Conceptual framework

The conceptual framework of this study was illustrated in Figure 1.1. As stated in the above problem statement, pig-producing households was prominent in pig producers in Vietnam and was small scale with limited their input resources in term of land, financial but they owned family labors. They tent to reach a high performance as much as possible to improve their income and secure their jobs.

Rasmussen (2013) has shown that three reasons for productivity changes: (1) improved efficiency can be improve the production per input unit; (2) technological improvements/technological changes; (3) changes in the scale of production. Also, Rasmussen (2013) has mentioned very clearly about the relationship among productivity, efficiency and technological changes. It can be shortly and simply summarized as follow for a production where only uses one input x to production one output y.

"*Productivity can be briefly defined as production (output) divided by input*". It means that: $Productivity = \frac{y}{x}$ (1.1)

"*Efficiency can be briefly defined as the achieved compared to what can be achieved*". It means that if used input x could potentially produce 100 units of output y but actually a producers only can produced 80 units of output, thus, the efficiency is 0.8 or 80%. Thus, changing (improving) the efficiency means that changing (improving) the position of a firm or a producer relatively to the current technological frontier.

"*Technological changes (or technical change) is defined as a shift in the production function over time"*, or in other words, *"Technological change means that the frontier of the technology moves through time."*

The scale of production means that "the point on the production function where production takes place". This point can be located in one of three areas of the production function: increasing returns to scale (IRS), decreasing returns to scale (DRS) and constant returns to scale (CRS).

Based on the theory of changes in productivity as shown above, this study assume that when farmers could get their highest performance or highest productivity with their current technologies with their current resources, also they need to assure the environment pollution by their production, they tent to find the other ways to improve their performances with their cost was the minimum as much as possible by scaling up their production scales and adopting new technologies or new management practices.

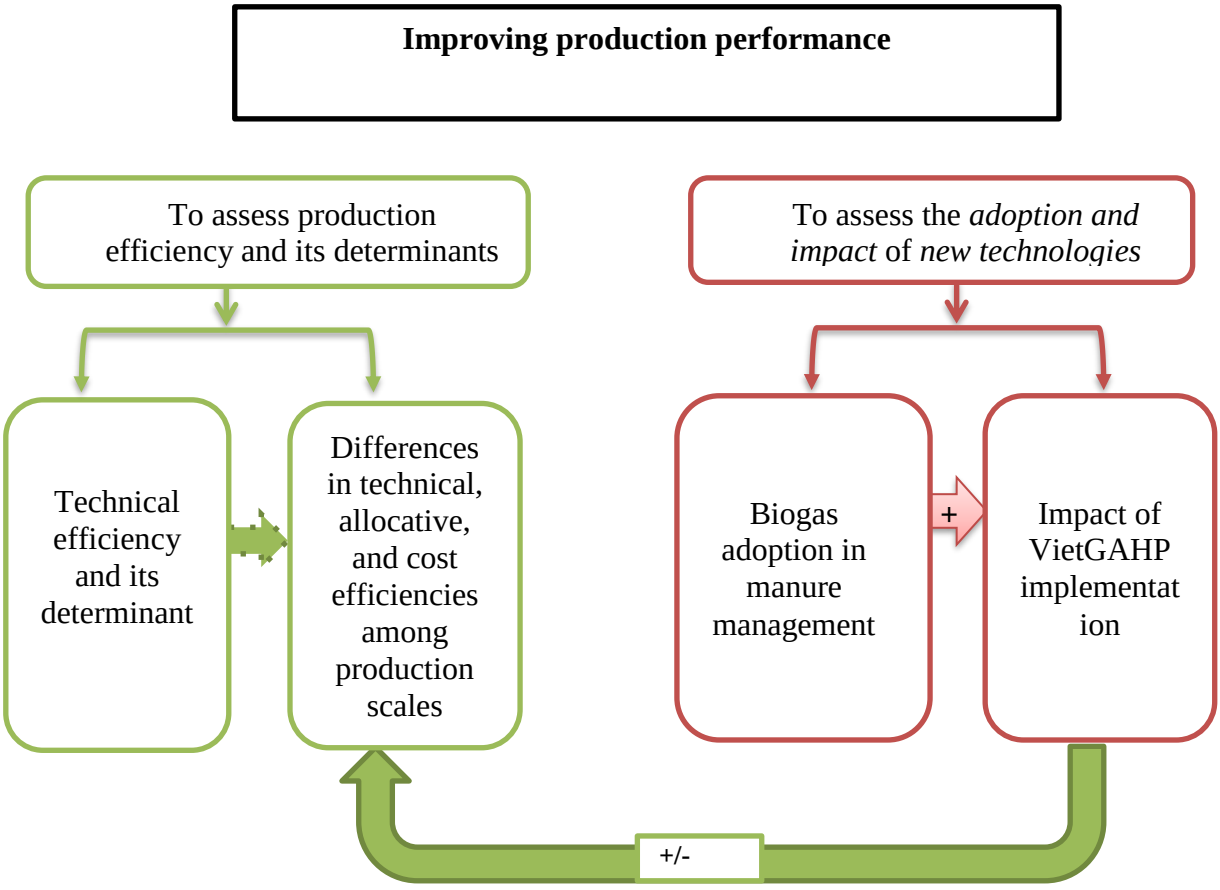


Figure 1.1 The conceptual framework

Note: +/- means that a positive/negative affect

There were some previous studies, which had focused on the relationship between the adoption of new technologies in agriculture and the production efficiency (i.e. technical efficiency). Amara et al., (1999) found that farmers who were using conservation practices had greater incentives to use production input efficiently because they wanted to prevent environmental problems. It means that the adoption might be brought higher efficiency. While Mayen et al. (2010) pointed out that the organic technology was less productive than the conventional technology in dairy farm in United State. Therefore, this study made a hypothesis that whether when farmers adopt new technologies, their performances are lower or higher than before adoption, they might be adopt or not adopt new technologies.

This study would like to contribute to the policy makers, farmers in Vietnam and other developing countries where would like to develop the pig production in term of increase the production efficiency, product quality and reduce the impact to the environment by scale up production scale and adopt new technologies.

1.4 Objective of the study

Against this background, this study aimed to achieve two objectives as follow:

(1) Objective 1: to measure production efficiency of household pig production and its determinants; and

(2) Objective 2: to assess the adoption and impacts of new technologies in pig management of households in Red River Delta of Vietnam

1.5 Structure of dissertation

The structure of dissertation was shown in the Figure 1.2 and it contained seven chapters. In which, chapter 3 was focused on the first objective and chapter 4, chapter 5 and chapter 6 were contributed to the second objective.

Chapter I: Introduction

In this chapter, the general background of this study was introduced, followed by the problem statements and the conceptual framework. It also introduced the objectives of this study and its overall structure.

Chapter II: Literature Review

This chapter described literature relevant to the research objectives of this dissertation. It is organized into three sections: (1) Vietnamese agriculture and trends of pig production; (2)

Definition and trends in household pig production in Vietnam; (3) Introducing the policy of scaling up the production scale in pig production and history of VietGAHP for household pig production

Chapter III: Technical efficiency and its determinants in household pig production

This chapter introduced detail about the role of pig production in households and the prominent of farrow-to-finish pig production type in Vietnam in the introduction part and the two-stage Data Envelopment Analysis approach in measurement of technical efficiency. The result and discussion of technical efficiency and its determinants in household pig production were shown. Last, the implication to improve the technical efficiency level was suggested.

Chapter IV: Biogas adoption in manure management of Vietnamese household pig production

This chapter used a logit model to determine the factors contributed to the decision to adopt Biogas system in manure management of households.

Chapter V: Impact of VietGAHP implementation on Vietnamese households ' pig production

This chapter used a probit model to indicate the factors contribute to the decision to adopt a new management practice that aimed to improve the farmer's production efficiency, high quality products as well as to reduce the impact on the environment and called VietGAHP. Also, this chapter assesses the impact of VietGAHP adoption in its implementation in terms of farmers' perception.

Chapter VI: Differences in technical, allocative, and cost efficiencies among production scales

This chapter used again the two-stage Data Envelopment Analysis approach was used in the Chapter III to estimate not only technical efficiency but also another two components of

production efficiency were allocative and cost efficiency. This chapter also measured the impact of production scale on these efficiencies and that of VietGAHP as well.

Chapter VII: Main conclusion and policy implication

This chapter summarized all the main findings in this study and suggested policy implications to improve the performance for households raising pig in Vietnam.

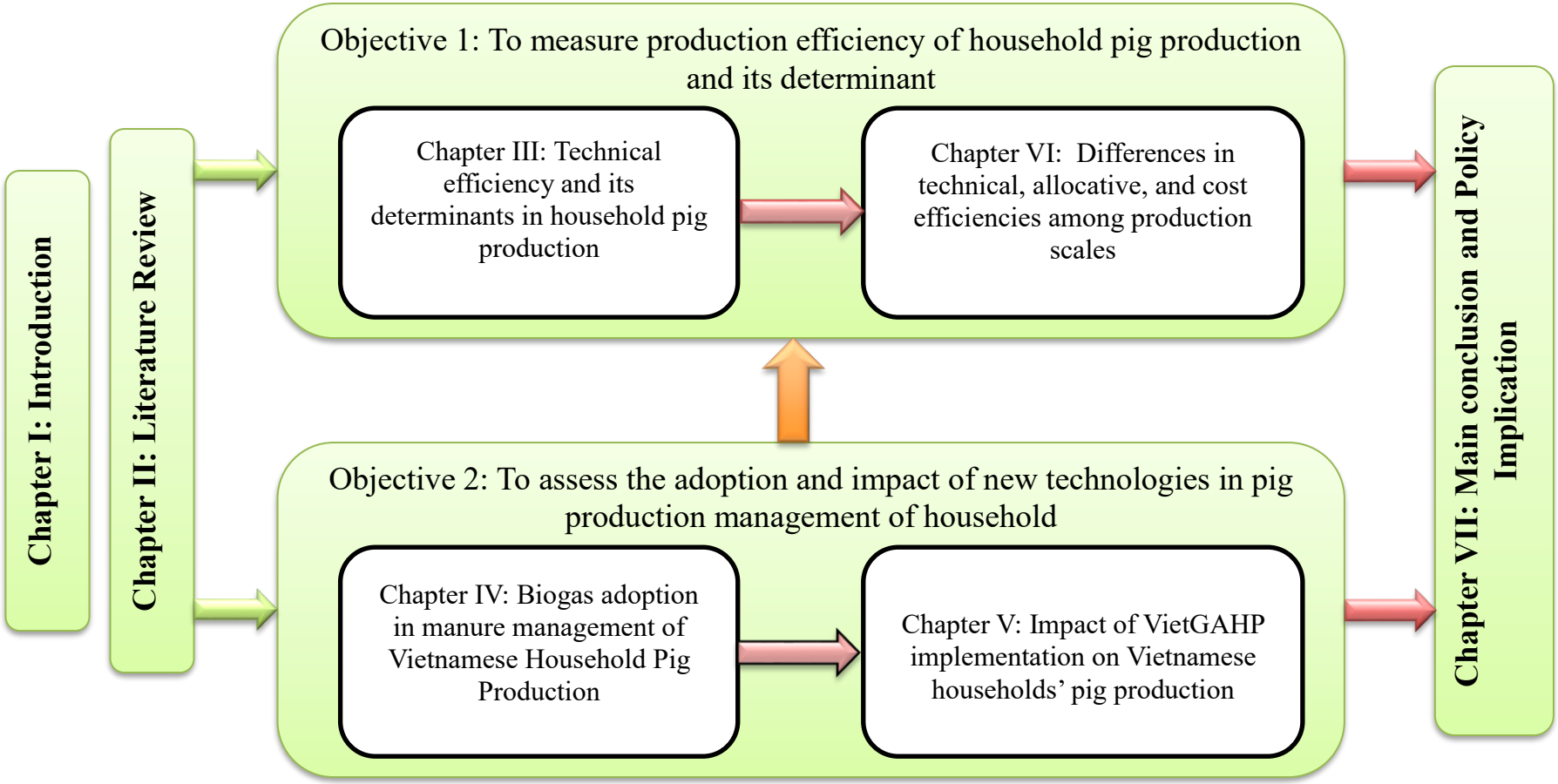


Figure 1.2 The structure of dissertation

CHAPTER II: LITERATURE REVIEW

This chapter will describe literature relevant to the research objectives of this dissertation. It is organized into three sections: (1) Vietnamese agriculture and trends of pig production; (2) Definition and trends in household pig production in Vietnam; (3) Introducing the history of VietGAHP for household pig production.

2.1 Vietnamese agriculture and pig production in Vietnam

2.1.1 Vietnamese agriculture

According to General Statistics Office of Vietnam, in 2017, GDP at current prices reached 5,006 trillion VND. In terms of 2017 economic structure, the agriculture, forestry and fishery sector continues the downtrend and made up 15.34% (Table 2.1).

Table 2.1 Shared of Vietnam's GDP by economic sector 2010-2018

Unit: %

Year	Agriculture, forestry and fishing	Industry and construction	Service	Products taxes less subsidies on products
2010	18.38	32.13	36.94	12.55
2011	19.57	32.24	36.73	11.46
2012	19.22	33.56	37.27	9.95
2013	17.96	33.19	38.74	10.11
2014	17.70	33.21	39.04	10.05
2015	16.99	33.25	39.73	10.02
2016	16.32	32.72	40.92	10.04
2017	15.34	33.40	41.26	10.00

Source: GSOV, 2019

While agriculture, forestry and fishing still shared the largest employed person at 15 year olds and above. It shared 55.09% of total employed persons in 2005 and shared 40.16% of total employed person in 2017 (Figure 2.1).

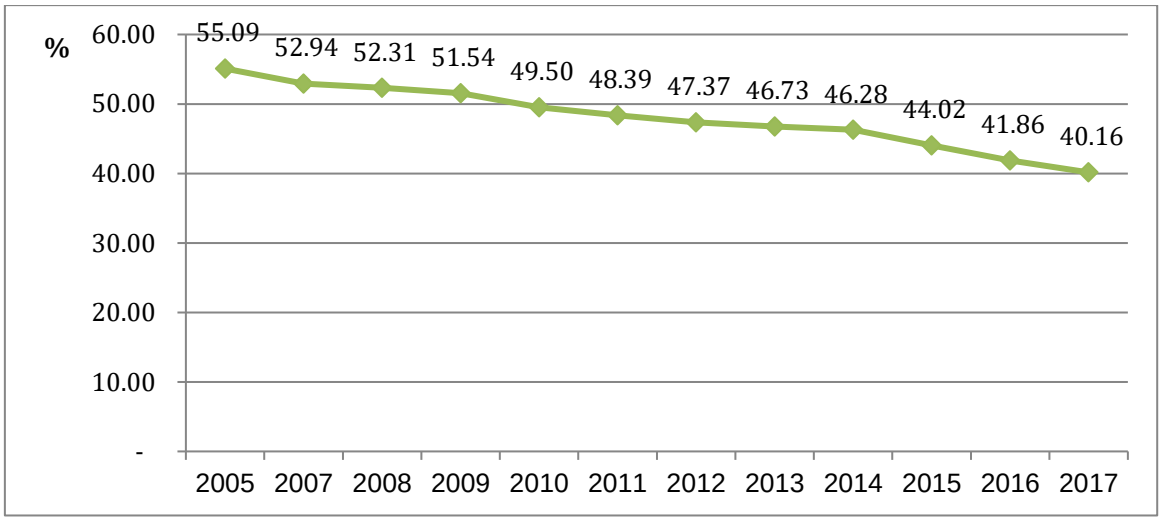


Figure 2.1 Shared of annual employed person at 15 years of age and above of agriculture, forestry and fishing

Source: GSOV, 2019

2.1.2 Trends of pig production

2.1.2.1 Trend of number of pig heads

According to General Statistics Office of Vietnam, the number of pigs as of annual 1st October in Vietnam fluctuated in the period of 2008-2017 (Figure 2.2). After the disease caused in 2008, the pig population in 2009 slight increased from 26,701,600 heads to 27,627,600 heads. Then the pig population as annual 1st October decreased gradually and reached a bottom to 26,264,400 heads in 2013. Again, the pig population rose and reached a peak at 29,075,300 heads in 2016 then fell in 2017 because of the price of output price fell.

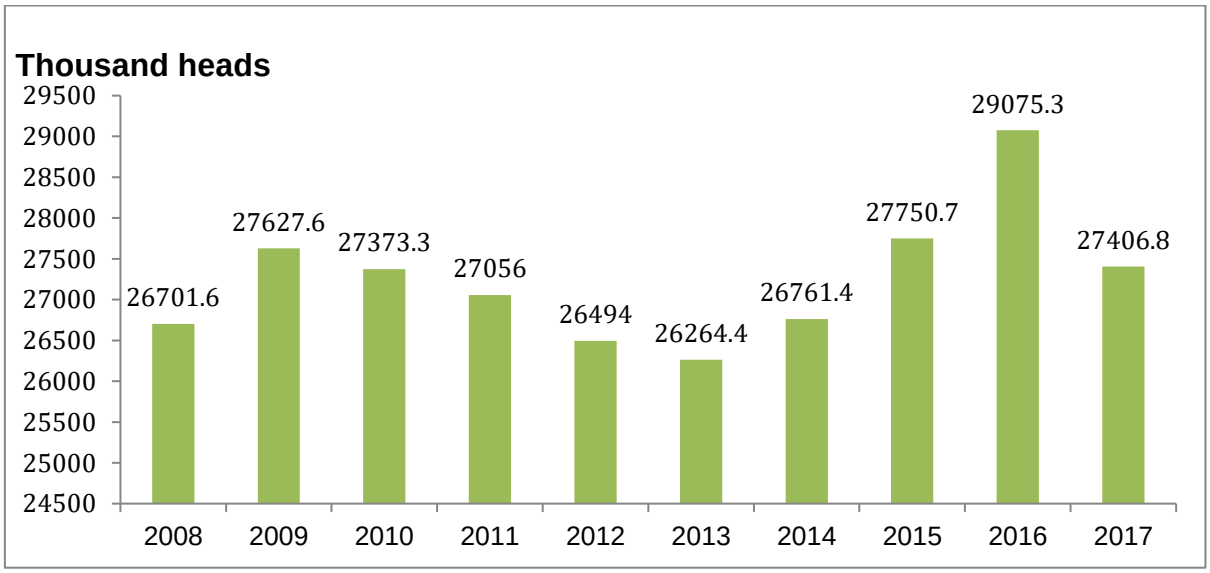


Figure 2.2 Pig populations as of annual 1st October in Vietnam, 2008 – 2017

Source: GSO, 2020

Broken down the number of pig heads by region, it can be seen that Red River Delta is the top of region (Figure 2.3), followed by Northern midlands and mountainous area and North Central and Central Coast Area. In which, the number of pig heads of Northern midlands and mountainous area increased over time, that of North central and central coast area decreased.

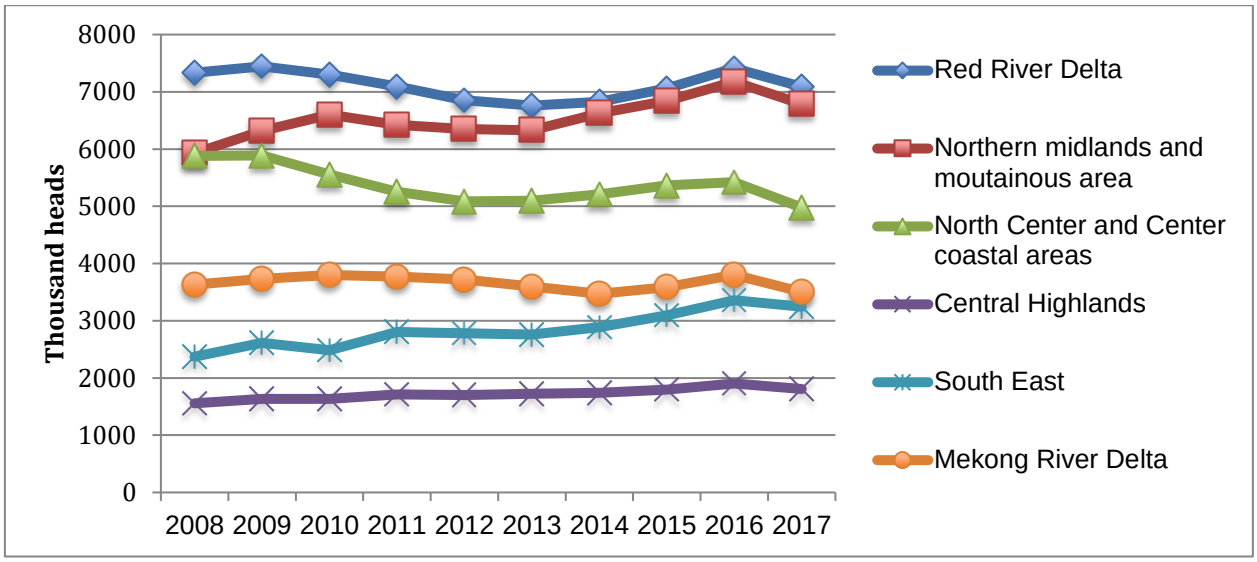


Figure 2.3 Pig populations as of annual 1st October in Vietnam, 2008 – 2017

Source: GSO, 2020

2.1.2.2 Trend of volume of pork production

In Vietnam, pork is the main source of meat and is consumed the most. Among main livestock products, pig shared 79% of total living weight in 2008 and continues sharing 72% in 2017 (Figure 2.4).

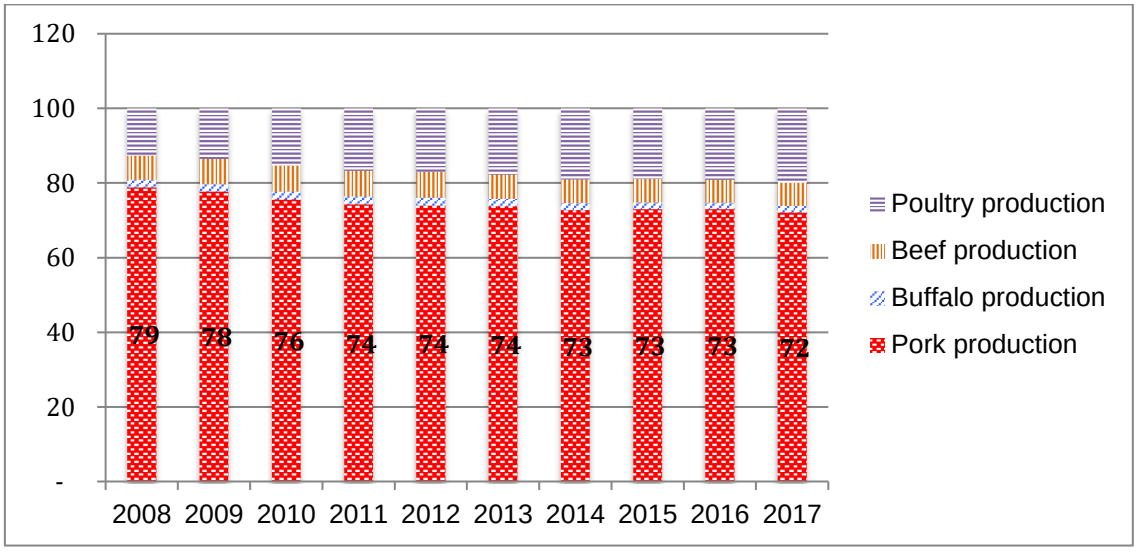


Figure 2.4 Share of living weight of pig among living weight of main livestock products 2008-2017

Source: GSO, 2020

Although the share of living weight of pig among living weight of main livestock products decreased slightly, total living weight of pig rise 34.2% over the period of ten year from 2008-2017 (Figure 2.5). The current of living weight of pig in 2017 is 3733.3 thousand tons and it continues to uptrend.

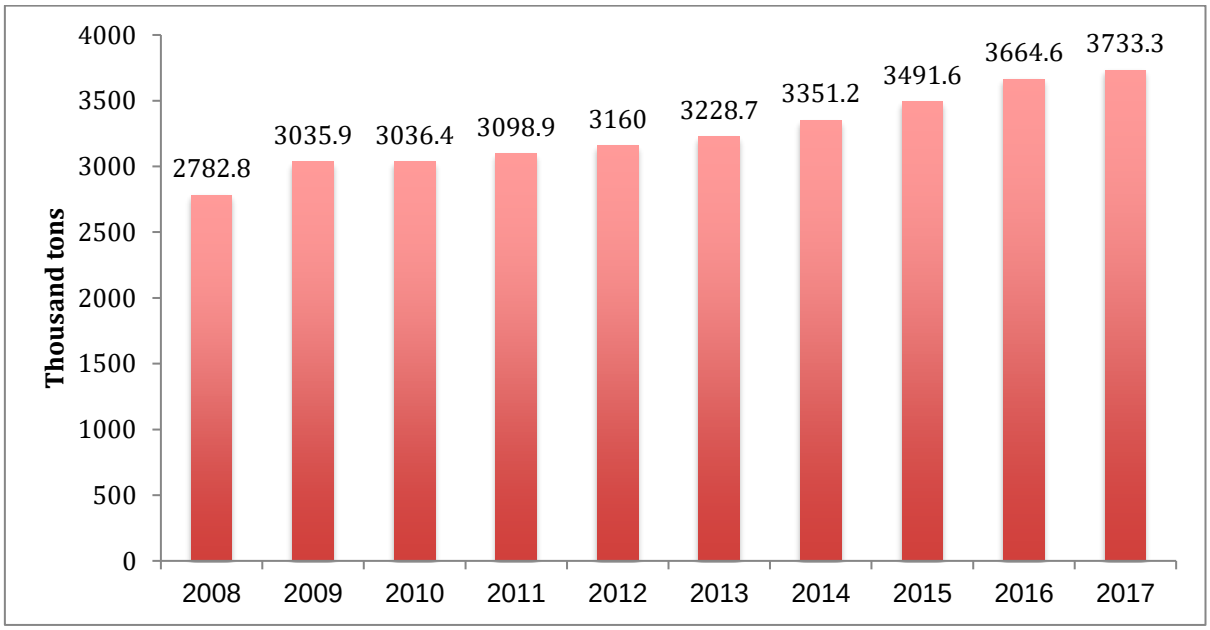


Figure 2.5 The living weight of pig in Vietnam, 2008 – 2017

Source: GSO, 2020

2.2 Definition and trends in pig-producing household in Vietnam

2.2.1 Definition of a pig-producing household

In general, a household joins in producing agricultural, forestry and finishing products is a household that all labors or most of labors take part in directly or indirectly in agriculture, forestry, and fishing activities. The household organizes their production and makes all decision of their production by their selves.

A livestock-producing household is a kind of livestock production at a family household with a scale production is less than the scale of a farm (usually called the commercial farm because it focus on produce the good selling to the market at a large scale) (MARD, 2016). The scale of a farm depends on the type of farms joining in producing livestock (MARD, 2011b). For the specialized farm in livestock production, it must have the total annual sale of livestock production at least 11 billion Vietnam dong. For the general farm

1 Exchange rate: US$ 1 = 22,454 Vietnamese dong at the surveyed time.

that has a livestock production activity, it has a total agricultural land area is 3.1 hectares for South East region and Mekong River Delta region or 2.1 hectares for the rest regions in Vietnam and this farm joins in producing livestock production.

A pig-producing household in this study is a livestock-producing household who joins in pig activity for sale and total sale of all livestock products as well as the total agricultural land of this household are not met the requirement of the commercial farm defined by (MARD, 2011b).

2.2.2 Trends of pig-producing households

In general, in the period from 2006-2016, the total number of household raising pig in Vietnam and the number of very small-scale households who raising less 5 pig heads decreased sharply. However, the number of medium and large scale households increased, especially the households raising 50 pig heads and above. Also, there was a change of the structure of the number of pig-producing households among regions.

2.2.2.1 Changes in the number of pig-raising households

The number of pig-producing households in 2016 in Vietnam stood at 3,441,066, continuing a downward trend (Figure 2.6). It decreased 45.7% in the total number of households raising pig in whole country in ten years (Table 2.2).

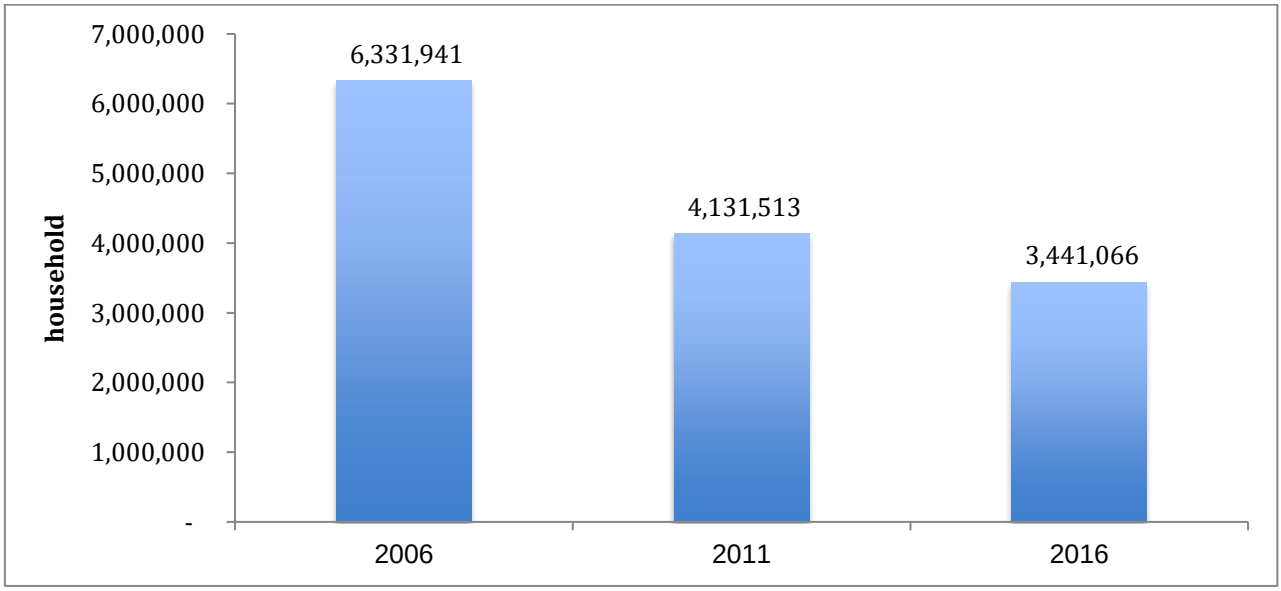


Figure 2.6 Changes in the number of households raising pig in 2006, 2011, 2016

Source: GSO, 2007, 2012; Ban Chi Dao Tong Dieu Tra Trung Uong, 2017

Table 2.2 Changes in the numbers of pig-producing households by regions

Unit: households

Years	Red River Delta	Northern midlands and mountainous area	North Center and Center coastal areas	Central Highlands	South East	Mekong River Delta	Whole country
2006	1,813,683	1,431,503	1,875,870	257,683	165,245	787,957	6,331,941
2011	870,504	1,204,391	1,238,887	210,796	110,075	496,860	4,131,513
2016	665,050	1,207,424	885,888	195,384	85,373	401,947	3,441,066
Changes (%)	-63.3	-15.7	-52.8	-24.2	-48.3	-49.0	-45.7

Source: GSO, 2007, 2012; Ban Chi Dao Tong Dieu Tra Trung Uong, 2017

When households broken down by regions also indicate that the numbers of pig-producing households in 2016 in each region decreased from 10 years earlier (Table 2.2), with a remarkable decrease being seen in the Red River Delta with 63.3%.

Total number of pig-producing households mainly locates in three main regions including the Red River Delta, Northern Midlands and Mountain Area and North Central and Central Coast Area that are account for around 80% of total households in Vietnam (Table 2.3).

Table 2.3 The changes in the structure of the number of households raising pig by regions in the period 2006-2016

Unit: %

Year	Red River Delta	Northern midlands and mountainous area	North Center and Center coastal areas	Central Highlands	South East	Mekong River Delta
2006	28.6	22.6	29.6	4.1	2.6	12.4
2011	21.1	29.2	30.0	5.1	2.7	12.0
2016	19.3	35.1	25.7	5.7	2.5	11.7
Changes (%)	-9.3	12.5	-3.9	1.6	-0.1	-0.8

Source: GSO, 2007, 2012; Ban Chi Dao Tong Dieu Tra Trung Uong, 2017

In term of the changes in the structure of the number of households raising pig by regions, it can be seen in the Table 2.3. This figure shows that there were sharply changes in the contribution of the Red River Delta and Northern midlands and mountainous area. The percentage of households raising pig in the Red River Delta decreased from 28.6% in 2006 to 19.3% in 2016 but that in the Northern midlands and mountainous area increased from 22.6% in 2006 to 35.1% in 2016.

2.2.2.2 Changes in the production scale of the pig-producing households

The secondly, the households broken down by production scale indicate that in whole country the number of households raising less than 10 pig heads in 2016 decreased from 5 years ealier, with a remarkable decrease being seen in the number of households owing 5 pig heads and less (Table 2.4). However, the number of households in 2016 increased from 5 years earlier for owning 10-pig head or larger scales, with a remarkable rise being seen in the number of households owning 100 pig heads and more (Table 2.4).

Table 2.4 Changes in the numbers of pig-producing households by production scale in whole country

Unit: households

Production scale	2011	2016	Changes (%)
1-5 head	3,203,989	2,324,426	-27.5
6-9 head	367,169	323,306	-11.9
10-19 head	377,609	439,342	16.3
20-49 head	150,692	266,289	76.7
50-99 head	22,803	59,645	161.6
100 head or more	9,251	28,058	203.3
Total	4,131,513	3,441,066	-16.7

Source: Ban Chi Dao Tong Dieu Tra Trung Uong, 2017

Also, households broken down by production scale in Red River Delta indicates that the number of households in 2016 increased from 5 years earlier for households owing 20 pig heads or more, also with a remarkable rise being seen in the number of households owning 100 pig heads and more (Table 2.5). It indicates that the progress in production scale expansion at household level.

Table 2.5 Changes in the numbers of pig-producing households by production scale in Red River Delta

Unit: households

Production scale	2011	2016	Changes (%)
1-5 head	624,580	387,169	-38.0
6-9 head	66,042	46,916	-29.0
10-19 head	113,280	110,132	-2.8
20-49 head	56,097	89,913	60.3
50-99 head	8,113	21,622	166.5
100 head or more	2,392	9,298	288.7
Total	870,504	665,050	-23.6

Source: Ban Chi Dao Tong Dieu Tra Trung Uong, 2017

The changes in the structure of the number of pig-producing households by production scales in whole country show in the Table 2.6. It can be seen that the households raises from 1

to pig heads accounted the largest proportion in the number of households raising pig in 2016 with 67.5% although it decreased from 77.6% in 2011. However the portions of the other production scales increased, with a remarkable increase of production scale of 10 to 19 pig heads, a 3.7 percentage point increase.

Table 2.6 Changes in the structure of the number of pig-producing households by production scale in whole country

Unit: %

Production scale	**2011**	**2016**
1-5 heads	77.6	67.5
6-9 heads	8.9	9.4
10-19 heads	9.1	12.8
20-49 heads	3.6	7.7
50-99 heads	0.6	1.7
100 heads and above	0.2	0.8
Total	100.0	100.0

Source: Ban Chi Dao Tong Dieu Tra Trung Uong, 2017

In term of the changes in the structure of the number of pig-producing households by production scale in each region, it can be seen in the Table 2.7. The share of households had production scale of 1-5 pig heads was the largest and decreased from 2011 to 2016 in all regions. The sharply decreases of the share of the household having production scale of 1 to 5 pig heads belonged to the Mekong River Delta and Red River Delta with 15.2 percentage point and 13.5 percentage point, respectively.

Table 2.7 Changes in the structure of the number of pig-producing households by production scale in each region

Unit: %

Production scale	Red River Delta		Northern Midlands and mountainous area		North Center and Center coastal areas		Central Highlands		South East		Mekong River Delta	
	2011	2016	2011	2016	2011	2016	2011	2016	2011	2016	2011	2016
1-5 heads	71.7	58.2	80.2	72.0	85.0	76.3	74.5	70.0	43.2	34.2	71.4	56.2
6-9 heads	7.6	7.1	10.0	10.7	7.7	8.0	9.7	8.9	10.6	7.9	10.6	12.8
10-19 heads	13.0	16.6	7.5	11.1	5.5	9.6	10.7	11.5	22.8	20.0	11.7	17.4
20-49 heads	6.4	13.5	2.0	4.9	1.5	4.8	4.2	7.2	16.1	21.6	5.1	10.5
50-99 heads	0.9	3.3	0.2	0.9	0.2	0.9	0.6	1.5	4.3	8.8	0.8	2.2
100 heads and above	0.3	1.4	0.1	0.3	0.1	0.4	0.3	0.8	3.1	7.4	0.3	0.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Ban Chi Dao Tong Dieu Tra Trung Uong, 2017

2.3 History of VietGAHP for pig production in Vietnam

This part will summarize the history of VietGAHP for pig production in Vietnam in Figure 2.7, which includes the year VietGAHP started, the characteristics of VietGAHP in each period and whose pig producers are applied by it. Also, this subsection will compare the detail the number of VietGAHP practices among their versions in Table 2.8 and Table 2.9

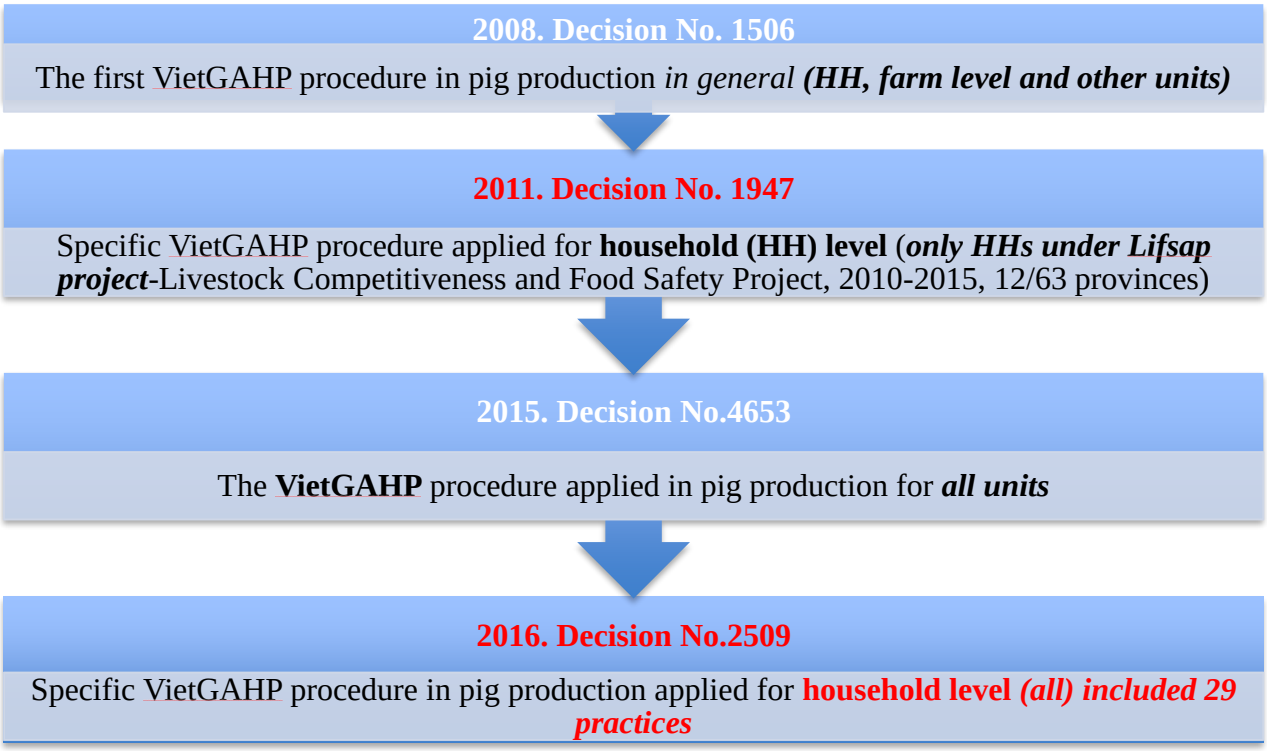


Figure 2.7 Flows of history of VietGAHP for pig production

Source: Author summarized from MARD, 2008, 2011, 2015, 2016

2.3.1 Decision No. 1506 (2008)

Firstly, the Vietnam's MARD has released the general VietGAHP procedure in pig production since 2008 under the Decision No.1506 (MARD, 2008) applied for all units who produces pigs in Vietnam including households, commercial farms, agricultural companies, agricultural cooperation and other individuals and organizations. This VietGAHP includes principles, guidance sequence for these organizations, production units to apply in their productions with purposes: (i) ensure their pig products to meet quality and food safety standards; (ii) ensure a social welfare, health's pig producers, health's pork consumers; (iii) protect the environment; and (iv) be product traceability;

This first assessment version includes 54 compulsory criteria (named A criteria) which have to follow if pig producers want to adopt VietGAHP in their pig production and 10

optional criteria (named B criteria) which are practices encourage to comply (Table 2.8). However, this version did not guide in detail to be satisfy and verify as an active VietGAHP pig producer that at least how many A and B criteria have to comply in full

Table 2.8 Assessment Checklist of VietGAHP for all pig producer untis

No.	Criteria group's name	Decision No. 1506 (2008)	Decision No.4653 (2015)
1	Location	3A, 0B	3A
2	Building infrastructure and equipment	9A, 3B	Design production area: 3A, 1B Building infrastructure and equipment: 3A, 0B
3	Breeding stocks and its management	3A, 0B	3A, 1B
4	Veterinary hygiene	9A, 0B	5A, 3B
5	Feeding, drinking water and cleaning water management	8A, 2B	5A, 2B
6	Pig herb management	1A, 1B	
7	Selling management	2A	
8	Transport	1A, 0B	1A, 1B
9	Disease management	2A, 0B	3A, 1B
10	How to use and storage of veterinary drug	1A, 0B	
11	How to prevent and treat diseases	3A, 0B	
12	Manure management	4A, 2B	2A,0B
13	Insects control	0A, 1B	0A, 1B
14	Human resources management	4A, 1B	1A, 2B
15	Recording production information, product traceability and product recall	1A, 0B	1A, 0B
16	Internal check	2A, 0B	1A, 1B
17	Complaint and its settlement	1A, 0B	0A, 1B
	Total	64 (54A, 10B)	45 (31A, 14B)
	At least	Not specify	31A and 7 B

Source: Author summarize from MARD, 2008, 2011, 2012, 2015, 2016. Note: A: Compulsory practices; B: Optional practices

2.3.2 Decision No. 1947 (2011)/Decision No. 2970 (2012)

From this decision, a specific VietGAHP applied for household level (only applied for the households under LIFSAP, 2010-2015, 12/63 provinces). LIFSAP aims to "increase the production efficiency of household-based livestock producers, reduce the environment impact of livestock production…" (World Bank, 2015).

Table 2.9 Assessment Checklist of VietGAHP for pig producing-household

Group No.	Criteria group's name	Decision No. 1947 (2011)/Decision No. 2970 (2012)	Decision No.2509 (2016)
1	Location, Building infrastructure and equipment	3A, 3B	3A, 3B
2	Breeding stocks and its management	2A, 1B	2A, 1B
3	Feeding and its management	1A, 3B	1A, 3B
4	Water and its management	0A, 2B	0A, 2B
5	Veterinary practices and its hygiene	5A, 3B	5A, 3B
6	Selling management	2A, 1B	2A, 1B
7	Manure management	1A, 1B	1A, 1B
8	Recording production information, product traceability and product recall	1A, 0B	1A, 0B
	Internal check		(1A if mutimembers)
	Total	29 (15A, 7B)	Individual: 29 (15A, 14B) Multimember: 30 (16A, 14B)
	At least	15A and 7B	Individual: 15A and 7B) Multimember: 16A and 7B

Source: Author summarize from MARD, 2011, 2012, 2016. Note: A: Compulsory practices; B: Optional practices

This version named VietGAHP for household based swine production which are principles, guidance sequence in order to**: (i)** ensure pig products to meet food safety standards; **(ii)** ensure a social security, health's pig producers, health's pork consumers; **(iii)** protect the environment; and (iv) be product traceability;

This version is simpler than the version of VietGAHP in 2015, it includes 15 compulsory (named A) and 14 optional criteria (named B criteria) in the checklist of assessment that attached in a Decision No. 2970, 23/Nov/2012 (Table 2.9). A household satisfied 15/15 A criteria and at least 7 B Criteria can become a VietGAHP household.

2.3.3 Decision No.4653 (2015)

The VietGAHP for pig production in Vietnam for all units nameds VietGAHP for for pig production. It aims to **(i)** ensure pig products to meet food safety standards; (ii) protect the environment; and (iii) protect the health of a community.

The assessment is basically based on the version assessment of Decision No. 1506 in 2008. It divided into 31 forced criteria (named A) and 14 optional criteria (named B criteria) in the checklist of VietGAHP for pig production assessment that attached in this decision (Table 2.8). However, this assessment version is clearly about the number of criteria that pig producers have to fully comply if they want to certify as an active VietGAHP pig producers. If a farm satisfied 31/31 A criteria and at least 7 B criteria can become a VietGAHP farm.

2.3.4 Decision No.2509 (2016)

The Decision No.2509 is the updated of the specific VietGAHP for household based swine production and it is applied for all households (that is not limited for only households under supported by LIFSAP). This version is basically based on the version of the Decision No.1947 and Decision No. 2970. It includes principles, guidance sequence to**: (i)** ensure and enhance the quality of pig products to meet food safety standards, the health of pig producers and the health of pork consumers; (ii) protect the environment; and (iii) be the product traceability;

The assessment of this VietGAHP version divided into 15 forced criteria (named A) and 14 optional criteria (named B criteria) in Table 2.9. If HH satisfied 15/15 A criteria and at least 7 B criteria can become a VietGAHP HH. All criteria is divided into 8 groups: Group 1: Location, pig housing and equipment used in the pig production (3A, 3B); Group 2: Breeds and breeding management (2A, 1B); Group 3: Feeds and feeding management (1A, 3B); Group 4: Water use (2B); Group 5: Veterinary and veterinary hygiene (5A, 3B); Group 6: Marketing (2A, 1B); Group 7: Environment (1A, 1B), and Group 8: Recording (1A) (Table

2.9). In this version, there is an updated criteria related to the group of producers who want to adopt VietGAHP for multi members in their groups. Beside to comply all 15A and at least 7B, they need to comply one more A criteria related to assess their internal group.

CHAPTER III: TECHNICAL EFFICIENCY IN VIETNAMESE HOUSEHOLDS' PIG PRODUCTION

3.1 Introduction

In Vietnam, pig production is not only one of the main agricultural sectors but also a major source of income and central household activity in rural areas. According to the General Statistics Office of Vietnam (GSO) (GSO, 2013), the value of livestock constitutes 26.8% of the gross agricultural output, a ratio that has been growing overtime. It is predicted that by 2020, livestock production, of which pig production is the greatest component, will constitute over 42% of agricultural output. It is further thought that pig production will come to supply 63% of the country's total meat production by that same time (Vietnamese Prime Minister, 2008). Pig production is almost entirely conducted by small farmers, who own approximately 80% of all pigs (AGAL, 2005). Epprecht (2005) argues that the pig sector is one of the most important contributors to household income within the livestock sector. However, household pig production is reliant on the family's own resources, such as labor, land, and feed produced from agricultural products. In addition, the Vietnamese government's strategy for the future of the pig sector through 2020 holds that production should be shifted from small-scale and family operations to large, intensive and commercial scale operations (Vietnamese Prime Minister, 2008). Thus, household pig production will face increased threats, though it is still believed that it will continue to dominate Vietnam's pork industry (Tisdell, 2010). Furthermore, it is also believed that household pig producers have a comparative advantage within the pig industry (Lapar et al., 2012).

Thus, if households want pig production to continue contributing to their income and to continue supplying pork, they must utilize their resources more efficiently. This study focuses on farrow-to-finish household pig producers who account for 55.85% of Vietnam's pig farmers (Tung, 2009). Farrow-to-finish is a full cycle pig production process that keeps breeding sows and producing piglets that are grown and fattened until they can be sold for their meat (Costales et al., 2006; Lapar et al., 2012). Furthermore, in order to create jobs and income, household farrow-to-finish pig producers increase the scale of their operation and utilize husbandry techniques, such as cross breeding and artificial insemination, in order to improve their performance.

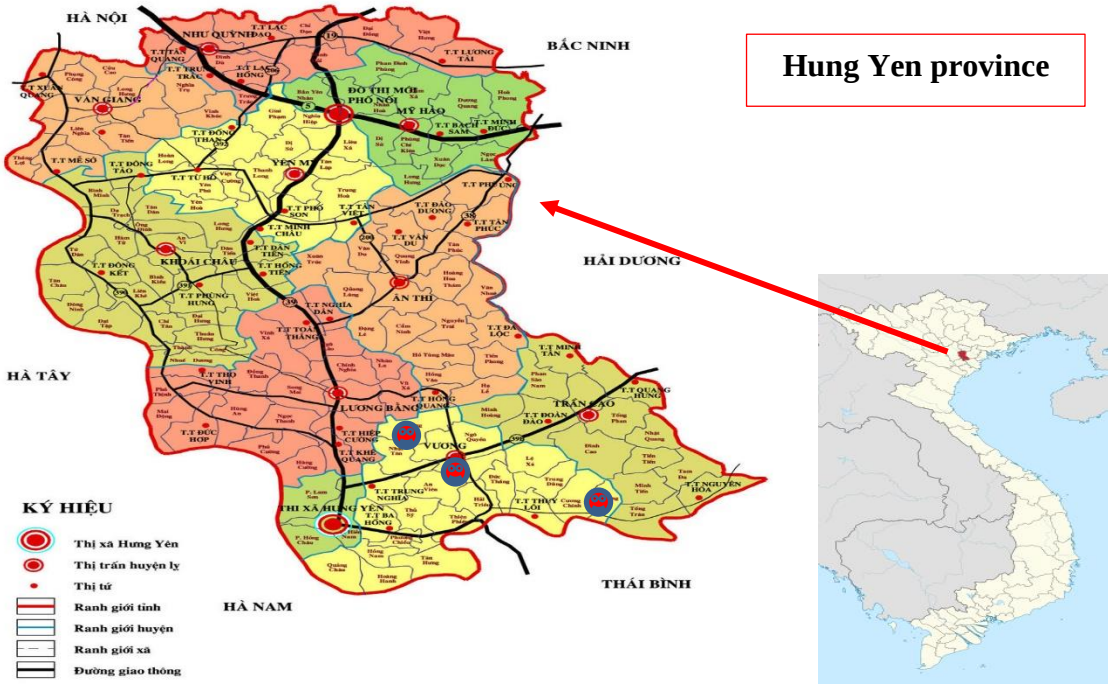
Based on Farrell (1957) seminal article, technical efficiency is defined as "the ability of a farm to use minimum level of inputs given the same output." Recently, several studies

have used DEA approaches to study productive efficiency in pig farming; however, most of these ignored small-scale household operations in developing countries, where pig production is integral to both the agricultural sector and to households. To our knowledge, only Mugera & Featherstone (2008) investigated technical efficiency and its determinants in backyard pig production, with their focus being limited to the Philippines.

However, they still face numerous challenges, such as limited resources, poor genetic stock, low quality feed and diseases, a lack of political support, and poor husbandry techniques (Lapar et al., 2012). As such, the technical efficiency in farrow-to-finish pig production varies based on both time and the farmer in question. It is necessary to improve the efficiency of pig production in households based on their condition combine with management practices in order to improve their income and the abitlity of pork supply in pig industry in Vietnam. This study aims to (i) estimate the level of technical efficiency (TE) in farrow-to–finish pig production in Vietnamese household and (ii) determine factors effecting on TE in farrow - to – finish pig production as well.

3.2 Data and Methodology

3.2.1 Study site



http://vi.wikipedia.org/wiki/H%C6%B0ng_Y%C3%AAn#mediaviewer/File:Hungyenmoi.jpg

http://en.wikipedia.org/wiki/H%C6%B0ng_Y%C3%AAn_Province

Figure 3.1 The located of Tien Lu district, Hung Yen province

Hung Yen province is one of the suburb agricultural province in the Red River Delta area, where located in the north of Vietnam (Figure 5.). About 90% of people living in rural area work in the field of agriculture. The gross product of livestock production in Hung Yen accounts for 45.5% in the total gross product of agriculture in 2009 and will be reach to 50.1 % (6,820 billion VND) in 2015 with the main contribution is from pig production, around 80% (Hung Yen Department of Agricultural and Rural Development, 2010). Hung Yen along with the Red River area have the high density population as well as the decrease of farm land, pig production continues being the main activity and source of income in household.

3.2.2 Data collection method

The field survey was conducted in Tien Lu district with 3 communes were selected randomly including: Hung Dao, Di Che and Minh Phuong. The reason why choosing Tien Lu district is Tien Lu will be become one of the main pig production area in Hung Yen province and also choosing randomly two communes are Minh Phuong and Hung Dao where belong to the main pig production area and one commune is Di Che where does not belong to this area in Tien Lu district (Hung Yen Department of Agricultural and Rural Development, 2010).

Primary data was gathered between August and September, 2014; 177 household farrow-to-finish pig producers were interviewed randomly by using structured and semi- structured questionnaire but only 161 were used to analysis as shown in Table 3.1.

Table 3.1 Total samples by each commune in Tien Lu district

Commune	Number of household pig producers
Minh Phuong	67
Hung Dao	75
Di Che	19
Total	161

Source: Authors' survey in 2014

This study uses the two-stage DEA approach proposed by Coelli et al. (2005). In the first step, DEA model will be calculated the efficiency of each household; and in the second step, the effect of factors on the efficiency score will be regressed by Tobit model.

3.2.3 Data envelopment analysis model

To accomplish the research objectives, two-stage DEA approach will be used in this paper as suggested by Coelli et al. (2005), the DEA model should calculate the efficiency of each household in the first step, and in the second step, a Tobit model should be used to determine the effect of each factor on the efficiency score. DEA models are linear programming methods that can be used to calculate the frontier production function of a set of households and evaluate their relative technical efficiency.

In this study, input-oriented models will be employed to use efficient resources in households with 2 models under two assumptions.

The first assumption is constant return to scale (CRS) to estimates technical efficiency associated with constant return to scale (TEcrs) or the overall technical efficiency Charnes et al. (1978) by solving the following linear program:

$$min_{\theta,\lambda}\theta, \tag{3.1}$$
$$Subject\ to - q_i + Q\lambda \geq 0,$$
$$\theta x_i - X\lambda \geq 0,$$
$$\lambda \geq 0$$

where $x_i$and q_i are the vectors of inputs and ouputs of DMU i respectively, i=1,2…I; X and Q are matrices of inputs and outputs of all DMU; λ is a I * 1 vector of constants; and θ is a scalar in [0,1] that identifies the technical efficiency scores of each DMU. It means that $\theta = 1$ indicates a technical efficiency; $\theta < 1$ indicates a technical inefficiency.

The second assumption is variable to scale to estimate technical efficiency under variable returns to scale (TEvrs) or pure technical efficiency (PTE) proposed by Banker et al. (1984) by reformulation in Eq. (1) with a convexity constraints $I1'\lambda = 1$ becoming equation (3.2) as follow:

$$min_{\theta,\lambda}\theta, \tag{3.2}$$
$$Subject\ to - q_i + Q\lambda \geq 0,$$
$$\theta x_i - X\lambda \geq 0,$$
$$I1' \lambda=1$$
$$\lambda \geq 0$$

in which $I1$ is an I *1 vector of ones.

Scale efficiency (SE): If there is a difference in the CRS and VRS TE scores for a particular firm, scale efficiency can be calculated as following:

$$SE = TEcrs/TEvrs \quad (3.3)$$

If SE = 1, firm has scale efficiency that firm operates at a point of constant returns to scale. If SE < 1, firm has scale inefficiency.

The DEA model employed in this study includes one output and four inputs as definition in Table 3.2.

The output and all of inputs in the first stage should be normalized by the number of sows per cycle to increase the variation of the selected variables and to identify whether pig farms have an optimal size related to the number of sows as Galanopoulos et al. (2006).

Table 3.2 Definition of variables use in DEA model

Variables	Description	Unit
Output (Y)		
Total live weight of fattening pig	The total live weigh of fattened pig produced per sow/cycle	Kg
Inputs		
Labor	Family and hired labor per sow/cycle	Man – day
Feed expenses	The total value of feedstuff using per sow/cycle	1000 VND*
Other variable costs	The total of all variable expenses exclude of labor and feed expenses, such as the electricity fee, the veterinary services, etc. per sow per cycle	1000 VND
Fixed cost	The depreciation of fixed assets per sow/cycle, including the buildings and barn for pig production, machinery, sow per sow/cycle	1000 VND

Note: *) Exchange rate in 2012: 1USD = 20.8197 Dong

3.2.4 Tobit model

The DEA efficiency scores are censored in the interval from 0 to 1, thus the Tobit model is often used to explain the differences among the efficiency score estimated in the first step by a given explanatory variables. Furthermore, the two-stage approach with Tobit analysis using in second stage also will be widen in the field of agriculture and farm area Liu et al. (2013). Moreover, there are a number of studies in agriculture, especially in livestock

production using the Tobit model to evaluate the effect of factors on the efficiency scores in the second stage DEA. Some of them used the dependent variable in the Tobit model with the inefficiency score such as Sharma et al. (1999), Galanopoulos et al. (2006), Yang (2009), but others used the efficiency score like Rowland et al. (1998), Lansink & Reinhard (2004), Hansson & Öhlmér (2008), Mugera & Featherstone (2008), Dhungana et al. (2010). In the former, the dependent variables (i.e. inefficiency scores) are bounded zero so these studies use the Tobit model with lower limit at zero. In contrast, the latter use the Tobit model with upper limit at one. The present study will use the latter approach to determine the factor affecting on the technical efficiency in farrow-to-finish pig production in households. Two Tobit models are used with dependent variables including TEvrs (pure technical efficiency) and SE with upper limit at one.

Thus, the empirical Tobit model is defined as:

$$y_i^* = \beta_0 + z_1\beta_{i1} + z_2\beta_{i2} + z_3\beta_{i3} + z_4\beta_{i4} + z_5\beta_{i5} + z_6\beta_{i6} + z_7\beta_{i7} + z_8\beta_{i8} + z_9\beta_{i9} + z_{10}\beta_{i10} + z_{11}\beta_{i11} + z_{12}\beta_{i12} + z_{13}\beta_{i14} + z_{15}\beta_{i15} + z_{16}\beta_{i16} + z_{17}\beta_{i17} + z_{18}\beta_{i18} + u_i$$

$$= z_i\beta + u_i \quad (3.4)$$

with the observed variable y given by

$$y_i = \begin{cases} y_i^* \; if y_i^* < 1 \\ 1 \; if \; otherwise \end{cases} \quad (3.5)$$

Where: y_i^* is the latent variable;

y_i: Dependent variables (TEvrs and SE)

- z_i denotes the vector of explanatory variables, including various farmer and household characteristic factors as defined in Table 3.3
- β denotes the relationship between the latent and the explanatory variables; and
- u_i is random error, normally distributed with mean zero and variance δ^2

Table 3.3 The definition of variables used in Tobit model

Variables	Description	Unit	Expected sign
	Household head characteristics		
Age (z_1)	Age of household head	Years	-
Gender (z_2)	Take 1 if household head is male and zero otherwise	Dummy	+
Education (z_3)	Years of schooling of household head	Years	+
Main OC (z_4)	Take 1 if household head's main occupation is livestock production and zero otherwise	Dummy	+
Experience (z_5);	Number of years household head has been engaged in farrow to finish pig production	Years	+
Training (z_6)	Take 1 if household head is trained in pig production and zero otherwise;	Dummy	+
Farm characteristics			
No sow (z_7)	The number of sows, which denotes the operating scale of farm. This variable is used to capture the effects of farm size	Numbers	+
Lwperfat (z_8)	Live weigh per fattening pig in kg is used as a measure of biological efficiency;	Number	+
Breeding time (z_9);	The number of months of a full cycle	Months	-
Family members (z_{10})	The number of family members join in pig production;	Numbers	+
Income pig (z_{11})	The income from pig of household in 2013	Million VND	+
Off-farm income (z_{12})	Take 1 if household has off-farm income and zero otherwise	Dummy	+
Self-prepared(z_{13})	Take 1 if a farm self-prepared feedstuff and zero otherwise	Dummy	+
Artificial insemination (z_{14})	Take 1 if pig farm uses artificial insemination and zero otherwise	Dummy	+
Gene type (z_{15})	Take 1 if pig farm uses the local sow and zero otherwise	Dummy	-
Access to credit (z_{16})	Take 1 if a farm has access to credit and zero otherwise;	Dummy	+
Access to veterinary (z_{17})	Take 1 if a farm has access to veterinary service and 0 otherwise.	Dummy	+

3.3 Results and Discussion

3.3.1 The inputs and output in pig production function

Table 3.4 presents the descriptive statistics for the inputs and output in the farrow-to-finish pig production function.

Table 3.4 Descriptive statistics for the DEA model's inputs and output

Variables	Unit	Mean	St. dev	Min	Max
Inputs					
Labor	man-day/sow	27.83	12.56	9.60	71.88
Feed	1000 VND/sow	29021.67	6926.11	13823.00	46793.25
Other variable costs	1000 VND/sow	1191.48	646.21	315.00	3295.00
Fixed cost	1000 VND/sow	1378.46	1032.28	325.83	6806.64
Output					
Total live weigh of fattening pig	kg/sow	915.44	184.30	500.00	1404.00

Source: Authors' survey in 2014

The results indicate that there are considerable variations in input usage. Of all the inputs, fixed cost shows the greatest variation with some farmers reporting expenses 20 times higher than their counterparts. This is because some household pig producers invest more in modernizing their barns than others. Feed expenses are the largest component of total cost, but they show the least variation with the greatest spenders only paying three times as much as more frugal farmers. The variations of labor and other expenses are over 7 and 10, respectively. Additionally, the physical output produced varies substantially, ranging from 500 kg to 1404 kg per sow. In conclusion, there are substantial variations in both the inputs and outputs, especially the in fixed cost and other variable costs of pig production. These variations indicate that there is poor management within the pig production sector.

3.3.2 The socioeconomic characteristics of households

The farmer and household characteristics used in the Tobit models are summarized in Table 3.5.

Most of household head take part in all of agricultural activities in household like crop cultivation, livestock and service. However, about 69% of household head having main occupation is livestock production which mainly raising pig. Moreover, they have an

experience in farrow-to-finish pig production of 10.77 years, lowest experience level is 1 year and highest one is 33 years. The age of household head lies between 28 and 72 with an average of 47.88 year olds. The average of schooling years of household head is 9.40 with a range from 0 to 16. It means that most of household head finishing secondary school levels and some of them gets higher education even though there is still some household heads do not go to school. About 56% of household head receive a training related to pig production. The average scale of household pig production is 1.37 sows per cycle with maximum sows is 4. It means that most of households keeps from 1 to 2 sows per cycle. It is characteristics of farrow-to-finish pig production in household in Vietnam. Live weigh per fattening pig lies between 70 and 120 kg with a mean of 90.76 kg. Furthermore, the time per cycle of farrow-to-finish pig production among households also varies substantially in the range from 7.57 to 10.46 months with an average of 9.03 months while there are there main stages in a typical cycle of farrow-to-finish pig production (breeding time) includes around 4 months for raising sow before and during pregnancy, 1 - 1.5 months for raising sow and offspring from after delivery to before fattening period and around 3.5 - 4 months for fattening pigs. The mean income from pig production is 45 million VND as well as nearly 2 people per household joining in pig production. It means that pig production supplies both the source of income and the job in household. In addition to the household management in farrow-to-finish pig production, the Tables 5 shows that the minor of household still keeps local breed sow, only 13%. Because it is said that local breed sow is easy to raise and productive in delivery though the live weight of fattening pigs or marketed pigs are not high. About 48% of household uses the artificial insemination method in pig production done by both themselves and veterinary services. More than half of households do not use this method because they said that it is not as effective as the direct insemination method. Around 57% of household pig producers self-prepared feed in pig production but mainly for sow. They use their owned agricultural products along with buying products from the feed agencies including maize, rice bran, vegetables, etc. to reduce the cost production. Most of household pig producer can access to the veterinary service, about 84% but they just received some materials and equipment in some disease preventing programs from government such as vaccination, disinfectant, protective clothing, etc. The main reason is that the pig producers not only are worried about spread of disease germs through veterinarians from household to household but also do not believe in veterinarians. The small proportion of pig holders access to credit, only 17% and they mainly use for their building barn, buying feed. The reason why others did not access to

credit is that the pig holders based on their current scale they have already enough money to run their businesses.

This shows that pig production much more depends on households' management. Furthermore, most households run only small scale operations with one to two sows per cycle and have about two people (who are usually the main laborers of the household) participating in pig production. These observations prove that pig production is very important for the households within the study area in terms of both employment and income.

Table 3.5 Descriptive statistics for the households' socioeconomic characteristics

Variables	Unit	Mean	St.dev	Min	Max
Household head charateristics					
Age (z1)	Years	47.88	9.31	28.00	72.00
Gender (z2)	Dummy	0.91	0.28	0.00	1.00
Education (z3)	Years	9.40	2.71	0.00	16.00
Main OC (z4)	Dummy	0.69	0.46	0.00	1.00
Experience (z5)	Years	10.77	7.20	1.00	33.00
Training (z6)	Dummy	0.56	0.50	0.00	1.00
Farm characteristics					
Lwperfat (z7)	Kg	90.76	9.70	70.00	120.00
Nosow (z8)	Numbers	1.37	0.63	1.00	4.00
Breeding time (z9)	Months	9.03	0.59	7.57	10.46
Family members (z10)	Numbers	1.83	0.54	1.00	6.00
Pig income (z11)	Million VND	45.08	37.79	-100.00	180.00
Off-farm (z12)	Dummy	0.72	0.45	0.00	1.00
Gene type (z13)	Dummy	0.13	0.34	0.00	1.00
Artificial insemination (z14)	Dummy	0.48	0.50	0.00	1.00
Seft-prepared (z15)	Dummy	0.57	0.50	0.00	1.00
Access to credit (z16)	Dummy	0.17	0.37	0.00	1.00
Access to veterinary (z17)	Dummy	0.84	0.37	0.00	1.00

Source: Authors' survey in 2014

3.3.3 Technical efficiency level

Table 3.6 reports the frequency and percentage distributions of the TEcrs, TEvrs, and SE scores. The results show that there are still rooms in both technical and scale inefficiencies in farrow-to-finish pig household keepers.

First, the means of overall TEcrs and TEvrs for the sample of pig owners are 80.40% and 85.94%, respectively. Moreover, the range of the TEcrs means is from 52.57% to 100% and that of TEvrs is from 57.31% to 100%. It is shown that there are substantial differences in technical efficiency scores among household pig producers. According to the variable returns to scale (VRS) model, 31 out of the entire sample of 161 households operate at full efficiency. However, under the CRS model, only 13 households are fully efficient. Although some households can produce on the frontier of the farrow-to-finish pig production function, or very near to it, 45.96% of households still operate with overall technical inefficiency scores more than 20%. Furthermore, 31.68% of households exhibit pure technical inefficiency more than 20%. Based on above evidence, it is clear that some pig producing households are not only incapable of achieving technical efficiency, but also unable to produce on an optimal scale.

Table 3.6 Frequency and percentage distribution of technical and scale efficiency

Efficiency score	TEcrs		TEvrs		SE	
	No.	%	No	%	No	%
Less than 0.60	6	3.73	2	1.24	0	0.00
0.60 - 0.70	29	18.01	11	6.83	1	0.62
0.70 - 0.80	39	24.22	38	23.60	10	6.21
0.80 - 0.90	48	29.81	47	29.19	23	14.29
0.90 - 1.00	26	16.15	32	19.88	114	70.81
1.00	13	8.07	31	19.25	13	8.07
Mean	0.8040		0.8594		0.9364	
Std.Dev.	0.1180		0.1117		0.0709	
Minimum	0.5257		0.5731		0.6958	
Maximum	1.0000		1.0000		1.0000	

Notes: 1) Authors' survey in 2014

Secondly, the mean of SE among farrow-to-finish pig keepers was 93.64% with a range from 69.58% to 100%. This means that, beyond their current resources, the household pig producers' size is nearly optimal. However, the households can still enhance their performance by an additional 6.4% by adjusting their scale. In terms of SE, 13 out of the 161 households produced under CRS.

Thirdly, the mean of TEvrs is lower than that of SE; this means that poor management, rather than operating scale, generates technical inefficiency in household farrow-to-finish pig production. This finding is similar to those of Mugera & Featherstone (2008), who analyze backyard pig production in the Philippines. Moreover, Table 3.7 shows the correlation matrix between different efficiency scores. It shows that overall efficiency score had a stronger relationship in pure efficiency score than in scale efficiency. This evidence indicates that an increase in the pure efficiency score will improve the overall efficiency score rather than the scale efficiency score. Thus, it may be concluded that household pig producers should enhance their performance by improving their management, rather than by changing the scale of their operation.

Table 3.7 The correlation matrix of technical efficiency

	TEcrs	**TEvrs**	**SE**
TEcrs	1.0000		
TEvrs	0.8397	1.0000	
SE	0.4582	-0.0938	1.0000

Source: Authors' survey in 2014

3.3.4 Factors affecting on technical efficiency

Table 3.8 displays the results of the Tobit models, which determine the factors that affect TEvrs and SE in farrow-to-finish pig production.

According to Gujarati & Handelshøyskolen (2011), the coefficient on an independent variable in a Tobit model cannot be interpreted as the marginal effect of that variable on the mean of the observed dependent variable, Y_i. This is because the coefficient will have two effects: the first being on the mean of the observed dependent variable, Y_i; the second being on the probability that the talent variable, Y_i*, will actually be observed. However, the sign on this coefficient can show the relationship between the explanatory variables and the dependent variable.

Table 3.8 Results of Tobit regression on pure technical and scale efficiency

Variables	TEvrs			SE		
	Coefficient		St. Error	Coefficient		St. Error
Constant	1.2979	***	0.1880	0.8539	***	0.1041
Age	-0.0019		0.0012	-0.0004		0.0007
Gender	-0.0092		0.0368	0.0277		0.0204
Education	-0.0018		0.0039	0.0038	*	0.0022
Main OC	0.0271		0.0231	0.0106		0.0131
Experience	0.0033	**	0.0016	-0.0004		0.0009
Training	0.0128		0.0225	0.0104		0.0127
Lwperfat	0.0022	*	0.0012	0.0016	**	0.0007
Nosow	-0.0027		0.0186	-0.0094		0.0105
Breeding time	-0.0612	***	0.0185	-0.0123		0.0103
Family members	0.0086		0.0197	0.0224	**	0.0111
Pig income	0.0004		0.0003	0.0003	*	0.0002
Off-farm	-0.0137		0.0248	0.0018		0.0138
Gene type	-0.0385		0.0306	0.0225		0.0173
Artificial insemination	-0.0086		0.0204	0.0021		0.0115
Self-prepared	0.0016		0.0213	-0.0076		0.0119
Access to credit	-0.0539	**	0.0270	-0.0393	***	0.0151
Access to veterinary	-0.0243		0.0291	-0.0347	**	0.0165
Log-likelihood	61.3621			176.8694		

Note: 1) ***,** and * indicate significant differences from 1%, 5% and 10% level, respectively.

2) Source: Authors' survey in 2014

In general, two parameters are found to be significant for both TEvrs and SE and they are live weight per fattened pig and access to credit. The former is used as a measure of biological efficiency and has a positive impact on the efficiency scores. This indicates that households who produce more kgs per fatter pig could achieve a higher technical efficiency scores. In addition to, Rowland et al. (1998), who study farrow-to-finish pig production in Kansas, find that pounds of pork produced per litter per year (used as a measure of biological efficiency) significantly and positively influence TEvrs but negatively affect SE without significance. The reasons for this might be that the sample households could

optimal breeding, the timely administration of vaccinations, and segregated early weaning could all contribute to this effect. In contrast the findings of Mugera & Featherstone (2008)), the results indicate that access to credit has a negative impact on both efficiency scores (i.e., households that had access to credit obtained lower technical efficiency than those who did not have access). The reason might be because households accessed to credit to invest in expansion and modernization their farm but their initial scales are not satisfied the conditions for getting credit's support from the government with low interest rate and long borrowing time. This makes their cost production is higher than that in households who did not access. Thus, households who had accessed to credit obtained lower technical efficiency than those who did not have access.

Aside from the two aforementioned variables, the only factors that affected TEvrs were experience and breeding time. Experience had a positive and significant impact on TEvrs, meaning that the more experience a household head had in farrow-to-finish pig production, the more efficient the household was. This result supports the work of Mugera & Featherstone (2008), who found similar effects in backyard pig production in the Philippines. This effect is quite natural in agricultural activities, especially in developing countries, because more skilled farmers are better able to manage their production and achieve greater efficiency. Moreover, experience plays a particularly major role in farrow-to-finish pig production as it requires the use of a wide variety of special techniques, such as sow and piglet care and fattening. Conversely, breeding time was found to have a negative effect; that is, the longer the breeding time is, the lower TEvrs is. In full cycle pig production, the breeding time mainly depends on the time it takes to raise a sow before it may be impregnated, the time necessary to wean piglets, and the fattening time. Households were inefficient because they took too long to impregnate their sows and to wean their piglets, which were ultimately infected with various diseases as well. It should be noted that none of the other variables had a significant effect on TEvrs. Though it is thought that the number of sows (representing the size of a household's operation) should positively and significantly affect TEvrs, the results indicate that its effect is negative as well as insignificant. This is inconsistent with the results reported by Galanopoulos et al. (2006), who showed that the number of sows had a positive and significant impact on TEvrs. One potential reason for this study's finding could be that the farms' sizes were captured by multiple variables, like the number of sows and the number of fattening pigs; this suggests that larger households are not necessarily more efficient than their smaller counterparts.

Table 3.9 Partial effects of Tobit regression on pure technical and scale efficiency

Variables	TEvrs		SE	
	Partial Effect	St. Error	Partial Effect	St. Error
Gender	-0.0078	0.0314	0.0224	0.0165
Age	-0.0016	0.0010	-0.0003	0.0005
Education	-0.0015	0.0033	0.0030 *	0.0018
Main OC	0.0231	0.0197	0.0086	0.0106
Experience	0.0028 **	0.0014	-0.0003	0.0007
Training	0.0109	0.0192	0.0084	0.0103
Lwperfat	0.0019 *	0.0010	0.0013 **	0.0005
Nosow	-0.0023	0.0159	-0.0076	0.0085
Breeding time	-0.0522 ***	0.0157	-0.0100	0.0083
Family members	0.0073	0.0168	0.0181 **	0.0090
Pig income	0.0003	0.0003	0.0002 *	0.0001
Off-farm	-0.0117	0.0212	0.0015	0.0112
Access to credit	-0.0460 **	0.0230	-0.0318 ***	0.0122
Self-prepared	0.0013	0.0181	-0.0061	0.0096
Access to veterinary	-0.0208	0.0248	-0.0280 **	0.0133
Gene type	-0.0328	0.0261	0.0182	0.0140
Artificial insemination	-0.0074	0.01742	0.00169	0.00927

Note: 1) ***,** and * indicate significant differences from 1%, 5% and 10% level, respectively.

2) Source: Authors' survey in 2014

Education, family members, pig income, and access to veterinary services all affected only SE. The results show that more educated farmers run their businesses on a more efficient scale than less educated farmers, which concurs with Dhungana et al (2004) and Mugera & Featherstone's (2008) findings. However, Galanopoulos et al (2006), who study commercial pig farming in Greece, found that education was negative and insignificant. It could be that education plays a greater role in agriculture in developing countries because well-educated farmers might have better management skills and greater access to information. In addition, households with more family members working in pig production and more income from pigs tend to have a greater SE score. Lastly, access to veterinary has

a negative and significant impact on SE. This contradicts Mugera & Featherstone's (2008) findings, as they reported that Filipino farmers who were visited by a veterinarian had higher SE scores those who were not visited. This may be because veterinary services in the study area were ineffective. Households who had access to veterinary care usually only received government support when their stock contracted diseases. They also elected to forego veterinarians'' advice on husbandry techniques as they believed that the veterinarians were both unqualified and likely to spread diseases from farm to farm. No other factors were found to have a significant impact on SE.

3.4 Conclusions and Implications

3.4.1 Conclusions

Households continue to produce most of Vietnam's pork supply; however, they must increase their performances despite facing challenges such as their small scale, limited resources, a lack of support, and poor husbandry techniques. Thus, they must endeavor to become more efficient at producing pigs.

First, this study showed that the mean of overall technical efficiency in household farrow-to-finish pig production was 80.40%; this means that households could reduce their inputs by nearly 20% and still produce the same level of output. Also this study indicated that there was a considerable variations in technical efficiency in pig production between household in Vietnam. Furthermore, this study found indications that the technical inefficiencies in pig production were mostly the product of low TEvrs rather than low SE. Thus, it may be concluded that households should concentrate on improving their managerial skills rather than changing their scale in order to enhance their performance.

Secondly, the main factors that affect technical efficiency are determined via regressing the farmer and household characteristic factors on TEvrs and SE using Tobit model. They can be listed as lwperfat (live weight per fattening pig), breeding time, education, experience, family members joining in pig production, pig income, access to credit and access to veterinary service.

3.4.2 Implications

From these results, several implications may be drawn for both households and the government. First, households could reduce their inputs and produce large quantities fattened pigs by utilizing breeding centers, which provide clear information on husbandry. Pig producers may also enhance their skills through training programs and by studying the best pig producers. Another option for inefficient households is to reduce their breeding time by taking better care

of the sows before they become pregnant and by weaning their piglets earlier (about 30 days after birth).

Second, government must emphasize that while it wishes to increase the production of small-scale household operations, that the pig industry is "changing from small, family based farm to large, intensive and commercial farm" (Vietnamese Prime Minister, 2008). Furthermore, they should also inform the public of breeding sources and specifications. The government could also supply credit at a lower interest rate and for longer periods to households with a high proportion of income from pigs and with more family members participating in pig production; this would assure that even households with very small-scale operations could still earn a living from pig production. Additionally, an effective veterinary service should be made available to pig producers in order to better prevent the spread of diseases

CHAPTER IV: BIOGAS ADOPTION IN MANURE MANAGEMENT OF VIETNAMESE HOUSEHOLDS' PIG PRODUCTION

4.1 Introduction

Livestock production is considered a main subsector of the Vietnamese agricultural sector and contributes to improving the livelihood of farmers in rural areas. Livestock production contributed 26.8% of agricultural gross domestic product in 2013 (GSO, 2013) but this is predicted to increase to more than 42% by 2020 (Vietnamese Prime Minister, 2008). However, livestock production has negative impacts on the environment, including air, soil, and water pollution from waste, especially manure from pig production. Thus, the management of animal manure sources is one of the biggest challenges currently facing pig production in Vietnam. According to Vu et al. (2007), slurry, liquid manure, and solid manure are the three major manure types in pig farming while the four categories of pig manure management are non-treatment with direct disposal to fields or fishponds, composting, storage without treatment, and biogas production. Biogas production is perceived a good way to reduce some environmental problems in manure management, such as the spreading of pathogens and noxious odor emissions (Vu et al., 2007).

Biogas technology was introduced in Vietnam in 2003 with the Biogas Program for the Animal Husbandry Sector in Vietnam (BPAHSV) encouraging construction of biogas digesters through cooperation between the Livestock Production Department of the Ministry of Agricultural and Rural Development and the Netherlands Development Organization (SNV) (BPAHSV, 2015b). The merits of biogas technology include the development of safe treatment of livestock waste and a clean environment, protecting against infectious diseases, producing cheap and clean energy for heating and cooking in households, improving the working environment for women, and, in particular, reducing deforestation in remote and mountainous areas (Tran et al., 2009).

Although biogas technology is a useful way of managing animal manure to reduce environmental problems in rural areas, many households that produce pigs still do not use biogas digesters. With regard to the literature, there are some studies on biogas adoption within the field of renewable energy, such as Mwirigi et al. (2009), Qu et al. (2013), and Walekhwa et al. (2009), but they have not focused on only pig farms, which have great potential for biogas production. Meanwhile, in Vietnam, to the best of our knowledge, there has been only one study on biogas production conducted by Thien Thu et al. (2012),

comparing manure management practices between farmers who have adopted biogas technology and those who have not but the authors only point out the reasons for non-adoption. These reasons were only farm characteristics, including insufficient money, number of animals, and land constraints to install biogas digesters. Thien Thu et al. (2012) did not indicate farmer characteristics in their study. Thus, the present study aims to determine the socioeconomic factors contributing to the adoption of biogas in manure management of household pig production.

4.2 Data and Methodology

4.2.1 Study sites and data collection

The study was conducted in Tien Lu district, a typical agricultural district in Hung Yen province located in the Red River Delta area, Vietnam. According to the Hung Yen Department of Agricultural and Rural Development (HYDARD, 2010), Tien Lu district is planned to become one of the two main largest pig production zones in Hung Yen province by 2020. Moreover, Hung Yen province is one of the provinces that has been implementing the Biogas Program for the Animal Husbandry Sector in Vietnam since 2009 (BPAHSV, 2015a).

The field survey was conducted in Tien Lu district with three communes, including Minh Phuong, Hung Dao, and Di Che. The first 2 communes were selected randomly from 5 target communes in the district that are to establish concentrated livestock production by 2020 (HYDARD, 2012) and the last commune was selected randomly from 13 other communes.

Primary data were gathered via personal and face-to-face interviews using structured and semi-structured questionnaires from August to September 2014. In total, 161 households were used in the analysis.

4.2.2 Logit model

To investigate the variety of factors contributing to the adoption of biogas in manure management of household pig production, a logit model is used, following Kabir et al. (2013) and Walekhwa et al. (2009).

The logit model is defined by Gujarati and Handelshøyskolen (2011) as follows:

$$Y = ln\left(\frac{P}{1-P}\right) = \beta X + u \qquad (4.1)$$

$$with\ P = \frac{e^{\beta X+u}}{1+e^{\beta X+u}} \qquad (4.2)$$

where Y is the dependent variable (Y=1 if the household adopt biogas and 0 otherwise). P is the probability of biogas adoption, X comprises the independent variables (Table 1), β are the parameters of the model, e is the base of the natural logarithm, and u is an error term.

Before choosing the final model with independent variables in Table 4.1, we attempt another two models using the age variable that is adopted usually in studies, such as Kabir et al. (2013), Qu et al. (2013), and Walekhwa et al. (2009). The first model has all the independent variables, as in Table 1, while the second model has the same variables as the first but the age variable changes from only age form to quadratic form with age and age squared (age2). Then, we compare the three above mentioned models using two conditions. The first condition is the Akaike Information Criterion (AIC) indicator, and the model defines the AIC indicator as small. The AIC indicators for the current model and the two comparison models are 196.4, 198.4, and 200.2, respectively. Thus, the current model is best. The second condition is the McFadden pseudo R-square. For the three models, these indicators are 12.9%, 12.78% and 12.88%, respectively. In addition, the age variable is not significant in both the comparison models.

Table 4.1 Definition of factors used in Logit model

Variable	Type	Description
Training	Binary	Take 1 if household head is trained in pig production and zero otherwise
Membership	Binary	Take 1 if household head is a member of any agricultural cooperatives or farmer groups and zero otherwise
Education	Continuous	Years of schooling of household head
Farm size	Categorical	Number of sow in 2014 (Small =1; Medium=2-3; Large >=4)
Family member	Continuous	Number of family members joining in pig production
Income	Continuous	Total household income in 2013 (in million VND*)

Note: *) The exchange rate in 2012 was 1USD = 20,820VND

4.3 Results and Discussion

4.3.1 Household pig production socioeconomic characteristics

Table 4.2 shows the mean and percentage values of all variables considered to have effects on adopting biogas in manure management in Vietnamese household pig production as well as a comparison of the differences between the biogas adoption group and the non-adoption group.

On the one hand, the mean schooling years of the household heads is 9.4, and it is 0.59 years higher in the adopted group than in the non-adopted group at the 10% significance level.

In general, 56% of household heads have been trained in pig husbandry techniques and 45% of them have joined at least one organization, such as a co-operative, farmers' association, and women's association, through which they can share and obtain information about, for example, production and markets. In addition, the proportions of household heads in the adoption group that have been trained and have become members of groups are significantly higher than in the non-adoption group by 17% and 16%, respectively. This proves that the adoption group might have better conditions for accessing the adoption of biogas as manure management in pig production.

Table 4.2 Descriptive statistics of factors used in logit model

Variable	Biogas non-adoption (n=52) (1)		Biogas adoption (n=109) (2)		Difference (1)-(2)		Total sample (n=161)	
	Mean	SD	Mean	SD			Mean	SD
Training	0.44	0.25	0.62	0.24	-0.17	**	0.56	0.50
Membership	0.35	0.23	0.51	0.25	-0.16	**	0.45	0.50
Farm size								
Small	0.27	0.20	0.18	0.51	0.09		0.21	0.41
Medium	0.56	0.25	0.41	0.25	0.15	**	0.46	0.50
Large	0.17	0.15	0.40	0.24	-0.23	***	0.33	0.47
Family member	1.85	0.53	1.82	0.19	0.03		1.83	0.54
Income	107.83	89.51	125.52	85.54	-17.69		119.81	86.96
Education	9.00	11.22	9.59	5.45	-0.59	*	9.40	2.71

Note: 1) ***, ** and * indicate significant difference from 1%, 5% and 10%, respectively
Source: Authors' survey in 2014

On the other hand, 79% of households have medium- and large-scale pig production but of them, most are medium-scale and keep 2–3 sows per year. Among farms of medium size, there are 14% more in the biogas non-adoption group than the biogas adoption group. In contrast, among large farms, there are 23% more in the biogas adoption group than in the non-adoption group. On the other hand, there is no difference in this proportion between the two groups among small households. In addition, there are no differences between the two groups in the number of family members joining pig production and the total household income. At this point, it is easy to see that there are not many differences in household conditions in adopting biogas for manure management.

4.3.2 Factors affecting biogas adoption in manure management

The results of the binominal logit model are shown in Table 4.3. First, the likelihood ratio (LR) Chi-square test is based on the assumption that at least one of the coefficients of its explanatory variables is not equal to zero. The LR Chi-squared with 9 degrees of freedom is 26.137 and is significant at 5%. This implies that the full model is better than the model with only a constant coefficient. Moreover, in measuring the goodness-of-fit of the logistic model, the McFadden pseudo R-square is 12.9%. Although this is relatively low, it is similar to the findings of Kabir et al. (2013) and Mwirigi et al. (2009), whose McFadden pseudo R-squares are 14.6% and 14.1%, respectively. Moreover, Gujarati and Handelshøyskolen (2011) emphasized that goodness-of-fit is the second most important measure in binominal regression models.

Table 4.3 Results of logit regression on biogas adoption in manure management

Variable	Coefficient		Standard Error	z	Prob. |z|>Z	Odds ratio	Partial Effect	
Training	0.44		0.38	1.16	0.25	1.55	0.08	
Membership	0.70	*	0.40	1.75	0.08	2.00	0.13	*
Farm size								
Medium	-0.04		0.45	-0.08	0.94	0.97	-0.01	
Large	1.42	**	0.58	2.44	0.01	4.12	0.24	***
Family member	-0.20		0.36	-0.55	0.58	0.82	-0.04	
Income	0.01	*	0.01	1.67	0.10	1.01	0.00	*
Income^2	.26D-04	*	.14D-04	-1.86	0.06	1.00	.47D-05	*
Education	0.63	**	0.25	2.50	0.01	1.87	0.12	**
Education^2	-0.03	**	0.01	-2.36	0.02	0.97	-0.01	**

Note: 1) nnnnn.D-xx or D+xx means that multiply by 10 to -xx or +xx.

2) ***, **, and * indicate significant difference from 1%, 5%, and 10% respectively

3) Log likelihood function = -88.216, Chi squared (9) = 26.137*** McFadden Pseudo R^2 = 12.90%

4) Hosmer-Lemeshow chi-squared (9 degree of freedom) = 17.639, P-value < 0.05

Source: Authors' survey in 2014; Sample size = 161,

Among the socioeconomic factors, the following variables are found to be statistically significant and to contribute to the adoption of biogas in manure management of household pig production: the education of household head (both education and education2 at 5%

significance), membership (at 10% significance), large farm size (at 5% significance) and total household income (both income and income2, at 10% significance).

The level of education of household head has a quadratic form with an inverse U-shape. This means that the probability of building a biogas system increases with a household head's level of education, but peaks at an education level of 10.5 years and then decreases. Moreover, the mean of schooling years of household heads in the study area is 9.4 years, meaning that household heads have just finished secondary school education. Thus, higher educated household heads are likely to adopt biogas. However, when the level of education is even higher, households tend not to adopt biogas. The reason might be that less educated household heads have less ability to access information on biogas production compared to their more educated counterparts but most educated household heads have more chances to access better technologies than biogas. This result is in line with the contrary results of Kabir et al. (2013) and Walekhwa et al. (2009). While Kabir et al. (2013) found that in Bangladesh, an increase of 1 year of education raises the odds of adopting biogas by 18.6%, Walekhwa et al. (2009) indicated that in Uganda, education was correlated negatively with biogas adoption. The reason might be, as Walekhwa et al. (2009) explained, that biogas technology tends to be consumed by less educated people in rural areas. It is clear that the average years of education of household heads in Bangladesh (8.75 years) is lower than in Uganda (11.34 years). Another issue is that the marginal effect of household head's education is not linear, and thus, it will change in accordance with the level of education.

Membership of organizations is the second factor that contributes to the expected potential adoption of biogas. The coefficient of the membership variable is 0.7. This means that the odds of biogas adoption for household heads who are members of organizations over those that are not members is 2.00. In other words, the odds of adopting biogas for household heads who are members are 100% higher than those for non-members. If household heads were to join any group, they would tend to build biogas systems in their pig production compared to non-members of groups. This is because the household head who becomes a member of a group might have the chance to access useful information about biogas for manure management. Moreover, the marginal effect of this factor is 0.13, which means that the probability of biogas adoption will be 13% higher for farmers who join some organization compared to farmers who do not.

Large farm size, measured by number of sows, has a positively significant impact on the log odds of biogas adoption for manure management. This implies that the odds of biogas

adoption for households that are large farms over the odds for households that are small farms is 4.12. In other words, the odds for households that are large farms of adopting biogas are 312% higher than the odds for households that are small farms. This is because more sows are equated with more manure released, affecting household decisions about whether to construct biogas plants. This result is similar to that of Thien Thu et al. (2012), who indicated that insufficient animals to support biogas production is one of the factors affecting farmers' decisions not to build biogas plants. In addition, this finding is consistent with a variety of studies that examined biogas adoption for the supply of energy, including Kabir et al. (2013) and Walekhwa et al. (2009). Moreover, the marginal effect of large farm size in the present study is 0.24, which shows that households with large-scale pig production tend to adopt biogas technology with a 24% higher probability compared to small households. In addition, this study finds no difference in the probability of biogas adoption between medium and small farm sizes. All of this evidence shows that farm size remains an important contributor to whether to adopt biogas technology in manure management.

Out of the four above mentioned factors, income is expected to be the most crucial factor influencing the adoption of biogas technology in manure management. This variable also has an inverse-U shape like the education of the household head. The mean of total household annual income in the study area, 119.81 million VND, is much lower than income at the top of the inverse U-shape, which is around 192.3 million VND. Thus, the probability of biogas adoption increases with household income; in other words, rich households are more likely to install biogas digesters, except for households with income higher than 192.3 million VND because they tend to find better technologies to manage their manure from pig production. The same results are shown by Kabir et al. (2013), Mwirigi et al. (2009), and Qu et al. (2013). Their reasoning is the high cost of constructing biogas digesters.

4.4 Conclusion and Implications

The main objective of this study is to investigate the key factors affecting the adoption of biogas technology for manure management in Vietnamese household pig production.

The results are as follows. First, there are differences in socioeconomic characteristics of household pig production between the biogas adoption and non-adoption groups. On the one hand, there are statistically significant differences in household heads' characteristics, including training, membership, and education. On the other hand, among farm characteristics, only farm size shows a statistically significant difference between the two groups, except for small farms.

Second, we establish the main factors affecting biogas adoption, including education of household heads, membership of groups, large farm size, and household income. All of these have positive impacts on the willingness to adopt biogas, except for some farmers with very high education and some households with high income, who might seek more modern manure management technologies.

Based on this evidence, to promote the application of biogas systems in pig production to contribute to reduced environmental pollution in livestock production, the Vietnamese government should spread more information related to the advantages of biogas digesters. In particular, enhanced communication channels among households would be effective. Moreover, farm size is a significant factor impacting on biogas adoption but this study proves no differences between small and medium households, which are the prominent farm size in pig production. Last but not least, financial programs should be offered to farmers, especially low-income households.

CHAPTER V: IMPACT OF VIETGAHP IMPLEMENTATION ON VIETNAMESE HOUSEHOLDS ' PIG PRODUCTION

5.1 Introduction

The Association of Southeast Asian Nations (ASEAN), including Vietnam, developed Good Agricultural Practices (GAP) after quality assurance and food safety pressures from international and domestic trading partners within the region, as well as in response to sustainable environmental development (Premier and Ledger, 2006). The GAP can be listed as a type of public good agricultural practices (Hobbs, 2007) that governments develop and support. Public GAP aim for food safety, quality assurance, and environmental protection goals while supporting smallholders joining global markets (Amekawa, 2009). The Vietnamese government has released a variety of GAPs for vegetables, fruits, livestock and aquaculture (MARD, 2008a, 2008b, 2008c, 2008d, 2008e, 2008f, 2010a, 2010b, 2011a, 2011b, 2011c, 2014, 2015, 2016). Specifically, the Vietnamese Good Animal Husbandry Practices (VietGAHP) publication describes GAPs for livestock (MARD, 2008c, 2008d, 2008e, 2008f, 2011b, 2011c, 2015, 2016).

The VietGAHP for household (HH) based pig production includes a sequence of principles and guidance to: (i) ensure and enhance the quality of pig products in order to meet food safety standards and improve the health of pig producers and pork consumers; (ii) protect the environment; and (iii) offer product traceability (Ministry of Agriculture and Rural Development – MARD, 2016). The original VietGAHP standard for pig production in Vietnam was released in 2008 by MARD. It has been promoted since 2008 to encourage pig production by all general production units including households, commercial farms, agricultural enterprises, cooperatives, and other organizations (MARD, 2008d). The VietGAHP for pig production has included specifications at the HH level since 2011 under the Livestock Competitiveness and Food Safety Project (LIFSAP) (MARD, 2011b). According to the World Bank (2009a), LIFSAP aims to "*increase the production efficiency of household-based livestock producers* [and] *reduce the environmental impact of livestock production*." This project operated from 2010 to 2015 and was expanded at the end of 2018, with 12 of 63 provinces selected to promote VietGAHP standards at the HH level. As a first step, they aimed to achieve LIFSAP's objectives, and ultimately aspired to promote and deeply diffuse VietGAHP standards in HH pig production.

Although HH pig production plays a vital role in the Vietnamese pig industry and has been promoted to produce safe pork meat based on the VietGAHP criteria, VietGAHP-based

pork product is limited. There were 3.44 million Vietnamese households participating in pig-raising in 2016 (General Statistics Office of Vietnam - GSOV, 2018). HH pig production supplied approximately 80% of Vietnamese pork (Lapar et al. 2011). Moreover, Lapar (2014) indicated that HH-based pig production will continue to dominate the Vietnamese pig sector over the next decade. Although the Vietnamese government has widely promoted VietGAHP standards for household-level pig production in particular, and among other production units in general, VietGAHP-compliant units only contributed 24.9 tons of pork in 2016, or 0.7% of total pork production (The Census Steering Committee Central, 2017).

Factors associating with VietGAHP adoption as well as the impact of VietGAHP adoption in Vietnamese pig production have been raised by Giang et al. (2017), Lapar et al., (2017), Nguyen (2017) and Vo (2017). Farmers' pig-raising experience, education, and pig-raising's role in terms of income distribution and within the HH's VAC system (in which "V" denotes the garden; "A" is the pond, and "C" is the barn) have been found to enhance the ability to adopt VietGAHP in HH pig production (Giang et al., 2017). VietGAHP adoption has had a positive impact including shorter pig breeding cycles (Lapar et al., 2017; Vo, 2017) and higher economic benefits (Lapar et al., 2017; Nguyen, 2017; Giang et al,. 2017).

Further, changes in farmers' behavior could be observed after VietGAHP adoption (Lapar et al., 2017). However, some questions on farmers' engagement and participation in the program still remain, as some VietGAHP standards are strict and difficult for farmers to adopt, especially for farmers with limited abilities (Nguyen, 2017). Moreover, the VietGAHP for HH pig production can be noted as a package of technologies with 29 practices. Thus, two sides of farmers' VietGAHP adoption can be investigated: (i) What are the factors related to the HH and institutional characteristics to adopt VietGAHP, and (ii) Are there any differences between the VietGAHP HH and conventional HH in implementing the VietGAHP criteria? This context is particularly important, as all VietGAHP households that lost their active VietGAHP status at the end of 2015 continue to implement VietGAHP criteria. Moreover, no studies have combined the determinants of VietGAHP in HH pig production and a measurement of differences in implementing VietGAHP criteria between VietGAHP and conventional households. This study aims to identify factors associated with VietGAHP adoption in HH pig production and to determine the impact of VietGAHP adoption on its criteria implementation toward fulfilling the 2016 VietGAHP.

5.2 Methodology

5.2.1 Site selection

Hung Yen province was 1 of 12 target provinces in LIFSAP located in Vietnam's Red River delta. The delta is the largest pig production region in Vietnam with 7.4 million pigs, and accounted for 25.5% of domestic pig production in 2016 (GSOV, 2017). Tien Lu and Khoai Chau were two of four districts promoting VietGAHP under LIFSAP support for HH pig production in Hung Yen province. In 2017, the ratio of agricultural production land to the total land of Tien Lu and Khoai Chau districts were highest in four districts at 63% and 60%, respectively. Also, these districts were the largest by total land area in the province at 7859 ha and 13098 ha, respectively (Hungyen Statistics Office, 2018).

5.2.2 VietGAHP criteria and adoption

The VietGAHP standard released in 2011 has only been applied for households registered as LIFSAP members, hereafter called "VietGAHP households" or "VietGAHP adopter households". The VietGAHP for HH pig production was updated in 2016 based on the VietGAHP for HH pig production released in 2011. HH based-pig production was defined as the total revenue received from pig production in a financial year totaling less than one billion Vietnamese dong (44,535 USD)[2] (MARD, 2016).

The 2016 VietGAHP standard included 29 practices or criteria divided into 15 compulsory "A criteria" and 14 optional "B criteria." These were categorized into eight groups, including Group I (location, building infrastructure, and equipment, or criteria 1 to 6), Group II (breeding and breeding management, or criteria 7 to 9), Group III (feeding and feeding management, or criteria 10 to 13), Group IV (water, or criteria 14 and 15), Group V (veterinary practices and veterinary hygiene, or criteria 16 to 23), Group VI (sales, or criteria 24 to 26), Group VII (environment, or criteria 27 and 28), and Group VIII (recording, or criterion 29). The definition and the detailed requirements of each criterion are described in Appendix A1. Furthermore, those aspiring to become active VietGAHP households must first satisfy all 15 A criteria and at least 7 B criteria (MARD, 2016).

5.2.3 Data collection

Primary data was collected in April 2018, and included 114 VietGAHP households and 116 conventional households. A VietGAHP HH is defined as a pig HH who registered as a member of their district's LIFSAP group. They were randomly chosen based on lists of VietGAHP groups. A conventional household (VietGAHP non-adopter) is a household pig

2 Exchange rate: US$ 1 = 22,454 Vietnamese dong at the surveyed time.

producer as defined by MARD (2016) and one which was not registered as a member of VietGAHP groups. They had not received any training regarding VietGAHP criteria, but they had basic amenities in place for their farms and for keeping pigs. Conventional households were randomly selected in the same district as VietGAHP households.

5.2.4 Empirical model of VietGAHP adoption

First, the literature on agricultural technology adoption indicates that the most appropriate approach used to specify the relationship between the decisions to adopt or not adopt, with a set of explanatory variables, would be the Logit or Probit models (Feder et al. 1985). The Probit model is preferable to the Logit model in econometrics due to the normality assumption for the error term (Wooldridge, 2014). Recent empirical studies have used the Probit model to discover the factors affecting the adoption of agricultural technology (Wang et al., 2012, Asfaw et al., 2012, Ghimire et al,. 2015, Saiful Islam et al., 2015, Coulibaly et al., 2017). Further, this approach has used in sustainable agricultural technology (Mariano et al., 2012, Srisopaporn et al., 2015, Marine et al., 2016). Therefore, this research uses the Probit model, based on the latent variable model (Wooldridge, 2014), to clarify the factors determining VietGAHP adoption in this research, as follows:

$$Y^* = \beta_0 + X\beta + e \tag{5.1}$$

$$with\ Y = 1\ if\ Y^* > 0\ and\ Y = 0\ if\ Y^* \leq 0$$

where Y^* is an unobserved or latent variable; Y is an observed variable of Y^*, with $Y = 1$ if the farmer is a VietGAHP HH, and 0 otherwise; X is the full set of explanatory variables; β is the set of parameters; and e is independent of X and has a standard normal distribution.

This study also estimated the average marginal effects of explanatory variables regarding the probability of becoming a VietGAHP HH to demonstrate the magnitude of these relationships, as Wooldridge (2014) proposed. This estimation is essentially based on the explanatory variables' partial effects on adoption probability. Wooldridge (2014) indicated that if x_j is a continuous variable, its marginal effect is calculated as in the below Equation (5.2):

$$\frac{\partial probability(Y=1)}{\partial x_j} = g(\beta_0 + X\beta)\beta_j \tag{5.2}$$

where g is a probability density function. This marginal effect always has the same sign as β_j. However, if x_l is a dichotomous explanatory variable, its marginal effect is simply the change in the predicted probability of adoption when x_l changes from zero to one, given all other variables being fixed.

5.2.5 Variables used in VietGAHP adoption model

Table 5.1 details the definition and expected sign of the explanatory variables used in the Probit model. The expected sign of each variable regarding VietGAHP adoption was based on an observation of literature regarding the adoption of agricultural technology (Feder et al., 1985; Asfaw et al., 2012), sustainable agricultural practices (Souza et al., 1990; Baumgart-getz et al., 2012; Mariano et al., 2012; Noltze et al., 2012; Wang et al., 2012; Ghimire et al., 2015; Saiful Islam et al., 2015; Coulibaly et al., 2017), and public GAP adoption (Giang et al., 2017; Srisopaporn et al., 2015; Marine et al., 2016). All explanatory variables were divided into three categories: farmer characteristics, represented by *Gender*, *Education*, *Experience*, and *Training*; HH characteristics, represented by *Farm size*, *Pig raisers*, *Pig_HH income*, *Off-farm income*, *HH income*, and *Biogas*; and institutional characteristics, represented by the *Credit access* and *Veterinary access* variables.

5.2.6 Measuring impact of VietGAHP adoption on its criteria implementation

The *z*-test was used to compare the two proportions in each VietGAHP criterion between the VietGAHP and conventional groups. P_1 is the proportion of VietGAHP group households who stated that they meet all VietGAHP criteria, divided by the total number of VietGAHP households; P_2 is the proportion of conventional group households who stated that they fulfilled all VietGAHP criteria, divided by the total number of conventional households.

Although each VietGAHP criterion has its own assessment method (MARD 2016; see also the Assessed Method column in Appendix A2) there can be one method or a combination of methods used for each, including reviewing record books and the VietGAHP manual, or observations and interviews. However, this study assessed the VietGAHP and conventional households' levels of adoption for each criterion by the same approach, specifically, interviewing farmers based on "yes or no" questions for each criterion requirement in two steps. First, farmers were asked whether they had adopted each criterion. If yes, the second step questioned them regarding the intensity of adoption, and whether this is complete. If farmers answered yes to all requirements, this was noted as a full adoption of that criterion, which means that the farmer could answer immediately about the requirement based on their current implementation. For criteria numbered 1–4, 6, 9–13, 16–19, 21, 22, and 24–26, we asked farmers directly using the above procedure. For the other criteria we asked more indirect questions regarding how they practiced these criteria in their frequently practiced activities. We subsequently compared their answers with each criterion's standards, as noted in the VietGAHP manual.

Table 5.1 Explanatory variables and their definitions as used in the Probit model

Variable	Definition	Expected Sign
Dependent variable		
VietGAHP HH	= 1 if HH adopted VietGAHP for their pig production and registered as a LIFSAP member, 0 otherwise	
Explanatory variables		
Farmer's characteristics		
Gender	= 1 if the respondent farmer is male, 0 otherwise	+
Education	Years of formal schooling (Year)	+
Experience	Years of pig production (Year)	+/-
Training	= 1 if the farmer has trained in pig production, 0 otherwise	+
HH's characteristics		
Farm size	Pig warehouse's area (m^2)	+
Pig raisers	Number of family members joining in pig production (Person)	+
Pig_HH income	Ratio of pig income to total HH income (%)	+
Off-farm income	= 1 if HH has income from activities external to the farm, 0 otherwise	+/-
HH income	The sum of the farm's total cash income and the HH's off-farm income in 2017 (Thousand USD)	+
Biogas	= 1 if households have a biogas system, 0 otherwise	+
Institutional characteristics		
Credit access	= 1 if households currently have loan credit for their pig production, 0 otherwise	+
Veterinary access	= 1 if household used veterinary services in their pig production, 0 otherwise	+

Note: + and- represent for positive and negative signs, respectively

Another important factor for implementing VietGAHP goals involves product traceability based on farmers' record books, but most conventional farmers did not know about the record book format for a comparison of the implementation of practices recorded for criteria 7, 9, 10, 20, 21, 23, and 27. This study only asked farmers if they fully recorded

information for these particular criteria, and did not mention the record book format included in criteria 29. All questions regarding the adoption of VietGAHP criteria were pretested to guarantee that farmers could answer them. Details are illustrated in this study's Appendix A2, in the Assessed Method column.

5.3 Results and Discussion

5.3.1 Characteristics of Vietnamese HH pig production

Table 5.2 displays the socio-economic characteristics of Vietnamese HH pig production, as well as the differences between VietGAHP and conventional groups. First, Vietnamese HH pig farmers only had 8.2 years of formal education, but 84.3% were trained in pig production techniques, with 16 years' experience in pig production. HH pig producers used only family labor, and 63% of their income came from pig production. On average, the pig warehouse area per HH was approximately 180 m^2, and the scale of pig production from the current survey was appropriate 34 pig heads per HH; 49.1% of farmers had accessed credit for their pig production, and 63.5% had access to veterinary services.

Second, differences can be noted in both groups' characteristics. It is noticeable that more farmers in the VietGAHP group were male and were trained in pig production than in the conventional group. In addition, the VietGAHP HH was richer and had more access to veterinary services than the conventional HH. In contrast to these, it was quite interesting that the conventional HH owned a larger farm size; ran a larger production scale and their pig activities contributed more to household income compared to the VietGAHP HH. Also, more HH had built a biogas system for their pig farms and had accessed credit services in the conventional group than in their counterparts.

Table 5.2 The differences in socio-economic characteristics between VietGAHP and conventional farmers

Variable	All HH (n = 230)		VietGAHP HH (n = 114)		Conventional HH (n = 116)		Difference	
	Mean	SD	Mean	SD	Mean	SD		
Farmer's characteristics								
Gender (male %)	69.13	46.30	76.32	3.98	62.07	4.51	14.25	**
Education (years)	8.27	2.23	8.01	0.20	8.52	0.21	-0.51	*
Experience (years)	15.69	8.78	16.68	0.73	14.72	0.89	1.96	*
Training (%)	84.35	36.41	95.61	1.93	73.28	4.13	22.34	***
HH's characteristics								
Farm size (m^2)	179.79	171.31	147.94	12.29	211.10	18.46	-63.16	***
Scale (heads)	33.57	29.97	29.18	24.21	37.88	34.28	-8.70	**
Pig raisers (persons)	1.71	0.54	1.70	0.05	1.72	0.05	-0.01	
Pig_HH income (%)	62.99	24.93	58.41	25.37	67.48	23.76	-9.07	***
Off-farm income (%)	71.74	45.12	67.54	4.39	75.86	3.97	-8.32	
HH income (thousand USD)	15.64	14.24	17.23	1.36	14.08	1.28	3.15	*
Biogas (%)	78.26	41.34	69.30	46.33	87.07	33.70	-17.77	**
Institutional characteristics								
Credit access (%)	49.13	50.10	40.35	4.59	57.76	4.59	-17.41	***
Veterinary access (%)	63.48	48.25	78.95	3.82	48.28	4.64	30.67	***

Source: Authors' survey in 2018; n = 230

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

5.3.2 Determinants of VietGAHP adoption in HH pig production

This study aims to uncover the major factors associating with VietGAHP adoption for HH pig production by combining all farmers', farm's, and institutional characteristics. The results were found that farmer's characteristics and institutional characteristics were the most positively associated with VietGAHP adoption while farm's characteristics were the most negatively associated with VietGAHP adoption.

The likelihood ratio test with 12 degrees of freedom suggests that the estimated model had a good fit, with a statistically significant score of 79.42 at 1%. The correctly classified estimated model indicated that the Probit model correctly predicted 76.52% of the observations (Table 5.3).

First, among the positive factors associating with VietGAHP adoption in Vietnamese HH pig production, *Training* and *Veterinary access* were found to be the most significant influences on the probability of becoming a VietGAHP adopter. This means that if farmers joined in training pig production technique programs and had access to veterinary services, their probability of adopting VietGAHP would increase by 35.0 and 22.4 percentage points, respectively (Table 3). These results met expectations and were consistent with the previous results on the adoption of agricultural technology in general and sustainable agricultural practices in particular (Asfaw et al., 2012, Baumgart-getz et al., 2012, Mariano et al., 2012, Noltze et al., 2012, Srisopaporn et al., 2015, and Ghimire et al., 2015). While these techniques in training programs aim to enhance farmers' managerial ability in pig production, and farmers could gain new information on production techniques, as VietGAHP required strictly integrated techniques, the farmers might gain better knowledge and access to information to influence them to adopt VietGAHP. In addition to this, accessing veterinary services allowed farmers to directly receive animal health services from the government such as consulting on animal health. The Vietnamese government mainly supplied both the technique-training programs through an agricultural extension activity for free (Lapar, 2014) and veterinary services (Nga et al., 2014) for farmers. Thus, enhancing approachability in training and the delivery of veterinary services for farmers would contribute to promoting VietGAHP in HH pig production.

Furthermore, *Gender* and *HH income* also contributed positively and significantly to VietGAHP adoption. As anticipated, male farmers were more willing to adopt VietGAHP in their production and the probability of VietGAHP adoption increased 11.5 percentage points compared to female farmers. This was expected, as HH heads in Vietnam were always male, and they might have better access to learning new agricultural techniques (Saiful Islam et al., 2015). Regarding the *HH income* factor, wealthier farmers were more willing to adopt

VietGAHP because target VietGAHP households had to have sufficient financial resources to satisfy high-standard VietGAHP requirements (World Bank, 2009b). Baumgart-getz et al. (2012) indicated similar results because wealthier farmers tend to adopt new technologies to seek higher benefits. However, this variable had a small estimated marginal effect of only 0.5 percentage points. Thus, this study confirmed again that *Gender* and *HH income* still played considerable roles in spreading agricultural technology adoption, especially in sustainable agricultural technology.

Table 5.3 Estimated coefficients and average marginal effects of factors associated with VietGAHP adoption

Variables	Coefficient		Std. Err.	Average Marginal Effects		Std. Err. (Delta Method)
Farmer's characteristics						
Gender (dummy)	0.386	*	0.221	0.115	*	0.065
Education (years)	-0.032		0.045	-0.009		0.013
Experience (years)	0.011		0.011	0.003		0.003
Training (dummy)	1.176	***	0.316	0.350	***	0.086
HH's characteristics						
Farm size (m^2)	-0.001	**	0.001	-0.0004	**	0.000
Pig raisers (persons)	-0.406	**	0.199	-0.121	**	0.058
Pig_HH income (%)	-0.569		0.436	-0.169		0.128
Off-farm income (dummy)	-0.412	*	0.230	-0.122	*	0.067
HH income (thousand USD)	0.017	**	0.008	0.005	**	0.002
Biogas (dummy)	-0.856	***	0.249	-0.254	***	0.068
Institutional characteristics						
Credit access (dummy)	-0.194		0.198	-0.058		0.059
Veterinary access (dummy)	0.755	***	0.201	0.224	***	0.054
Constant	0.401		0.657			

Source: Authors' survey in 2018; n = 230

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively; log likelihood = -119.703; LR Chi2 (12) = 79.42***; pseudo-R2 = 0.2491; correctly classified = 76.52%.

Second and interestingly, it was noted that all factors inversely related to VietGAHP adoption belonged to the owned characteristics of HH, excepted for *HH income*. It was unexpected that households with larger pigsty areas and more family members participating in pig production were less likely to adopt VietGAHP. Although farm size had been considered an important factor in prior decades in agricultural innovations' early diffusion process in developing countries, it was no longer an important factor in the final stage (Feder et al., 1985). Further, VietGAHP for pig production was still in an initial diffusion phase, as the Vietnamese government had anticipated that VietGAHP adopters, or the farmers who had registered and joined VietGAHP groups, would primarily contribute to enhancing adoption rates in the future. As VietGAHP for pig production required significant initial one-time investments—such as restructuring pigsties and separating the farm from residential areas by fencing and an enclosed gate—farmers with larger-sized farms must invest more for initial costs; Hobbs (2003) noted this as an economic deterrent to the adoption of public GAPs. Also, Feder et al. (1985) indicated that the probability of adoption would decrease with the increase in fixed costs. Thus, farmers with larger farms might have insufficient sources of capital to support simultaneous VietGAHP adoption. However, the farm size's estimated marginal effect indicated that the probability of adoption decreased only very slightly: by 0.04 %, per m^2 change in farm size. HH pig producers were primarily small-scale, with pigsties on average 180m^2/HH, and these pig farms were located in residential areas. Regarding the *Pig raisers* variable, the likelihood of adoption decreased by 12.1 % for each family member joining in pig production, as households only use family members, and they seem to very carefully consider when new techniques were presented. These results implied that farm size played an important role in the adoption of sustainable agricultural technology even among small households who included only their family members in their agricultural activities.

Off-farm income was found to be negative and significant in influencing VietGAHP adoption; thus, households with off-farm income had a probability of VietGAHP adoption decreasing by 12.2 %, with all other variables fixed. This might indicate that farmers who could earn from non-farm activities may attempt to do so, rather than investing in new agricultural technology that may be risky (Feder et al., 1985). Furthermore, this research was conducted in 2018, when pig production in Vietnam was affected by the sharp decrease in the output price, and farmers tended to find off-farm activities to earn from, and thus, kept their agricultural production unchanged.

Biogas was considered a positive factor in supporting VietGAHP adoption in terms of decreasing the cost of manure waste treatment. However, this variable was unexpectedly and inversely related to adoption; the estimated marginal effects suggested that an available

biogas system decreased the probability of adoption by 25.4 %. The current biogas system had been in existence for many years to treat manure waste, although such a waste treatment system might not satisfy VietGAHP standards. This might result in higher investment costs for farmers when they adopt VietGAHP. Reinvestment costs were also a priority issue in pig farmers' VietGAHP adoption, which had been noted in Vietnam's Hai Duong province (Nguyen, 2017).

Last, among the factors found not to be associated with VietGAHP adoption, *Education* was expected to positively influence VietGAHP adoption because VietGAHP adoption seemed to require a higher level of education, and the *Education* factor was seen as a means for farmers to learn new skills. This result contrasted findings by Souza et al. (1990), Asfaw et al. (2012), Mariano et al. (2012), Ghimire et al. (2015), Srisopaporn et al. (2015), and Giang et al. (2017); these authors indicated that farmers with a higher formal education tended to adopt new agricultural technology because they had a better ability to reach and process new information. However, this study's findings reflect those found by Noltze et al. (2012) and Saiful Islam et al. (2015), who supposed that the farmer's education simply allowed them to acquire low-level knowledge that may be insufficient or irrelevant for adopting intensive new agricultural techniques. Further, a meta-analysis on the adoption of best management practices in the United States revealed that formal education did not seem to affect adoption (Baumgart-getz et al., 2012). On average, farmers' education in this study area met Vietnam's universal secondary education standards, and thus, farmers' educational levels were not high enough to lead to a difference in the adoption of strict, high-standard agricultural technologies, such as VietGAHP. *Experience* also was a positively non-significant factor impacting VietGAHP adoption. Although it was anticipated that this variable would be associated with better techniques and these farmers would more easily adapt with new techniques, the results do not support this expectation, which parallels results from Asfaw et al. (2012), Srisopaporn et al. (2015), and Marine et al. (2016). Experience was perhaps highly positively associated with the farmer's age, which negatively affects their adoption of new agricultural technology.

5.3.3 Current status of implementing VietGAHP criteria on HH pig production

More than 50% of the farmers surveyed had fully adopted 6 of the 15 compulsory VietGAHP practices, including: Having a dried floor (A2), not using banned substances (A10), pigs for sale are in good health (A12), having a waste treatment system (A3), fully vaccinating pigs intended for breeding (A5), and periodically disinfecting the pigsty (A7) (Figure 5.1). Based on farmers' experience, most farmers adopting these criteria might

assume that A2 and A5 were the most important practices to help maintain their pigs' health and prevent disease. A3 and A7 were also listed as the most important practices to maintain a good environment for preventing disease. Regarding A10 and A12, the farmers noted that their chosen feeds were quality-guaranteed, without banned substances, and that their pigs intended for sale were in good health.

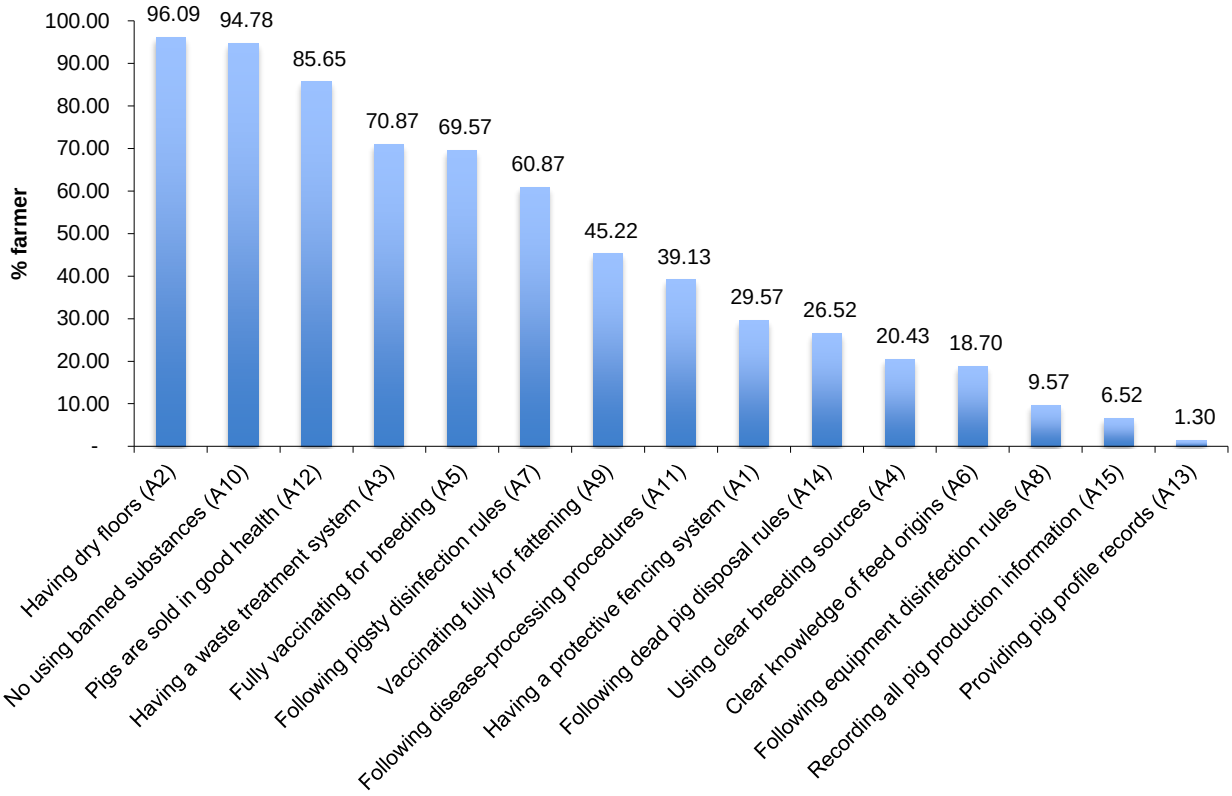


Figure 5.1 Frequency of farmers adopting each compulsory VietGAHP criterion

Source: Authors' survey in 2018; n = 230

Moreover, the least adopted practices, with less than 10% of farmers were: providing pig profile records (A13), recording all pig production information (A15), and following equipment disinfection rules (A8). The same results from A13 and A15 were found in work by Nguyen (2017), which revealed that no VietGAHP farmers in Hai Duong province fully adopted those criteria, with only 7.32% of VietGAHP farmers implementing 50 to 80% of these criteria. One explanation for this result was that these practices did not affect pig productivity, and were not perceived as important VietGAHP criteria to ensure product traceability in the market (Nguyen, 2017). Thus, it is important to enhance farmers' awareness of the importance of each practice in VietGAHP adoption.

Regarding the rest of the compulsory criteria adopted by less than 50% of farmers, Lapar et al. (2017) found the same results for following disease processing procedures (A11), having a protective fencing system (A1), following dead pig disposal rules (A14), and using clear breeding sources (A4). However, these contrast results for fully vaccinating fattened pigs (A9) and having clear knowledge of feed origins (A6). The contrasting results found in this study might be due to a decrease in the price for fattened pigs at the time of the survey, from 2016 until March 2018, which compelled farmers to save on production costs as much as possible by decreasing vaccination costs and using less commercial feed.

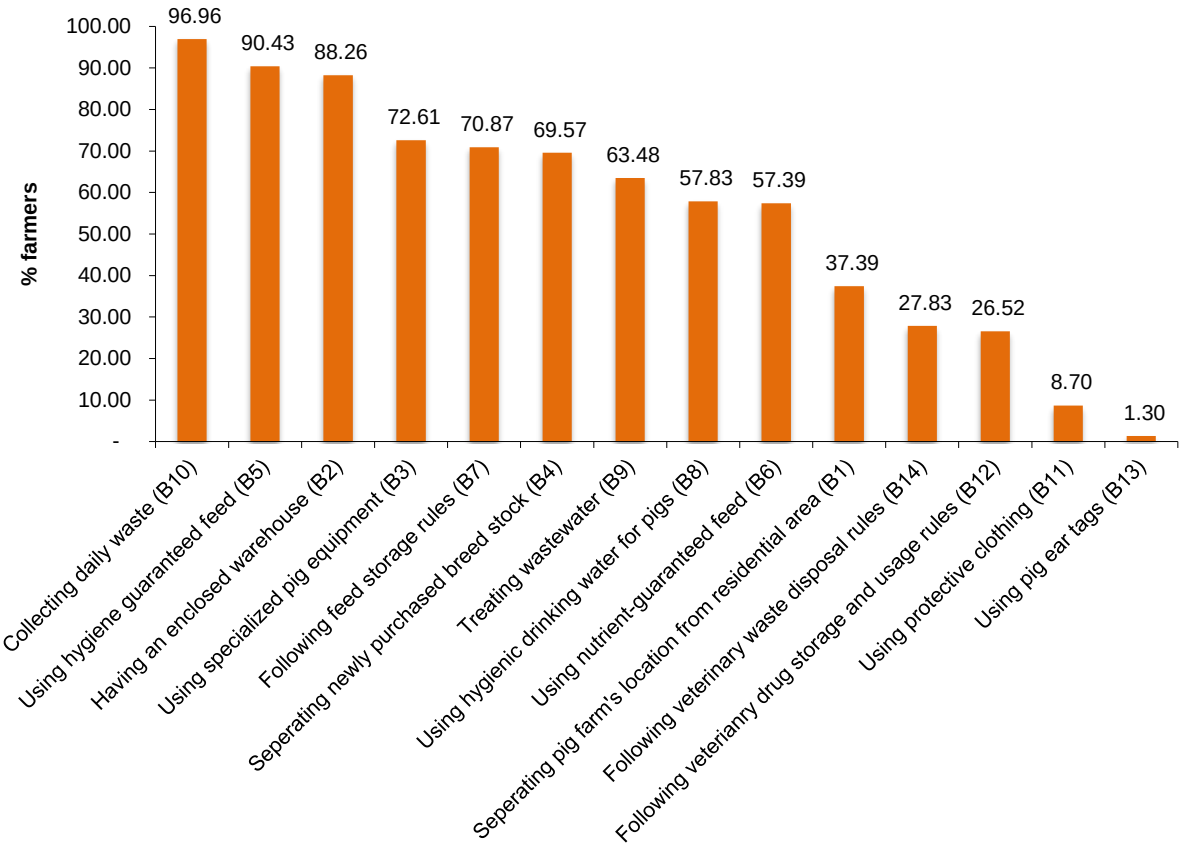


Figure 5.2 Frequency of farmers adopting each optional VietGAHP criteria

Source: Authors' survey in 2018; n = 230

Nine of the fourteen optional practices were adopted by more than half the surveyed farmers including collecting daily waste (B10), using hygiene-guaranteed feed (B5), having an enclosed warehouse (B2), using specialized pig production equipment (B3), following feed storage rules (B7), separating newly acquired breeding stock (B4), treating wastewater (B9), using hygienic drinking water for pigs (B8), and using nutrient-guaranteed feed (B6) (Figure 5.2). The results from implementing B10, B5, B2, B9, B6, and B8 paralleled findings from Lapar et al. (2017), as those practices clearly kept pigs in good health, while the authors found

B3, B4, and B7 had low levels of implementation. The level of commercialization in pig production might be affected by these practices.

5.3.4 Impact of VietGAHP adoption on implementing its criteria

Besides pointing out the most influential factors in adopting VietGAHP, this study was the first to explore the impact of VietGAHP application on the implementation of each of its criteria. This impact was indicated by the difference in implementing each criterion between VietGAHP group and convention group. To become an active VietGAHP household, an HH must satisfy all 15 compulsory criteria and at least 7 optional criteria (MARD 2016). Therefore, this study measured the impact of VietGAHP adoption on implementing the compulsory criteria group and the optional criteria group separately. Overall, VietGAHP adoption had an impact on implementing difficult criteria and had a greater impact on compulsory criteria implementation compared to optional criteria implementation.

5.3.4.1 Compulsory "A" criteria

Full adoption rates in nine of the fifteen A criteria were significantly higher within the VietGAHP group than in the conventional group; no difference was noted in the adoption rates between two groups in 5 of the 15 A criteria, and only 1 of the 15 A criteria was fully adopted by more farmers in the conventional group than in the VietGAHP group (Table 5.4).

Table 5.4 The difference in the full implementation rates for each compulsory criteria between the two groups (% farmers)

Group	Criteria	All HH (n = 230)	VietGAHP HH (n = 114)	Conventional HH (n = 116)	Difference		*z*-value	*p*-value
V	Following disease-processing procedures (A11)	39.13	47.37	31.03	16.34	**	2.54	0.011
I	Having a protective fencing system (A1)	29.57	37.72	21.55	16.17	***	2.69	0.007
VII	Following dead pig disposal rules (A14)	26.52	33.33	19.83	13.50	**	2.18	0.020
V	Periodically disinfecting pigsties (A7)	60.87	67.54	54.31	13.23	**	2.06	0.040
VIII	Recording all pig production information (A15)	6.52	12.28	0.86	11.42	***	3.51	0.001
V	Fully vaccinating fattened pigs (A9)	45.22	50.88	39.66	11.22	*	1.71	0.087
II	Using clear breeding sources (A4)	20.43	25.44	15.52	9.92	*	1.87	0.062
V	Disinfecting equipment (A8)	9.57	14.04	5.17	8.87	**	2.28	0.022
III	Clearly knowing feed origins (A6)	18.70	21.05	16.38	4.67		0.91	0.363
VI	Providing pig profile records (A13)	1.30	2.63	0.00	2.63	*	1.76	0.079
II	Fully vaccinating breeding stock (A5)	69.57	70.18	68.97	1.21		0.05	0.842
I	Having a dried floor (A2)	96.09	96.49	95.69	0.80		0.90	0.754
V	Not using banned substances (A10)	94.78	94.74	94.83	-0.09		-0.32	0.975
VI	Pigs for sale have good health (A12)	85.65	84.21	87.07	-2.86		-0.80	0.536
I	Having a waste treatment system (A3)	70.87	64.04	77.59	-13.55	**	-2.11	0.024

Source: Authors' survey in 2018; n = 230

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Specifically, and in order from the largest to smallest differences among the 9 of 15 A criteria implemented by more farmers in the VietGAHP group, these include: following disease-processing procedures (A11), having a protective fencing system (A1), following dead pig disposal rules (A14), periodically disinfecting pigsties (A7), following record-keeping rules (A15), fully vaccinating fattening pigs (A9), using clear breeding sources (A4), disinfecting equipment (A8), and providing pig profile records (A13), with the largest and smallest differences being 16.33% and 2.63%, respectively. First, these practices could be considered financial practices (A1, A7, A9, A4, and A8), as farmers must invest more money in adopting these criteria, and could become a financial burden to farmers if the resulting production did not bring a good return on investment. These practices could be economic deterrents to adopting GAPs, as Hobbs (2003) noted, especially in terms of increasing production costs and investing assets (Feder et al., 1985). Additionally, less than 50% of the farmers adopted these practices, except for A7, as these generally became barriers to adopt VietGAHP. The results reveal that VietGAHP farmers adopted these procedures more than conventional famers, possibly because VietGAHP farmers received some subsidies from LIFSAP, such as two million dong in cash, storage for veterinary medicines, disinfectant, and disinfection tools to increase adoption rates. Thus, direct-incentive economics might be an option for the government in promoting VietGAHP for HH pig production. Second, the remaining practices can be listed as practices related to empirical knowledge. Farmers with better access to VietGAHP information—and subsequently, better knowledge—might successfully implement these practices in their pig production. One reason why VietGAHP farmers might have adopted these practices more than conventional farmers could be that the former received training from frequent meetings organized by LIFSAP, and they better understood and adopted such practices. Thus, spreading empirical knowledge throughout training could enhance the VietGAHP adoption rate among pig producers.

The practice of having a waste treatment system (A3) was the only practice that farmers in the conventional group adopted more often than those in the VietGAHP group. This reflected findings found by Lapar et al. (2017) in Vietnam's Nghe An province. This might be due to VietGAHP farmers using manure from their pig production for other farming activities, such as fish-feeding in their ponds instead of building the waste treatment system to save their production costs. Similarly, Giang et al. (2017) demonstrated that fish ponds were an important factor impacting households' VietGAHP adoption in the Hung Yen province's Tien Lu district. Thus, VietGAHP adoption might have negative consequences for farmers' perceptions of its implementation.

Regarding the clear knowledge of feed origins (A6), this criterion did not differ in farmers' perceptions, but was adopted by less than 50% of the farmers because they bought feed based on their trust in the feed seller and the feed's brand; they did not know whether the feed was guaranteed as per the relevant standard. These farmers suggested that the government should play a role in clarifying the feed's origin then inform them if the brand-name feed satisfied feed standards for pig production. Further, this criterion as well as four other compulsory criteria did not differ between the two groups—including: fully vaccinating pigs for breeding (A5), having a dried floor (A2), not using banned substances (A10), and selling pigs in good health (A12)—and were adopted by more than 50% of farmers. This was because these practices correlated well with pig production's basic conditions, which involved keeping pigs in good health, and could be partially controlled by the farmers themselves.

In summary, it could be concluded that VietGAHP adoption had only had a positive impact by increasing the proportion of farmers implementing difficult compulsory criteria through financial and equipment support and training.

5.3.4.2 Optional "B" criteria

The two groups differed in their implementation of 8 of the 14 optional (B) VietGAHP criteria, including using hygienic drinking water for pigs (B8), separating newly purchased breeding stock (B4), following feed storage rules (B7), using specialized pig equipment (B3), separating the pig farm's location from the residential area (B1), using protective clothing (B11), collecting daily waste (B10), and using pig ear tags (B13) (Table 5.5).

These were also practiced among groups that needed credit for investments, except for collecting daily waste (B10). Among them, using protective clothing (B11) and using pig ear tags (B13) were the least adopted, as farmers perceived these as unnecessary for their current contexts, and these increased production costs. However, more VietGAHP farmers adopted them than conventional farmers because they received support from LIFSAP. More farmers in the VietGAHP group also followed feed storage rules and practices than in the conventional group, as the former also received training on these practices, and LIFSAP delivered some equipment to satisfy these VietGAHP standards. The above results lead to the conclusion that VietGAHP adoption positively impacted these practices, and primarily through the distribution of supporting equipment. However, these practices were soon eliminated when the equipment was no longer usable, as these require further costs to maintain and farmers did not perceive them as directly affecting pig productivity. Aside from the equipment distributed to support farmers by decreasing their short-term production costs, the long-term benefit of each VietGAHP practice should be emphasized to improve general VietGAHP adoption in pig production.

More than 50% of farmers adopted the remaining practices—except for *separating the pig farm location from the residential area (B1)* as these also correlated well with pig production's basic objective: to maintain pigs' good health. More farmers in the VietGAHP group upheld these practices than in the conventional group, possibly because the former included wealthier farmers who were well-trained as a result of becoming VietGAHP adopters. Again, VietGAHP adoption could enhance the practices associated with maintaining pigs' good health, at least in terms of diffusing knowledge. Regarding the separating of the pig farm location from the residential area (B1), this was impacted by households' land limitations, as farmers would absorb the cost of such a project if they had to invest more to build pigsties separated from their houses. This was observed as the most difficult practice for farmers in Hai Duong province (Nguyen, 2017). More farmers in the VietGAHP group adopted this criterion than in the conventional group, possibly because they had better land location and financial conditions. Thus, in priority order, training and financial support might be suitable to enhance these VietGAHP practices.

The same reason might be applied—in that the practices correlate well with pig production's basic objective to keep pigs in good health—as no difference could be noted for the waste water treatment (B9), using hygiene-guaranteed feed (B5), and using nutrient-guaranteed feed (B6) practices when these were upheld by more than 50% of farmers, although more so in the conventional group than in the VietGAHP group. This might also be because VietGAHP farmers were better trained and better understood the VietGAHP criteria, and they assessed their own practices as unfit compared to VietGAHP standards.

The other practices without differences among the two groups included following rules for using and storing veterinary medicines (B12) and following veterinary waste disposal rules (B14), with average compliance rates of 26.52 and 27.83, respectively. This was because farmers assumed that it was unnecessary to follow veterinary medicine storage and usage rules (B12) when they had always consulted veterinary sales and used all veterinary medicines without storage. Further, following veterinary waste disposal rules (B14) did not affect their pig production, and farmers consequently perceived this as normal HH waste. Thus, the impact of VietGAHP adoption seem to fail in the practices related to managing farmers' knowledge without strict governmental control.

Table 5.5 The difference in full implementation rates of each optional criteria between the two groups (% farmers)

Group	Criteria	All HH (n = 230)	VietGAHP HH (n = 114)	Conventional HH (n = 116)	Difference		*z*-value	*p*-value
IV	Using hygienic drinking water for pigs (B8)	57.83	69.30	46.55	22.75	***	3.49	0.001
II	Separating newly bought breeding stock (B4)	69.57	78.07	61.21	16.86	***	2.91	0.006
III	Following feed storage rules (B7)	70.87	78.95	62.93	16.02	***	2.67	0.008
I	Using specialized pig equipment (B3)	72.61	79.82	65.52	14.30	**	2.43	0.015
I	Separating the pig farm's location from the residential area (B1)	37.39	43.86	31.03	12.83	**	2.01	0.044
V	Using protective clothing (B11)	8.70	13.16	4.31	8.85	**	2.39	0.017
V	Following veterinary drug storage and usage rules (B12)	26.52	30.70	22.41	8.29		1.42	0.155
I	Having an enclosed warehouse (B2)	88.26	90.35	83.62	6.73		1.52	0.13
V	Collecting daily waste (B10)	96.96	100.00	93.97	6.03	***	2.66	0.008
VI	Using pig ear tags (B13)	1.30	2.63	0.00	2.63	*	1.76	0.079
VII	Following veterinary waste disposal rules (B14)	27.83	28.95	26.72	2.23		0.38	0.707
IV	Treating wastewater (B9)	63.48	63.16	63.79	-0.63		-0.10	0.92
III	Using hygiene-guaranteed feed (B5)	90.43	87.72	93.10	-5.38		-1.39	0.165
III	Using nutrient-guaranteed feed (B6)	57.39	54.39	60.34	-5.95		-0.91	0.361

Source: Authors' survey in 2018; n = 230

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Generally, VietGAHP adoption seemed to positively affect the practices adopted by most farmers in improving pigs' health and productivity through training to enhancing farmers' management. Regarding the more difficult optional practices unrelated to improving pigs' health and productivity but enhancing production costs, these were promoted through the distribution of supporting equipment.

5.4 Conclusions and Implications

Unlike previous studies, we combine all factors regarding farmer's characteristics, farm's characteristics, and institutional characteristics to clarify which factors affected the probability of becoming a VietGAHP HH and to measure the impact of VietGAHP adoption on the implementation of its criteria. Furthermore, this study showed which factors contributed most to VietGAHP adoption and which criteria was most affected by VietGAHP adoption. It was really meaningful for the Vietnamese government to improve VietGAHP adoption rate for households in pig production in particular and other agricultural products in general. Further, our results would be valuable for other public GAP programs for small farmers in the world, for example, in ASEAN countries.

First, among the significant positive factors associated with VietGAHP adoption, namely gender, training, HH income, and access to veterinary services, it was training and access to veterinary services that were the most important. The government was mostly responsible for fomenting these two factors. Thus, the Vietnamese government should first continue to focus on these two channels to widely promote VietGAHP and enhance its adoption rate.

Aside from these positive factors, interestingly, farm size, the number of pig raisers, off-farm income, and biogas were proven to significantly decrease VietGAHP adoption; all belonged to the owned characteristics of HH, and the biogas factor was the most influential factor. This indicated that economic deterrent, or what Hobbs (2003) indicated as "new capital investment" in GAP adoption even among small households who only utilized family members for their agricultural activities. Thus, if the government wants households to develop larger-scale pig production, more family members participating in pig production should adopt VietGAHP, and the government should design a financial support system to reduce the effects of the cost deterrent.

Second, VietGAHP adoption had a considerable influence on implementing eight difficult compulsory criteria that were implemented by less than 50% of all farmers. Besides this, among the eight optional criteria that VietGAHP had a significantly positive impact on implementing, three criteria could be listed as difficult optional criteria and farmers perceived these criteria as unnecessary and taken costs. VietGAHP adoption clearly enabled the goal of

meeting at least seven optional criteria to satisfy the condition of becoming an active VietGAHP HH (MARD, 2016). These were possible because VietGAHP farmers were supported through technical training and financial resources provided by LIFSAP (World Bank 2009b). The government's support played a vital role in improving the implementation of VietGAHP criteria and the technical training and financial support should be delivered to all households.

CHAPTER VI: DIFFERENCES IN TECHNICAL, ALLOCATIVE, AND COST EFFICIENCIES AMONG PRODUCTION SCALES

6.1 Introduction

Smallholders, or pig-farming households, commercial pig farms, and integrated commercial farms are the main pig producers in Vietnam. Pig production plays an important role in the Vietnamese meat supply, and smallholders are the main source, having supplied 3,733.3 thousand tons, accounting for 72.14% of the total live weight of livestock, in 2017 (GSOV, 2019a). Pig-farming households are those raising pig but whose annual revenue from pig farming is less than 1 billion dong (US$44,500). Although the Vietnamese government has a strategy to shift the pig industry from predominantly small-scale and household farms to large-scale and commercial farms, household pig production is currently the main source of pork in Vietnam (80%) (Lapar et al., 2011) and is expected to retain this position until the 2030s (Lapar, 2014). According to the General Statistics Office of Vietnam, the total number of households raising pigs declined from around 4.1 million in 2011 to 3.44 million in 2016 (GSOV, 2018a). In term of structural changes, the percentage of households keeping 1–5 pigs decreased significantly (down 10%), from 77.55% in 2011 to 67.55% in 2016; however, the percentage of households with more than five pigs increased in 2016 compared to 2011, with the greatest increase found among households with 20–49 pigs (up 4.09%).

This structural change was supported by the Vietnamese government; however, the small-scale format still dominates (GSOV, 2018a). Further, the production efficiency of household pig production is low and the outcome unstable, owing to fluctuations in both production costs and product prices as well as disease outbreaks (GSOV, 2018a). To remain successful as pork suppliers in the Vietnamese pig industry, pig-raising households need to use their farm resources efficiently, especially with respect to reducing production costs.

Building on Farrell's (1957) definition and measurements of farm efficiency, there have been additional studies on livestock production incorporating measures of all components of efficiency, including research by Sharma et al. (1999), Johansson (2005), Hansson (2008), Tonsor and Featherstone (2009); additionally, there have been single-efficiency studies (i.e., technical efficiency) by Jabbar and Akter (2008), Ly et al. (2016), and Tian et al., (2015). The findings have indicated that farm size and production scale influence these efficiencies. For example, Sharma et al. (1999) found that under variable returns to scale (RTS), the means of technical, allocative, and cost efficiencies were 75.9%, 80.2%, and 60.4%, respectively; under constant returns to scale (CRS), these scores were 74.5%, 73.9%, and 45.7%, respectively.

They also found that farm size, in terms of the number of sows, had a positive impact on the technical, allocative, and cost efficiencies under CRS, and suggested that cost inefficiency could be reduced by exploiting economies of size (reduced cost per unit).

Both Johansson (2005) and Hansson (2008), who conducted their research at dairy farms in Sweden, indicated that the level of technical, allocative, and cost efficiencies were influenced by farm size, such that cost efficiency was more severely and negatively affected by allocative inefficiency than by technical inefficiency. Johansson (2005) found that larger farms were more allocative and thus had higher cost efficiencies than medium and small farms, but there were no differences in technical efficiency according to farm size. Hansson (2008) studied the effects of farm size in term of income from milk on technical, allocative, and cost efficiencies, as well as the effects of farm size in terms of the number of hectares on just technical and cost efficiencies, and found that the relationship between farm size and technical efficiency was not a linear one, first decreasing and then increasing with farm size.

Tonsor and Featherstone (2009) focused on all efficiency components, including technical, allocative, scale, and overall efficiencies, in all types of specialized pig production, including farrow-to-finish, farrow-to-feeder, feeder-to-finish, farrow-to-weanling, and weanling-to-feeder. Their studies indicated that all the components of efficiency varied across and among types of specialized pig production, especially technical efficiency. Overall efficiency suffered owing to poor technical, allocative, and scale efficiencies in all types of specialized pig production. A large farm size, in terms of production scale, had a mixed impact on overall efficiency depending on the type of specialized pig production.

Tian et al., (2015) analyzed the technical efficiency of Chinese pig production and found that the average mean of technical efficiency was 0.5914; the scale of production in terms of the number of pigs did not impact that efficiency because of the lack of large-scale observation in the data.

In their study of levels of efficiency and the impact of farm size on the efficiency of pig production in Vietnam, Jabbar and Akter (2008) found that the technical efficiency of commercial pig farms was 73% and 78% in the northern and southern Vietnam and Vietnam, respectively; farm size in terms of the number of pigs had a positive impact on technical efficiency in both regions. In other research on Vietnamese pig production, Ly et al. (2016) indicated that the pure technical and scale efficiencies were 85.9% and 93.6%, respectively, for Vietnamese household pig production; they further reported that farm size in terms of the number of sows did not affect the efficiency levels.

Most existing studies have explored the various efficiency components in large and commercial farms; only Tian et al. (2015) and Ly et al. (2016) focused on smallholder farms. However, their studies focused only on a single efficiency: technical efficiency. Further, they did not find the exits of the relationship between farm size and technical efficiency. Hence, it could be that there was no substantial variation in farm size among the smallholders, whereas among the large and commercial farms, the technical, allocative, and cost efficiencies somewhat increase with farm-size scale. Moreover, current trends in Vietnamese pig-production industry notwithstanding, it is difficult to change immediately from a production characterized by small-scale farms to that of large-scale and commercial farms (Lapar, 2014; Tisdell, 2009). Thus, the question remains whether there is any advantage to having pig-farming households scale up their production to improve farm performance.

We could find no past studies that provided an analysis of the effect of production scale on all relevant efficiencies in the context of Vietnamese household pig farming. Therefore, this research sought to estimate the technical, allocative, and cost efficiencies in Vietnamese household pig production and the influence of production scale along with other factors on these efficiencies. This research provides empirical evidence that even among smallholders, the scale of production has greatly positive impacts on farms' performance in terms of improving allocative and cost efficiencies. This result will be useful is establishing programs and policies to improve the performance of smallholders, currently the main agricultural producers, and sheds light on the future of East Asian small farming (Rigg et al, 2016), including in countries like Vietnam.

6.2 Methodology

6.2.1 Study Site

The Hung Yen province of northern Vietnam benefits from its location in one of the two important deltas in the country, the Red River Delta; the delta features of a flat topography and plentiful fresh water are particularly well suited to farming. Thus, it is not surprising that as of 2016, agricultural areas comprised 58.1% (93 thousand hectares) of Hung Yen's total area and supplied 8.4% of the total 7.4 million pigs produced in the country (GSOV, 2018b). For these reasons, Hung Yen was chosen as the site of this study. The region has been continuously ranked as the top pig-producing region annually since 1995 and accounted for 25.4% of the total number of pigs in Vietnam in October 2018 (GSOV, 2019b). The production scale of this region has been changing: the total number of households raising

fewer than 20 pigs declined from 803,902 in 2011 to 544,217 in 2016; during that same period, the number households raising 20–50 pigs increased from 56,097 to 89,913 and those raising 50 or more pigs increased from 10,505 to 30,920 (The state steering committee of the rural, agricultural and fishery census, 2017).

Among the province's 10 districts, Khoai-Chau and Tien-Lu and were purposely chosen for data collection because those two districts combined are expected to supply 30% and 30.6% of the total number of pigs produced in Hung Yen in 2020 and 2030, respectively (Hung Yen Department of Agriculture and Rural Development, 2017).

6.2.2 Data Collection

The data used in this studied were collected in April 2018 from a survey of pig-farming households in the Khoai-Chau and Tien-Lu districts of the Hung Yen province in Vietnam. A final sample of 230 pig-farming households that were producing and selling fattening pigs to the market as a final output were used in the analysis. All households were selected randomly from a list of households in five targeted communes in the third administrative tier of the Vietnamese administrative hierarchy at the district level; these targeted communes were chosen after consultation with the staff office of the Department of Agriculture and Rural Development for each district.

To explore the level of production efficiency by scale, this study divided the pig-farming production scale into three categories: small scale, which included all households raising fewer than 20 pigs; medium scale, which included all households raising 20–49 pigs, and large scale, which included all households raising 50 pigs or more. The distribution of sample size by production scale is shown in Table 6.1.

Table 6.1 Distribution of sample size (%)

District	Small scale (n = 78)	Medium scale (n = 112)	Large scale (n = 40)	Total (n = 230)
Tien-Lu	55.1	66.1	82.5	65.2
Khoai-Chau	44.9	33.9	17.5	34.8
Total	100.0	100.0	100.0	100.0

Source: Authors' survey in 2018; n = 230

6.2.3 Data Envelopment Analysis

Data envelopment analysis (DEA) is a well-known nonparametric method used widely in economics to measure production efficiency. Originally based on Farrell's (1957) definition of relative efficiency and used to measure firms' performance, DEA has the advantages of removing assumptions regarding the functional form of the frontier and the distributional form of the error term (Coelli, 1995). Most notably for our purposes, DEA can be used on data at the farm level without the likelihood of any significant influence caused by measurement error (e.g., missing variables, weather factors) (Coelli, 1995). Thus, we determined that DEA was an appropriate method to measure production efficiency and all its components—technical, allocative, and cost efficiencies—after examining other empirical studies on livestock production (e.g., Johansson, 2005; Sharma et al., 1999). Hence, this study used DEA to estimate technical, allocative, and cost efficiencies in household pig production in Vietnam.

Technical Efficiency (TE). Input-oriented, TE is defined as the ability of a household to produce an unchanged level of output while using minimal inputs. To estimate TE, we used the input-oriented DEA model under variable returns to scale (VRS) (Banker et al., 1984) as shown in Equation (6.1):

$$\begin{gathered} min_{\theta,\lambda}\theta, \\ Subject\ to - y_i + Y\lambda \geq 0, \\ \theta x_i - X\lambda \geq 0, \\ \text{N1'}\ \lambda=1 \\ \lambda \geq 0 \end{gathered} \tag{6.1}$$

where x_i and y_i are the vectors of inputs and output of household i, respectively; i = 1, 2…N; X and Y are matrices of inputs and output of all households; N1 is an N * 1 vector of constants; and θ is the pure TE or TE_{vrs} is a scalar in [0, 1], indicating the TE of a household. If θ = 1, the household would be on the frontier and would thus be a technically efficient household; however, if θ < 1, the household would be technically inefficient. The linear programming problem had to be solved N times, once for each household in the sample to obtain a value of θ for each household.

Allocative efficiency (AE) and cost efficiency (CE). To estimate the CE and AE of pig production for a Vietnamese household, we solved the following cost-minimizing DEA model

under the VRS assumption (Chavas & Aliber, 1993; Coelli et al., 2002; Färe et al., 1985; Ferrier & Lovell, 1990; Lovell, 1994), as shown in Equation (6.2):

$$min_{\lambda,x_i^*} w_i' x_i^*, \tag{6.2}$$

Subject to

$$-y_i + Y\lambda \geq 0,$$
$$x_i^* - X\lambda \geq 0,$$
$$N1' \lambda = 1$$
$$\lambda \geq 0$$

where w_i is a $N \times 1$ vector of input prices of household j; and x_i^* is the cost–minimum vector of input quantities for household i given the input prices w_i and the output levels y_i (which is calculated by the model), the CE of the i-th household can be measured as in Equation (6.3):

$$CE = w_i' x_i^* / w_i' x_i \tag{6.3}$$

is the ratio of minimum cost to observed cost for the i-th household. AE is the ability of a household to combine its inputs under optimal proportions, given the unchanged nature of their prices and the production technology (Farrell, 1957) and is calculated using Equation (6.4):

$$AE = CE/TE \tag{6.4}$$

Scale efficiency (SE). Scale efficiency means that a household must operate at a size that reaches a minimizing average cost; SE makes a comparison between a household's current operational size and what is most efficient in terms of minimizing average cost (Chavas & Aliber, 1993, Coelli et al., 2005). Thus

$$SE = TE_{crs}/TE_{vrs} \tag{6.5}$$

in which, TE_{crs} is the overall TE that is reached when farmers operate at the optimal scale (Coelli et al. 2002; Färe et al., 1985), and it includes TE_{vrs} and SE (Färe et al., 1985). TE_{crs} is obtained by deleting a constraint, N1' $\lambda = 1$ from Equation (6.1); Equation (6.6) was proposed by Charnes et al. (1978):

$$min_{\theta,\lambda} \theta, \tag{6.6}$$

$$Subject\ to$$
$$-y_i + Y\lambda \geq 0,$$
$$\theta x_i - X\lambda \geq 0,$$
$$\lambda \geq 0$$

in which the following are true: if SE = 1, then that is the optimal scale or CRS; if SE < 1, then the scale has inefficiency. However, when the SE does not reach the optimal scale, it will not show whether the household has increasing return to scale (IRS) or decreasing return to scale (DRS) (Coelli et al., 2005). Thus, it requires an additional DEA model with nonincreasing returns to scale (NIRS) by using $\mathrm{N1}'\lambda \leq 1$ instead of $\mathrm{N1}'\lambda = 1$ in Equation (1) (Coelli et al., 2002, 2005) to estimate TE_{NIRS}, as shown in Equation (6.7):

$$min_{\theta,\lambda}\theta, \tag{6.7}$$

$$Subject\ to$$

$$-y_i + Y\lambda \geq 0,$$

$$\theta x_i - X\lambda \geq 0,$$

$$\mathrm{N1}'\lambda \leq 1$$

$$\lambda \geq 0$$

If the TE_{NIRS} equals the TE_{vrs}, the household produces at the DRS. Inversely, if the TE_{NIRS} does not equal the TE_{vrs}, the household produces at the IRS.

Variables used in the DEA model. This study only focused on the efficiency analysis of pig-farming households that produced fattening pigs. Thus, the pig production had five inputs and one output. The output and inputs used in this study were based on the data of one cycle per household. The detailed definition and units of the output and inputs variables are: one *Output* (Y) is the total live weight of fattening pigs per household in one selling cycle (in tons); *Labor* (X_1) is the total amount of family labor used in one selling cycle per household (in person-days); *Feed* (X_2) is the total feedstuff expenses for one selling cycle per household (tons); *Breed* (X_3) is total number of piglets raised in one selling cycle per household (piglets by head count); *Other* variable inputs (X_4) is the total of all variable expenses, excluding labor, feed, and breed, such as electricity, breeding costs, and veterinary services in one selling cycle per household (in millions of dong); and *Fixed input* (X_5) is the depreciation of fixed assets (including buildings, tools, and sows) in one selling cycle per household (in millions of dong).

To solve the cost-minimizing DEA model to estimate CE, the prices of all five inputs we used are presented here: *Labor price* (W_1) was assumed to be zero per one person-day of family labor because the households (HHs) used only family labor; *Feed price* (W_2) is the price of feed per ton and equaled total feed expenses divided by X_2 (millions of dong/ton);

and *Breed price* (W_3) is the price of breeding one piglet and equaled total breeding expenses divided by X_3 (millions of dong/piglets by head count). Because units of X_4 and X_5 are expressed in monetary terms, the calculation of the price of X_4 and X_5 was far from satisfactory. Following Ferrier and Lovell (1990) and other authors using the same DEA model to estimate TE, AE, and CE in agriculture fields (e.g., Chavas & Aliber, 1993; Coelli et al., 2002; Dhungana et al., 2004; Sharma et al., 1999), we assumed the prices of X_4 and X_5 to be the same and equal to one million dong for all households.

6.2.4 Tobit Model

Because of the bounded nature of the efficiencies (from 0% to 100%), the Tobit model has been widely adopted to regress factors on efficiency scores in the second stage of the DEA approach (Coelli et al., 2002; Dhungana et al., 2004; Johansson, 2005). We applied an empirical upper-limited Tobit model as shown in Equation (6.8):

$$y_i^* = \beta Z + u_i, with\ y_i = \begin{cases} y_i^*\ if\ y_i^* < 100 \\ 100\ otherwise \end{cases} \quad (6.8)$$

where y_i^* is the latent variable and an unobserved variable y_i, which is the efficiency score (three Tobit models with three observed dependent variables are TE, AE, and CE scores in percentages, respectively): Z is the vector of explained variables, including the characteristics of main pig producers in the households (Gender (1 = male, 0 = female), Education (years of formal schooling), Experience (years of experience in pig production), Training (1 = farmer trained in pig production technique, 0 otherwise)), Production scale as defined in 6.2.2 Data collection, No. pig raisers (family members joining in pig activity, R_Pig_ttincome (% of income from pig production in total income of household, Nonfarm income (1 = if household had income outside of agricultural activities, 0 otherwise), Total HH income (1 = if household had income outside of agricultural activities, 0 otherwise), Credit access (1 = accessed credit for pig activity, 0 otherwise), Veterinary access (1 = accessed veterinary services, 0 otherwise); β are parameters; and u_i is a random error (we assumed that it followed a normal distribution in which the mean is 0 and variance is δ^2).

6.3. Results and Discussion

6.3.1 Descriptive Statistics for Output, Inputs, and Characteristics of Vietnamese household pig production and their differences by Production Scale

The descriptive statistics for the output, input variables, and input prices are shown in Table 6.2. The results showed that, on average, each household raised around 17 pigs (by head count), requiring about 56 person-days and 4 tons of feed with other variable inputs (2.335 million dong) and fixed inputs (4.638 million dong) in one production cycle. The total output of one cycle was 1.741 tons per household. This means that the average live weight per fattening pig was 102.5 kg. Regarding the prices of feed and breed inputs, these varied substantially among households. The mean feed price was 9.885 million dong per ton, with a range 6.345 to 13.755 million dong per ton; the mean of breed price was 0.501 million dong per piglet, with a range from 0.120 to 1.108 million dong.

Table 6.2 Descriptive statistics for output and input variables and input prices used in DEA model

Variable	Unit	Mean	Std. Dev.	Min.	Max.
Output (Y)	Ton/HH	1.741	1.017	0.360	7.200
Labor (X_1)	Person-days/HH	55.951	32.796	7.125	228.375
Feed (X_2)	Ton/HH	4.080	2.369	0.800	15.000
Breed (X_3)	heads	16.978	9.566	4.000	60.000
Other variable inputs (X_4)	Million dong/HH	2.335	2.262	0.165	17.500
Fixed input (X_5)	Million dong/HH	4.638	4.104	0.515	26.300
Labor price (W_1)	Thousand dong/person-day	0.000	0.000	0.000	0.000
Feed price (W_2)	Million dong/ton	9.885	0.912	6.345	13.755
Breed price (W_3)	Million dong/head	0.501	0.155	0.120	1.108
Price of other variable inputs (W_4)*	Million dong	1.000	0.000	1.000	1.000
Price of fixed input (W_5)*	Million dong	1.000	0.000	1.000	1.000

Source: Authors' survey in 2018; n = 230; Note: * According to Ferrier and Lovell (1990; Chavas and Aliber, 1993; Sharma et al., 1999; Coelli et al., 2002; Dhungana et al., 2004), prices of X4 and X5 are assumed the same and equal to one million dong for all households.

There were differences in output, inputs, and some characteristics of pig-farm households by production scale (Table 6.3), with significant differences for output and feed input, breed input, other variable input, and fixed input. With respect to the farms' characteristics, we found statistically significant differences in the number of years of pig-farming experience, the number of family members involved in pig activity, the role of pig activity in terms of contributing to household income, total household income, and credit access for pig activity. Farmers in larger-scale operations had less experience in pig activity because the farmers running the bigger farms were generally younger than those running smaller farms. Other characteristics of larger farms: more family members were involved in pig activity; pig activity played a more important role in terms of contributing to household income; total incomes were higher; and they accessed credit services more often than the small farms did. We found no difference by production scale for gender, education, training, production type, off-farm income, or veterinary access.

Table 6.3 Differences in output and inputs of Vietnamese household pig production by production scale

Variable	Small-scale (n = 78)		Medium-scale (n = 112)		Large-scale (n = 40)		Differences
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
Output (Y) (Ton/HH)	1.3	0.6	1.8	1.0	2.5	1.3	***
Inputs and inputs price							
Labor (X1) (person-day/HH)	56.5	32.4	55.2	33.8	57.0	31.3	
Feed (X2) (ton/HH)	3.2	1.5	4.2	2.3	5.6	3.0	***
Breed (X3) (heads)	13.1	6.0	17.3	9.3	23.7	11.9	***
Other variable inputs (X4) (million dong/HH)	1.7	1.5	2.2	1.9	4.1	3.4	***
Fixed input (X5) (million dong/HH)	4.7	4.8	4.2	3.3	5.7	4.5	*
Feed price (W2) (million dong/ton)	9.9	1.1	9.8	0.9	10.0	0.7	
Breed price (W3) (million dong/head)	0.5	0.2	0.5	0.1	0.5	0.1	

Source: Authors' survey in 2018; n = 230. Notes: ***, **, * = statistically significant at 1%, 5%, and 10% respectively; test of differences among group: Pearson's chi-squared test (Fisher's exact test) for dummy variable; Kruskal–Wallis test for measurement variable; US$1 = 22,454 dong)

Table 6.4 Differences in characteristics of Vietnamese household pig production by production scale

Variable	Small-scale (n = 78)		Medium-scale (n = 112)		Large-scale (n = 40)		Differences
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
Pig-farm household characteristics							
Gender (% male)	62.0	49.0	72.0	44.9	75.0	43.9	
Education (years)	8.2	2.2	8.1	2.0	8.7	2.8	
Experience (years)	17.5	8.9	15.3	8.8	13.5	7.9	**
Training (% of farmers)	87.0	33.6	80.0	39.9	90.0	30.4	
No. pig raisers (people)	1.6	0.5	1.7	0.5	1.9	0.6	*
R_Pig_ttincome (%)	53.4	25.6	65.8	23.6	73.7	21.3	***
Nonfarm income (% of HH)	74.0	43.9	71.0	45.8	70.0	46.4	
Total income (million dong)	257.3	263.7	318.3	252.2	626.6	428.5	***
Credit access (% of HH)	36.0	48.3	48.0	50.2	76.0	42.3	***
Veterinary access (% of HH)	71.0	45.9	62.0	48.9	55.0	50.4	

Source: Authors' survey in 2018; n = 230. Notes: ***, **, * = statistically significant at 1%, 5%, and 10% respectively; test of differences among group: Pearson's chi-squared test (Fisher's exact test) for dummy variable; Kruskal–Wallis test for measurement variable; US$1 = 22,454 dong)

6.3.2 Level of Technical, Allocative, Cost, and Scale Efficiencies

Firstly, this research was interested in measuring each component of efficiency and scale efficiency. The frequency distribution of the technical, allocative, cost, and scale efficiencies of Vietnamese household pig-production subjects is shown in Table 6.5.

Table 6.5 Frequency distributions of TE, AE, CE, and SE scores

Efficiency scores	TE		AE		CE		SE	
	No. of HH	% of HH	No. of HH	% of HH	No. of HH	% of HH	No. of HH	% of HH
<70%	1	0.4	9	3.9	69	30	0	0
70–80%	25	10.9	57	24.8	97	42.2	3	1.3
80–90%	105	45.7	99	43	42	18.3	21	9.1
90–100%	55	23.9	59	25.7	16	7	177	77
100%	44	19.1	6	2.6	6	2.6	29	12.6
Mean (%)	89.2		84.6		75.3		95.8	
Std. Dev. (%)	7.8		9.3		10.2		4.8	
Min. (%)	66.1		52.3		46.6		73.4	
Max. (%)	100		100		100		100	

Source: Authors' survey in 2018; n = 230; HH = household

The mean of TE was 89.2%, with 44 households being fully efficient. This level of TE for the pig-farming households was significantly higher than what Sharma et al. (1999) found in for swine production in Hawaii (75.9%); what Tian et al. (2015) found for Chinese pig production (59.14%); or even what Jabbar and Akter (2008) found for pig production in northern Vietnam (73%). However, the level of TE found by this research is still reasonable when compared with the other research using the same methods to find TE means, such as Hansson's (2008) study of dairies in Sweden (87.7%); Lansink and Reinhard's (2004) study of pig farming in the Netherlands (89%); Wu and Prato's (2006) study of farms in Missouri (92%); and Ly et al.'s (2016) study of pig-farming households in Vietnam (85.4%). Variation can occur because the concept of efficiency is related to the frontier production based on the observed inputs and output data, and high levels in the TE score means are due to the homogeneity of the inputs and output data. This also occurred in our research because we focused on smallholders whose annual revenue from pigs was less than 1 billion dong (US$44,500). The high TE mean in our findings (89.2%) indicated that, on average, the pig-

farming households in the Hung Yen province of northern Vietnam that we studied could save 10.8% of their physical inputs to produce the same level of output.

Secondly, the mean of AE was 84.6%, with only six fully efficient households. This result suggested a second way that these pig farming households could produce the same level of output but with costs reduced by 15.4%: by combining input quantities based on their relative input prices. When we combined the TE and AE into CE, the mean CE score was 75.3%, with six fully efficient households. This means that, on average, households could reduce total costs by 24.7% without any change to output levels. A cost inefficiency was contributed by allocative inefficiency and technical inefficiency, respectively. The same result was found by Hansson (2008) and Johansson (2005) for Swedish dairy farms and Wu and Prato (2006) for Missouri farms. The similarities may be because both these studies and our study focused on exploiting the advantage of cost efficiency to increase economic efficiency while the mean of TE was high; therefore, the cost efficiency was much more dependent on AE than on TE.

Table 6.5 shows that the percentage of pig-farming households with a level of efficiency of less than 70% was 30% for CE, 0.40% for TE, and 3.9% for AE. This suggests that there is still significant potential for increasing economic efficiency, in terms of improving cost efficiency, for these pig-farming households in Vietnam.

Table 6.6 Distribution of scale efficiency of pig-farming households by production scale (% of households)

IRS	Small	Medium	Large	Total
CRS	10.26	14.29	12.50	12.61
DRS	8.97	18.75	30.00	17.39
IRS	80.77	66.96	57.50	70.00
Total	100.00	100.00	100.00	100.00

Source: Authors' survey in 2018. Pearson's chi-square (4) = 9.878**. Note: ** is statistically significant level at 5%; CRS: constant return to scale; DRS decreasing to scale and IRS: Increasing return to scale

Another interesting result was that the mean of SE was 95.8%, with the variation ranging from 73.4% to 100% (Table 6.5) and 12.61% of pig-farming households reaching the optimal scale (Table 6.6). This result indicated that pig-farming households were close to their optimal scale with their current resources in Vietnam, but 70% of them still produced under IRS. This means that they still had to make changes to improve their efficiency—specifically, increasing

their production scale. This result was in line with the findings of Hansson (2008) for Swedish dairy farms. Moreover, a Pearson's Chi-squared test proved that the number of households producing at IRS decreased for large-scale production, confirming that increasing production scale enhanced overall efficiency—the combination of scale, technical, and allocative efficiencies.

6.3.3 Influence of Production Scale and Other Factors on Technical, Allocative, and Cost Efficiencies

The second objective of this study was to identify the influence of various factors on technical, allocative, and cost efficiencies, especially the influence of production scale. The coefficients of the Tobit model explained these as a linear relationship between explanatory variables and efficiency scores. As mentioned above, the inefficiency of CE was caused more by AE inefficiency than by TE inefficiency, and the mean of TE was high. We combined the results of the Tobit model with those of three statistical tests (i.e., Spearman's correlation, analysis of variance, and the Kruskal–Wallis test) to measure the influence of production of scale on the efficiency scores. The influence of production scale on allocative and cost efficiencies was consistent. Thus, the following paragraphs focus on the effect of production scale and other factors on the level efficiency of AE and CE to improve efficiency levels in household pig farming.

Firstly, the scale of production, training, and access to veterinary services were found to have positively significant impacts on AE (Table 6.7), with the largest impact being production scale. Households producing on a large scale had 5.8% higher AE scores then households producing on a small scale when all other variables remained constant. This means that large farms had a better combination of inputs based on their prices compared to small farms. This relationship was also true when comparing medium- and small-size farms. Other factors that also increased AE scores were training (by 3.2%) and access to veterinary services (by 2.3%) (Table 6.7). Training and access to veterinary services were supplied free to pig farmers by the Vietnamese government; the results confirm the positive effect of the government's investment. One notable finding was that access to credit services had a negative influence on AE (a 3.6% decrease); all the households in this study that had accessed credit services had done so freely through the market, without any special support from the government to remain in business. The cost of credit services contributed to the total cost of pig production of the households and the farms' sustainability.

Table 6.7 Factors' influences on technical, allocative, and cost efficiencies in Vietnamese household pig production

Variables	TE		AE		CE	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Gender	1.142	1.395	1.410	1.346	2.134	1.462
Education	-0.076	0.283	0.414	0.273	0.360	0.297
Experience	0.169**	0.073	0.069	0.070	0.179**	0.076
Training	-3.195*	1.809	3.165*	1.723	0.943	1.872
VietGAHP adopter	2.277*	1.360	0.270	1.309	1.676	1.421
Scale						
Medium	2.565*	1.411	2.914**	1.368	4.543***	1.486
Large	2.420	2.199	7.739***	2.125	8.858***	2.307
No. pig raisers	-0.018	1.216	0.259	1.165	0.260	1.265
R_Pig_ttincome	-2.984	2.896	2.310	2.791	-0.223	3.032
Nonfarm income	2.405*	1.417	2.117	1.377	3.619**	1.494
Total income	0.086*	0.051	-0.100**	0.002	-0.025	0.053
Credit access	-1.947	1.305	-3.682***	1.260	-4.735***	1.368
Veterinary access	-2.053	1.308	2.451*	1.264	1.043	1.373
Constant	88.253***	4.275	72.027***	4.120	61.940***	4.471
Sigma	8.738	0.477	8.615	0.410	9.359	0.446
LR chi-squared (13)	27.98***		41.99***		47.40***	
Log-likelihood	-713.598		-807.911		-827.81851	

Source: Authors' survey, 2018; n = 230. Notes: ***, **, and * = statistically significant at level 1%, 5%, and 10%, respectively

With respect to CE, large farms, nonfarm income, and experience were all have found to have positive impacts, while access to credit had a negative impact, as with AE (Table 6.6). Large and medium farms had better CEs compared to small farms (8.4% and 4.4%, respectively) (Table 6.7). Unexpectedly, nonfarm income increased CE by 3.4%, because the price of pork in the market decreased significantly and continuously from January 2017 into the study period, April 2018 (Dan, 2018; Hien, 2017); to survive and sustain their pig-production operations, household pig farmers added other non-agricultural sources of income. Further, unexpectedly, access to credit services reduced CE by 4.8% (Table 6.6).

In summary, the trends observed in the large farms showed that production scale had the greatest impact on AE and CE: larger production led to great efficiency. The relationship between production scale and these scores is revealed by their Spearman's correlations, shown in Table 6.8; there were weak positive correlations between AE, CE, and scale, and these were statistically significant at 5% with Spearman's coefficients (0.146 and 0.165, respectively) (Table 6.8).

Table 6.8 Factors' influences on technical, allocative, and cost efficiencies in Vietnamese household pig production

Efficiency	Spearman's coefficient
TE	0.033
AE	0.146**
CE	0.165**

Source: Authors' survey, 2018; n = 230. Notes: ** = statistically significant at level 5%

The results of the analysis of variance and Kruskal–Wallis tests showed that there were significant differences in the means of AE and CE by production scale (Table 6.9). This means that large farms had greater allocative and cost efficiency than small farms did, confirming that increasing the scale of production improved the chances of achieving higher allocative and cost efficiency scores for Vietnamese household pig farms.

Table 6.9 Statistical test of impact of production scale on the mean of TE, AE, and CE

Scale	TE (%)	AE (%)	CE (%)	SE (%)
Small scale (<20 pigs)	88.12	82.87	72.81	94.73
Medium scale (20–49 pigs)	89.79	84.74	76.00	96.04
Large scale (>=50 pigs)	89.45	87.52	78.42	97.05
Analysis of variance	1.08	3.43 **	4.63**	3.59**
Kruskal–Wallis test	1.47	5.01*	6.61**	8.04**

Source: Authors' survey, 2018; n = 230. Notes: ***, **, and * = statistically significant at level 1%, 5%, and 10%, respectively

6.4. Conclusions and Policy Implications

In keeping with the Vietnamese government's policy of supporting an expansion in pig-production scales, household-based pig production has been changing, with an increasing

number of small farms scaling up to become large-scale operations. The country is increasingly trending toward the consolidation of diverse smallholder farms into larger, pig-specializing farms (Tisdell, 2009). However, the rate of change is slow, and smallholder pig-farm households are still the main pork suppliers in Vietnam (VGSO, 2018a). The households studied lacked the resources to become large commercial farms; therefore, to remain competitive, it was imperative that they produce with maximum efficiency, changing their production scale to the extent possible to keep up with the market competition. The objective of the study was to measure the technical, allocative, and cost efficiencies and the influence of production scale, along with other factors, on these efficiencies in Vietnamese household pig production.

First, we found high efficiency scores among the Vietnamese pig-farming households: TE 89.2%, AE 84.6%, CE 75.3%, and SE 95.4%. However, the households still could reduce their total costs by 24.7% with no decrease in output. Their inefficiency of cost was caused by their allocative and technical inefficiency. Although the pig-farming households nearly reached their optimal production scale, 70% of them were still producing on too small a scale, and they could enhance their SE by producing at their optimal production scale.

Second, we used a combination of the results of the Tobit model and of three tests (Spearman's correlation, analysis of variance, and the Kruskal–Wallis test), and found production scale to exert a positive influence on allocative and cost efficiencies for these Vietnamese household pig farms. However, the influence of production scale on TE could not be confirmed because the results of the Tobit model showed that medium- and large-scale operations could lead to higher levels of TE, while the other three tests did not provide evidence of a relationship between TE and production scale. Hence, one possible implication was that scaling up household pig farms could enhance their production efficiency by taking advantage of allocative and cost efficiencies. Thus, to improve allocative and cost efficiency, the government should continue to deliver training and access to veterinary services to small-hold farmers. Additionally, the government should reduce the negative impact of the cost of credit by giving the farmers favorable credit conditions, such as longer borrowing periods, lower interest rates, or both, comparable to the credit services available in the market. Furthermore, the government should encourage less experienced farmers or young farmers who tend to scale up their farms to reduce their vulnerability through special training programs such as learning trips and consultations with high- efficiency farmers. Last, the adoption of VietGAHP brought the higher level of TE but the influence of production scale

on TE was not clear. Thus, further study is required to more clearly elucidate the relationship between production scale and the level of TE among smallholders in pig production.

CHAPTER VII: MAIN CONCLUSION AND POLICY IMPLICATION

7.1 Main conclusion

The main goals of this study were to measure production efficiency of household pig production and its determinant, and to assess the adoption and impacts of new technologies in pig management of households in Red River Delta of Vietnam.

Firstly, this study has shown that the mean of overall technical efficiency in household pig production was high, was equivalent 80.40% but households still could reduce their inputs by nearly 20% and still produce the same level of output. Also this study indicated that there was a considerable variation in the overall technical efficiency in pig production among households in Vietnam. Furthermore, this study found indications that the technical inefficiencies in pig production were mostly the product of low TEvrs rather than low SE. Besides this result, the main factors that contributed in improving the pure technical efficiency were live weight per fattening pig and experience while access to credit and access to veterinary service made it less efficient.

Secondly, regarding to the factors associating with the Biogas adoption and VietGAHP adoption in pig production of households, on the one hand, we found that the main factors affecting biogas adoption in manure management of pig-production households were education of household heads, becoming a member of any groups, large farm size, and household income. All of these have positive impacts on the willingness to adopt biogas, except for some farmers with very high education and some households with high income, who might seek more modern manure management technologies. On the other hand, the significant positive factors associated with VietGAHP adoption, namely gender, training, HH income, and access to veterinary services while farm size, the number of pig raisers, off-farm income, and biogas were proven to significantly decrease VietGAHP adoption. In general, farmers' financial ability in term of household's income became the common factor effecting on the adoption of new technology. However, there was a conflict in adopting these new technologies because they had not yet supported each other.

Thirdly, regarding to the impacts of VietGAHP adoption on its implementation, there was a considerable influence on implementing eight difficult compulsory criteria that were implemented by less than 50% of all farmers. Besides this, among the eight optional criteria that VietGAHP had a significantly positive impact on implementing, three criteria could be listed as difficult optional criteria and farmers perceived these criteria as unnecessary and taken costs.

Lastly, we found that cost efficiency in pig-farming households was 75.3%, the households still could reduce their total costs by 24.7% with no decrease in output. Their inefficiency of cost was caused by their allocative rather than their technical inefficiencies. We also found that production scale exerted a positive influence on allocative and cost efficiencies for these Vietnamese household pig farms. However, production scale has not been proved that it effected on the technical efficiency score of pig-producing household but VietGAHP adoption had significantly impacted on it.

7.2 Policy Implication

Firstly, from the first results of the level of overall technical efficiency, it can be seen that the technical inefficiencies in pig production were caused by the inefficiency in pure technical efficiency than that of scale efficiency. Thus, it may be concluded that households should concentrate on improving their managerial skills rather than changing their scale in order to enhance their performance. In this regard, households could enhance their skills through studying the best pig producers. Another option for inefficient households is to reduce their breeding time by taking better care of the sows before they become pregnant and by weaning their piglets earlier (about 30 days after birth) for the farrow-to-finish pig production. Furthermore, the government could supply credit at a lower interest rate and for longer periods to households with a high proportion of income from pigs and with more family members participating in pig production; this would assure that even households with small-scale operations could still earn a living from pig production.

Secondly, on the one hand, based on the general result of Biogas adoption and VietGAHP adoption, it could see that farmers' financial ability in term of household's income became the common factor but there was a conflict in adopting these new management practices. Thus, it is crucial to formulate a suitable guidance in adopting among new management practices that can be combined and supplemented each other. In addition to, the government should establish a suitably formal credit system for household who were low income to access when adopting new management practices. On the other hand, in detail to promote adopt Biogas and VietGAHP separately, for the application of Biogas systems in pig production, which aimed to contribute to reduce environmental pollution in livestock production, the Vietnamese government should spread more information related to the advantages of biogas digesters. In particular, enhanced communication channels among households would be effective. Moreover, farm size is a significant factor impacting on biogas adoption but this study proves no differences between small and medium households,

which are the prominent farm size in pig production. For encouraging VietGAHP adoption, the Vietnamese government should first continue to focus on training and access to veterinary services that were the most important factors influencing on the adoption decision.

Lastly, regarding to answer the question whether scaling up the production scale to improve the farmers' performance, one possible implication was that scaling up household pig farms could enhance their production efficiency by taking advantage of allocative and cost efficiencies. Thus, to improve allocative and cost efficiency, the government should continue to deliver training and access to veterinary services to small-hold farmers. Additionally, the government should reduce the negative impact of the cost of credit by giving the farmers favorable credit conditions, such as longer borrowing periods, lower interest rates, or both, comparable to the credit services available in the market. Also, the government can introduced and encouraged pig-producing household who could not change their production scale in the future to adopt VietGAHP to improve their performances through improving technical efficiency.

LIST OF PUBLICATIONS AND PRESENTATIONS

1 List of publications

1. Nguyen Thi Ly, Teruaki Nanseki, Yosuke Chomei, 2015. Determinants of Biogas Adoption in Manure Management of Vietnamese Household Pig Production: A Case Study in Tien Lu District, Hung Yen Province *Journal of Faculty of Agriculture Kyushu University*, 60, 577–581
2. Nguyen Thi Ly, Teruaki Nanseki, Yosuke Chomei, 2016. Technical Efficiency and Its Determinants in Household Pig Production in Vietnam: A DEA Approach *Japanese Journal of Rural Economics*, 18, 56–61
3. Ly Thi Nguyen, Teruaki Nanseki, Yosuke Chomei, 2019. The Impact of VietGAHP Implementation on Vietnamese Households ' Pig Production *Environment, Development and Sustainability*, doi: 10.1007/s10668-019-00543-w (Springer Netherlands)
4. Nguyen Thi Ly, Teruaki Nanseki, Yosuke Chomei. Are There Differences in Technical, Allocative, and Cost Efficiencies among Production Scales?: The Case of Vietnamese Household Pig Production.*(Submitted in May, 2020*: *Journal of Faculty of Agriculture, Kyushu University*)

2 List of presentations

1. Nguyen Thi Ly, Teruaki Nanseki, Yosuke Chomei, 2015. Technical Efficiency and Its Determinants in Pig Production in Household, Vietnam: A DEA Approach, The Annual Agricultural Economics Society of Japan Conference 2015, (Tokyo)
2. Nguyen Thi Ly, Teruaki Nanseki, Yosuke Chomei, 2018. Impacts of VietGAHP Adoption on Implementing Its Criteria in Vietnamese Household Pig Production, The 12th Annual Meeting of The Food, Agricultural and Resource Economics Society of Japan, (Nagasaki)
3. Nguyen Thi Ly, Teruaki Nanseki, Yosuke Chomei, 2019a. Technical, Allocative and Cost Efficiencies in Vietnamese Household Pig Production, The Annual Agricultural Economics Society of Japan Conference 2019, (Tokyo)
4. Nguyen Thi Ly, Teruaki Nanseki, Yosuke Chomei, 2019b. Farmer Perception of Main Constraints Facing to Develop VietGAHP for Household Pig Production in Vietnam, The 19th Study Conference of The Farm Management Society of Japan, (Sendai)

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APPENDIXES

Appendix A1 Definition and requirements for each VietGAHP criterion for HH pig production

No.	Criterion	Adopted Level*	Requirements
	Group I. Location, building infrastructure, and equipment		
1	Separating pig farm's location from residential area (B1)	B	Farm is separated from residential areas as well as drinking water sources
2	Having a protective fence system (A1)	A	Having a walled or fenced enclosure; having a gated entrance into the pigsty; having an antiseptic system at the gated entrance
3	Having dry floors (A2)	A	Farm has no standing water on the floor
4	Having an enclosed warehouse (B2)	B	Warehouse has no leaks or drafts
5	Having a waste treatment system (A3)	A	Having a waste treatment system to collect and dispose solid and liquid wastes
6	Using specialized pig equipment (B3)	B	Having specialized pig production tools and equipment
	Group II. Breeding and breeding management		
7	Using a clear breeding source (A4)	A	Having clear breeding sources and fully recording these sources
8	Fully vaccinating for breeding (A5)	A	All pigs are fully vaccinated
9	Separating newly acquired breeding stock (B4)	B	Separating newly purchased breeding stock and maintaining their records
	Group III. Feeding and feeding management		
10	Clearly knowing feed origins (A6)	A	All feed has a clear origin, including the shop address and production address, with records
11	Guaranteeing hygiene (B5)	B	Concentrated or compound feed and the

			ingredients for pig feed must be hygienic, with no mold; agricultural products must be well-cooked before serving
12	Using nutrient-guaranteed feed (B6)	B	Concentrated feed must have clear, suitable guidelines for each type of pig; compound feeds must be verified with a stamp; mixed feeds must have a mixed formulation
13	Following feeding storage rules (B7)	B	Store feed on shelves and packed in sealed bags; a separate storage location should protect the feed from insects and rodents
	Group IV. Water		
14	Using clean drinking water for pigs (B8)	B	Use clean, sufficient drinking water sources for pig production
15	Wastewater is treated (B9)	B	Treated by a waste treatment system
	Group V. Veterinary practices and veterinary hygiene		
16	Following rule of pigsty disinfection (A7)		Disinfecting pigsty before raising pigs every seven days and right after selling pigs; periodic disinfection around the pigsty area
17	Collecting waste daily (B10)	B	Clean and collect daily solid and liquid wastes
18	Using protective clothing (B11)	B	Change clothes and use protective equipment when entering the pigsty area; periodically disinfect clothes and protective equipment
19	Following equipment disinfection rules (A8)	A	Disinfect shoes when entering and exiting the pigsty; tools and equipment must be disinfected before taking in and out of the pigsty area
20	Vaccinating fully for fattening (A9)	A	Fully vaccinate pigs for required diseases and maintain full vaccination records
21	Following rules for using and storing veterinary medicines (B12)	B	All veterinary medicine, including the purchase of antibiotics, must follow a veterinarian’s guidance, with full records maintained; veterinary medicine should be kept in separate storage

22	No using banned substances (A10)	A	Do not use banned substances, such as banned antibiotics
23	Following disease-processing procedures (A11)	A	Households must inform local authorities of disease occurrences; full records must be kept regarding such diseases
	Group VI. Sale		
24	Pigs are sold in good health (A12)	A	Veterinary medicine is stopped after a suitable time as described on the drug label; pigs are sold as healthy
25	Providing pig profile records (A13)	A	Full records are provided to buyer when selling pigs
26	Using pig ear tags (B13)	B	Fattened pigs sold for meat must have an ear tag
	Group VII. Environment		
27	Following dead pig disposal rules (A14)	A	Dead pigs must be collected as proposed in veterinary rules; Full records must be kept regarding these dead pigs
28	Following veterinary waste disposal rules (B14)	B	Needles, plastic bags, and plastic containers must be collected for separate treatment
	Group VIII. Recording		
29	Recording all pig production information (A15)	A	Maintain precise and complete records based on the recording sample attached to this decision

Source: MARD (2016)

Note: * A represents compulsory criteria, and B represents optional criteria.

Appendix A2: Assessed method of VietGAHP criteria for HH pig production

Criterion No.	Criterion	MARD Verification Method	This Study's Verification Method*
1	Separating pig farm's location from residential area (B1)	VietGAHP manual and observation	Asked directly regarding each requirement.
2	Having a protective fence system (A1)	VietGAHP manual and observation	Asked directly regarding each requirement.
3	Having dry floors (A2)	VietGAHP manual and observation	Asked directly regarding each requirement.
4	Having an enclosed warehouse (B2)	VietGAHP manual and observation	Asked directly regarding each requirement.
5	Having a waste treatment system (A3)	VietGAHP manual and observation	Asked indirectly whether a biogas system or other waste treatment system exists.
6	Using specialized pig equipment (B3)	VietGAHP manual and observation	Asked directly regarding each requirement.
7	Using a clear breeding source (A4)	Reviewing recording book and observation	Asked indirectly through separate questions. First, "What kind of breeding source is used—self-produced or purchased?" If self-produced, the breeding source is clearly known. If purchased, does the respondent know the seller and sales location? If they know, this criterion

			is assessed as fully adopted.
8	Fully vaccinating for breeding (A5)	Vaccinated certificate (if any), Reviewing recording book and interview	Asked indirectly through the question: "What types of vaccinations are used for breeding?" If farmers injected all three compulsory vaccinations, including those for diarrhea, Pasteurella, and foot and mouth disease, and these are frequently used, then this criterion is assessed as fully adopted.
9	Separating newly acquired breeding stock (B4)	Observation, interview and reviewing recording book	Asked directly regarding each requirement.
10	Clearly knowing feed origins (A6)	Reviewing recording book and observation	Asked directly regarding each requirement.
11	Guaranteeing hygiene (B5)	Observation	Asked directly regarding each requirement.
12	Using nutrient-guaranteed feed (B6)	Observation, interview and recording book	Asked directly regarding each requirement.
13	Following feeding storage rules (B7)	Observation	Asked directly regarding each requirement.
14	Using clean drinking water for pigs (B8)	Observation	Asked indirectly for the first requirement using two questions regarding the types of drinking water sources, and whether they have been treated prior to use. Asked directly for the second requirement.

15	Wastewater is treated (B9)	VietGAHP manual and observation	Asked indirectly, “Do you have a biogas system or other waste treatment system?”
16	Following rule of pigsty disinfection (A7)	Interview and reviewing recording book	Asked directly regarding each requirement.
17	Collecting waste daily (B10)	Observation	Asked directly regarding each requirement.
18	Using protective clothing (B11)	Observation	Asked directly regarding each requirement.
19	Following equipment disinfection rules (A8)	Observation	Asked directly regarding each requirement.
20	Vaccinating fully for fattening (A9)	Reviewing recording book	Asked directly, “What types of vaccinations do you use in pig fattening?” If farmers injected both compulsory vaccinations (for diarrhea and Pasteurella) and they were frequently used, then this criterion is assessed as fully adopted.
21	Following rules for using and storing veterinary medicines (B12)	Reviewing recording book	Asked directly regarding each requirement.
22	No using banned substances (A10)	Interview	Asked directly regarding each requirement.
23	Following disease-processing procedures (A11)	Reviewing recording book	Asked indirectly, “When diseases occur, what do you do?” If they inform the local authorities, this criterion is assessed as fully adopted.
24	Pigs are sold in good health (A12)	Interview and Reviewing recording book	Asked directly regarding each requirement.

25	Providing pig profile records (A13)	Reviewing recording book	Asked directly regarding each requirement.
26	Using pig ear tags (B13)	Reviewing recording book and observation	Asked directly regarding each requirement.
27	Following dead pig disposal rules (A14)	Reviewing recording book	Asked indirectly, "How do you dispose of dead pigs?" and comparing with this rule mentioned in VietGAHP manual.
28	Following veterinary waste disposal rules (B14)	Observation	Asked indirectly using a question regarding how they disposed of their veterinary waste and comparing with this rule mentioned in VietGAHP manual.
29	Recording all pig production information (A15)	Reviewing recording book	Asked indirectly, "What type of content do you record?" and "Does this follow the sample record book released by the government?"

Source: MARD (2016)

Note: *) The authors' own proposal.

Appendix A3. Household survey questionnaire for FARROW-TO-FINISH type in 2014

QUESTIONAIRE FOR HOUSEHOLD PIG PRODUCER

This questionnaire is designed to collect farrow to finish pig production information in Hung Yen province. Please kindly note that all information provided will be used for research purpose only, and shall be kept strictly confidential. Thank you!

Code No: _____ Date: _____

Interviewer:_____ _____

A. General information about household

I Respondent information

1. Name: _____
2. Address: _____

II Information of household head

3. Name: _____

4. Gender (V01): [ ] Male = 1 [ ] Female = 0

5. Age (V02):_____ (years)

6. Years of schooling (V04):_____ (years)

7. If years of schooling is highers 12 years, what levels of education have you finished?

Levels	Tick X if Yes	Detail
1= Vocational college		
2 = College, University		
2 = Post graduate		

8. Main occupation (V03): [ ] Livestock production = 1; [ ] Cultivation = 2;

[ ] others= 3: (detail)_____

9. Years of experience in pig production (V05): _____ (years)

10. Have you jointed any **training programs** in pig production **(V06)**?

[ ] Yes = 1 [ ] No = 0

11. If yes, who held in organizations listed below and what main **kinds of information** do you get from them?

Organizations (mark X if joint)	Tick X if joint	How many times do you joint in 2013?	Kinds of **main information** (can choose more than 1 choice):		
			1= information on husbandry technique	2= Market information	3= other (detail)
Local extension centers					
Jointed groups (farmer, producer)					
Feed company					
Others (detail):……					

12. Which **groups do you joint as listed below**? And what main kinds of information do you get from it? **(V07)**

Groups (Mark X if joint)	1=Yes; 0= No	The group you joint the most frequency mark X	Kinds of main **information** (can choose more than 1 choice):		
			1= information on husbandry technique;	2= market information (input and output price);	3= other (detail)
Co-operatives					
Farmer association					
Women association					
livestock producer group					
Other (detail): ……					

III Information on household

13. Family member information

- The number of people in family?: _____ (people)
- The number of labours: _____ (labors)
- The number of family members join in pig production: _____ (people);

In which, labor: _____(labors), not labor: _____(people)

14. Main pig producers in family (V08)?

[ ] Household head = 1; [ ] Husband/wife = 2; [ ] both husband and wife= 3;

[ ] others =4 (detail):_____

15. Information on family members **joining in pig production**

Name	Relationship with HH head Wife/husband =1; Children = 2; parents = 3; others = 4 (detail)	Gender Male = 1; Female= 0	Age (years)	Years of schooling (years)	**Occupation** livestock production *=1; Cultivation=2; other =3 (detail)*	Do they joint any training program in pig production? Yes = 1; No = 0

16. Income **in 2013**

16A. From pig: _____(million VND)

In which:

From fattening pig:_____(million VND)

(Percentage of own produced breeding: _____(%))

From others: _____(million VND)

16B. From other livestock:_____(million VND)

In which:

From chicken:_____(million VND)

From duck: _____(million VND)

From musk duck: _____(million VND)

From buffalo: _____(million VND)

From cow:_____(million VND)

From fish: _____(million VND)

From others: _____(million VND)

16C From crops: _____(million VND)

In which:

Other farm activities	Unit	Production amount	Selling amount	Price (1000 VND)	Revenue (million VND)	Income (million VND)	% using for pig production
I Cultivation							
1.Rice	ton						
2.Maize	ton						
3.Vegetable crop							
4.Fruit crop							
5. Others							

16D Do you have off-farm income in 2013 (V12)?[ ] Yes=1; [ ]No=0.

If **yes,** please list income source from off farm activities in 2013 in the table below

Off farm income sources	Total income in 2013 (1000VNd)
1. Salary	
2. Gift	
3. Trade	
4. Hired	
5. Others	

18. Classify household followed by income in 2013

[ ] Rich =1; [ ] Medium =2; **[ ]** Poor =3

19. Classify household followed by activities (V11):

[ ] Livestock production=1; [ ] Cultivation =2; **[ ] Trade** =3; **[ ]** Off-farm =4

20. In 2014, how many sows do you have? _____(sows)

22. Do you apply all-in-all-out technique in pig production?

[ ] Yes=1; Reason: _____

[ ]No=0; Reason: _____

PART B: Production cost and Revenue for latest farrow to finish pig production cycle

B1. Revenue (V22)

1. In the latest cycle, how much do you get?

Items	No.heads (head)	Total amount selling (kg)	Price (1000VND/kg)	Total revenue (1000 VND)
1 From selling fattenning pig				
2 From selling piglets				
3 Other revenues,....				

2. How many sows giving births at the same time in latest cycle?:…….(sows) **(V20, V18)**

Sow no.	**Type of breed** (1=local breed; 0=others: detail)	**Source of breed:** *1= Own produce; 2= buy from other farmer; 3= buy from traders; 4=Breeding center; 5 = other.*	**Price (1000 VND)**	**Year bought**	Raising cost for gilt (1000 VNd)	Total No.of potential litters/cycles	The no.fattening pig sold in latest cycle(head)	The no.piglets die in latest cycle? (head)	Latest cycle is cycle times?
1									
2									
3									
4									
5									

B2. Cost

3. **Insemination (V20)**

Gilt No.	No.of times doing insemination	**Insemination method** 0 = directly insemination 1 = artificial insemination	Cost (1000VND)	Type breeds of boar:		
				1= Local	2= Crossed	3= Exotic
1						
2						
3						
4						
5						

4. **Feed cost (V20)**

Types of feeds	Days feeding (days)	Feeding/day (kg/day)	Total amount/**cycle (kg)**	Price (1000VND/kg)	Total cost (1000VND)
1. For sows during replacement time					
Rice bran					
Maize					
Concentrated feeds					
Commercial Feed for sow I					
Commercial feed for sow II					
Others:					

Types of feeds	Days feeding (days)	Feeding/day (kg/day)	Total amount/**cycle (kg)**	Price (1000VND/kg)	Total cost (1000VND)
2. For sows during birth giving					
Rice bran					
Maize					
Concentrated feeds					
Commercial Feed for sow I					
Commercial feed for sow II					
Others:					
3. For sows during feeding piglets					
Rice bran					
Maize					
Concentrated feeds					
Commercial Feed for sow I					
Commercial feed for sow II					
Others:					
4. For piglets before separate from sow					
Rice bran					
Maize					
Concentrated feeds					

Commercial Feed for fattening pig					
Commercial feed for piglets					
Others:					
5. For piglet after separating from sow					
Rice bran					
Maize					
Concentrated feeds					
Commercial Feed for fattening pig					
Commercial feed for piglets					
Others:					
6.For fattening pig					
Rice bran					
Maize					
Concentrated feeds					
Commercial Feed for fattening pig					
Commercial feed for piglets					
Others:					

5. **The cost for animal health services and diseases prevention (V20)?**

Types of medicine	unit	amount	Price (000)	No.times using/cycle	Total cost (000)
1 For sows					
3 For piglets					
4 For fattening pigs					

6) Other variable costs? (V20)

	Times/month (times)	No.months/cycle (months)	Total times (times)	Price (1000 VND/time)	Total cost (1000 VND)
1.Disinfecting barns					
2.Feeding Transportation					
3.Water and electricity fee					
4. Others					

7. Time trade offs for latest cycle (V18)

Activities	Family labours									Hired labour							
	Male			Female			Labour under 18 yrs old and above 60 yrs olds			Male				Female			
	No. people/ Day	No. hours/ people/ day	No. days/ cycles	No. people/ Day	No. hours/ people/ day	No. days/ cycles	No. people/ Day	No. hours/ people/ day	No.days/ cycles	No. people/ Day	No. hours/ people/ day	No. days/ cycles	Hired price (‘000đ/ People /day)	No. people/ Day	No. hours/ people/ day	No. days/ cycles	Hired price (‘000đ/ People /day)
I. Feeding time																	
1 For sows during replacement time																	
2 For sow during time from insemination until giving																	

birth																	
3. For sow and piglets during time from giving birth until separating piglets from sow																	
4 For piglets from separating from sow until selling																	
II.Diseases prevention																	
III.Selling time																	

Part C: Farrow-to-finish pig production resources in household

I Capital

1. In 2014, do you access to credit for pig production (V24)? [ ] Yes = 1; [ ] No=2

2. If yes, please answer the following question:

Sources	amount (1000VND)	terms (years)	Interest rate (%/year)	Purpose		
				1= Improving infrastructures for pig production	2= Buying feeding	3= other (detail)
1						
2						
3						

II Infrastructure for pig production

3. In 2013, how many m^2 for pig shelter area do you have?_____(m^2)

Please answer detail the following information listed below **(V20)**

Barn and storage area	**Area (m2)**	**Year of construction**	**Constructing cost (1000VN)**	**Repaired cost (1000 Vnd)**	**Potential using year (years)**
I Barn					
-Barn built in the 1st time					
-Barn built in the 2nd time					
-Barn built in the 3rd time					
-Barn built in the 4th time					
II: Storage house					

4. Do you rent land for pig production (V13)? [ ] Yes = 1; [ ] No = 0.

5. If rent, how much you must pay per year? _____ (1000vnd/year)

6. If rent, how long have you rented?: _____(year);

7. Equipments/machines used for pig production

Items	**unit**	**Amount**	**price (1000 đ)**	**Repairing cost (1000Vnd)**	**Potentian using year (year)**
Biogas system					
Water system					
Electricity system					
Feeding system					
Feed mixer					
Fan					
Others					

III Feeding

11. Do you feeding mixed self prepare in pig production (V15)?

[ ] 1 = feeding self prepare from 100% own agricultural produced;

[ ] 2= Feeding mixed self prepare between own agicultural produced and commercial feed (Ratio own produced/commercial feed = _____ .%);

[ ] 3= Using 100% commercial feed.

12. **If feeding self prepare**, are you based on what source?

[ ] 1= based on experience; [ ] 2= based on media, extension worker; [ ] 3= asking other farmers; [ ] 4= other (detail); _____

13. **If using 100% commercial feed, are you based on what source?**

[ ] 1= Based on experience; [ ] 2= base on media, extension worker; [ ] 3= asking other farmers; [ ] 4= other (detail):_____

_____

14. Do you access to veterinary service during latest cycle (V25)? [ ] Yes = 1; [ ] No = 0.

15. The numbers of veterinarians visited your farm in latest cycle? _____(times)

16. What kinds of veterinary services do you use in the latest cycle?

Kinds of veterinary services	No.times of visiting per cycle
Vacination service	
Medical service	

Materials supply	
Others	

17. Who visited your farm in latest cycle beside veterinarian? The no. times of visiting per cycle? And purpose of visting

Visitors	**No.times** of visiting per cycle	**Main purpose of visiting**: 1= consulting husbandry technique; 2= Vacination prevention; 3= others (detail)
Feed supplier		
Traders		
Other farmers		
Other		

Part D: Other information

18. Where do you usually get the reference information to sell pig?

Source	**Mark X if yes**	**wht is the most important source?**
Other producers		
Traders		
Jointed groups		
Media		
Others (detail:.....)		

19. Who do you usually sell fattening pig?

Buyers	**Mark X if yes**	**who is the most important buyer**
Local abator		
Slaughters		
Traders		
other (detail:.....)		

20. In the present, please list the 3 most difficulties have you met in farrow to finish pig production?

First difficulty: _____

Second difficulty: _____

Third difficulty: _____

21. **In future, do you have any plan to change scale** in farrow to finish pig production**?**

[ ] Increase =1; Reason: _____

[ ] Decrease =2; Reason: _____

[ ] No change=0; Reason: _____

22. In future, do you want to **change into other pig production system**?

[ ] 1= Change to farrowing pig production system; Reason: _____

[ ] 2= Change to finishing pig production system. Reason: _____

[ ] 0 = No change. Reason: _____

23. What do you need to improve effectiveness in farrow to finish pig production?

_____

_____

THANK YOU SO MUCH FOR YOUR INFORMATION!

Kyushu University
Graduate School of Bioresource and Bioenvironmental Science
Department of Agricultural and Resources Economics

Laboratory of Agriculture and Farm Management
Supervisor: Prof. Teruaki Nanseki, PhD
Assistant Prof. Yosuke Chomei, PhD
Student: Nguyen Thi Ly

CODE NO.:

Appendix A4. Questionaire for household pig producer: Regarding to VietGAHP for household pig production

This questionnaire is designed to collect pig production information in Hung Yen province. Please kindly note that all information provided will be used for research purpose only, and shall be kept strictly confidential. Thank you!

Interviewer:_____ _____

Interview date: _____ _____

A FARMER AND FARM CHARACTERISTICS

I Respondent information

6. Name: _____
7. Address: _____

II Farmer household head's characteristics

8. Name: _____
9. Gender (V01): [ ] Male = 1 [ ] Female = 0
10. Age (V02): _____ (years)
11. Years of schooling (V03): _____ (years)

7. If years of schooling is highers 12 years, what levels of education have you finished?

Levels	Tick X if Yes	Detail
1= Vocational college		
2 = College, University		
3 = Post graduate		

8. **Main occupation (V04):** [ ] Livestock production = 1; [ ] Cultivation =2; [ ] Trade= 3; [ ] Others= 4; : (detail).....
9. Years of experience in pig production (V05): _____ (years)
10. **Have you been trained in pig production ? (V06)?[ ]** Yes=1; [ ]No=0.

    No. training class in 2017:.....(times).

    Detail content of training (multiple choice apply)

    [ ] Production technique .....(times);

    [ ] Market Access; .....(times)

    [ ] others, detail:.....(times)

III Farm characteristics

11. The number of family members in family in 2017?:_____ (people)

12. The number of family labours: _____ (labors)

13. The number of family members join in pig production **(V07:** _____ (people);

14. Information on family members **joining in pig production**

No.	Main labor in pig production (1= yes; 0= no)	Gender Male = 1; Female= 0	Age (years)	Years of schooling (years)	Training in pig production? ***Yes = 1; (detail: type and no.times)*** No = 0	Experience (years)
1						
2						
3						
4						

15. Total Gross farm Income <u>except</u> pig production in 2017 (V08): .....

Total Net farm income <u>except</u> pig production in 2017:.....

15a. From on farm income <u>except</u> pig production: _____(million VND). In which:

Other farm activities	Unit	Production amount	Selling amount	Price (1000 VND)	Revenue (million VND)	Profit (mil.VND)	% using for pig production
1.Rice	ton						
2.Maize	ton						
3.Vegetable crop							
4. Other crops							
5. Poultry (chicken, duck,)							
6. Cattle/Buffalo							
7.							

Aquaculture production							
8. other livestock productions except pig production							

15b. Do you have off-farm income in 2017 (V09)?[ ] Yes=1; [ ]No=0.

Off farm income sources	Total income in 2017 (million VNd)
a. Salary	
b. Gift	
c. Trade	
d. Hired/seasonal	
e. Others	

16. Classify household followed by sources of income (V10):

[ ] Livestock production=1; [ ] Cultivation =2; **[ ]** Trade/Service =3; **[ ]** Others =4

B COST AND REVENUE FROM PIG PRODUCTION

B1. Revenue and income from pig production in 2017

17. Total revenue from pig production in 2017? _____ Mil.VND

Total income from pig production in 2017? _____ Mil.VND

In detail, how many times you sold pig in 2017? _____ Times

Please detail following information

Time No.	When? (month)	Type of pig sold? 0=piglet 1=Growner 2=Fattenning 3=others	No.heads (head)	Total amount selling (kg)	Price (1000VND/kg)	Total revenue (1000 VND)	Variable costs (1000 VND)	Income (mil.vnd)	Who sell for? 0=Abaitor 1=Slaughter 2=Trader 3=others (detail)
1st time									
2nd time									
3rd time									
4th time									
5th time									

18. Type of production system (V11)?

[ ] Fattening; [ ] Farrowing-to-finish; [ ] Other

19. Total production scale in the current time (V12)? _____ (pig heads)

- No. fattening heads: _____ (heads)
- No. of growner heads: _____ (heads)
- No. of sows: _____ (heads)
- No. of soars: (heads)

20. Compare to 2016, how did the scale and income from pig of 2017 change?

20a) The scale of pig production

[ ] 1= Increase. How many% _____

[ ] 2= Decrease. How many % _____

[ ] 3= Constant

Reason?_____

_____

19b Income from pig production

[ ] 1= Increase. How many% _____

[ ] 2= Decrease. How many % _____

[ ] 3= Constant

Reason?_____

B2. Production cost and Revenue for <u>latest</u> pig production cycle

21. When is the latest pig cycle that you sold? .....

<u>Please specify detail Production cost and revenue for the latest cycle that you sold as follow:</u>

22. How many herds you sold in the last cycles? _____Herds

Detail for each herds:

Herd no.	No. Heads/herd	Total sold weight (kg) **(V15)**	Price **(V16)** (1000VND/kg)	revenue (1000 VND)	*<u>Breeding time? (months)</u>* **(V17)**	***<u>Source of breeding q*</u>*** (0=owned produce; 1= buy from other farmers; 2=buy from breeding center; 3=others)	Type of breed (0=local breed 1=cross breed; 2=exotic breed;; 3=not known
Herd no.1							
Herd no. 2							
Herd no.3							

<u>Source of breeding*: if owned produce, pls ask from Question 23a, if others ask from Question 23b. If using both ask both Quesion 23a and 23b</u>

23. Breeding cost (V18)

23a When source of Breed is owned produce

(i) How many sows gave breeding in the latest cycle?:…….(sows) **(V18)**

Specify information for those sows?:

Sow no.	**Type of breed** (1=local breed; 0=others: detail)	**Source of breed:** *1= Own produce; 2= buy from other farmer; 3= buy from traders;4=Breeding center; 5 = other.*	**Price (million VND)**	**Year bought/ raised**	Raising cost for gilt period (million VNd)	No.of potential litters/cycles	no.fattening pig sold in latest cycle (head)	no.piglets die in latest cycle? (head)	Latest cycle is cycle time No.?	Insemination cost	Type breeds of boar: 0= Not known; 1=Local; 2=crossed (Specify F No.??) 3= Exotic
1											
2											
3											

(ii) cost for raising sow and piglet until piglets separate from sow

Types of feeds	Days feeding (days)	Feeding/day (kg/day)	Total amount**(kg)**	Price (1000VND/kg)	Total cost (1000VND)
I. Feeding cost					
1. For sows during replacement time					
Rice bran					
Maize					
Cassava					
Concentrated feeds					
Commercial Feed for sow I					
Commercial feed for sow II					
Others:					
2. For sows during birth giving					
Rice bran					
Maize					
Cassava					
Concentrated feeds					
Commercial Feed for sow I					
Commercial feed for sow II					

Others:					
3. For sows during feeding piglets					
Rice bran					
Maize					
Cassava					
Concentrated feeds					
Commercial Feed for sow I					
Commercial feed for sow II					
Others:					
4. For piglets before separate from sow					
Rice bran					
Maize					
Cassava					
Concentrated feeds					
Commercial feed for piglets					
Others:					
II. Veterinary cost for sow and piglets before separate from sow					
2.1 Veterinary cost for sow					
2.2 veterinary cost for piglets before separate from					

sow					
III. Other cost for making breeding (electrics, water,…)					
IV. Labor for making breeding	No. days	No.labors	Hours/day	Price/man-day	**Total cost**
Family labor					
Hired family					

23b) when <u>Breeding source bought from other farmer/traders/breeding center/others,</u>

No. Piglets bought:_____ heads

Total of weight (kg):_____ kg

Price:_____ (1000 dong)

Total cost of breeding:_____ (mil.dong)

24. <u>Feeding cost for fattening pig (V19)</u>

Type of feed	Days feeding (days)	Feeding/day (kg/day)	Total amount/ **<u>cycle (kg)</u>**	Price (1000VND/kg)	Total cost (million VND)
Rice bran					
Maize					
Concentrated feeds					
Commercial Feed for fattening pig					
Commercial feed for piglets					
Others:					

25. **The cost for animal health services and diseases prevention (V20)?**

Types of medicine	unit	amount	Price (000)	Total cost (1000 VND)
Vaccination				
medicine				
Disinfecting barns				
others				

26. Other variable costs? **(V20) (calculated per months)**

Type of costs	Times/month (times)	No.months/cycle (months)	Total times (times)	Price (1000 VND/time)	Total cost (1000 VND)
Hired permanent labor					
Electric fee					
Water fee					
others					

27. Labors (V21)

Type of works	Hours/day	No.days	No.of labors	Total labors (man-days)
1. buying breeding				
2. prepare and feeding				
3. disinfecting barns				
4. disease treatment				
5. vaccination				
6. selling				
7. buying feed				

8.others				

C. Resources in household for pig production

C1. Infrastructure for pig production

28. How much pig production area do you have **(V13)**? _____ (m^2)

29. How many m^2 for pig shelter area do you have? _____ (m^2)

Please answer detail the following information listed below **(V22)**

Barn and storage area	**Area (m2)**	**Year of construction**	**Constructing cost (1000VN)**	**Repaired cost (1000 Vnd)**	**Potential using year (years)**
I Barn					
-Barn built in the 1st time					
-Barn built in the 2nd time					
-Barn built in the 3rd time					
-Barn built in the 4th time					
II: Storage house					

30. Where is your pig area located **(V14)**?

[ ] in the same your residential area

[ ] Far away the your residential area, specify how far: _____ (km)

[ ] in the concentrated livestock area

31. Do you rent land for pig production **(V22)**?[ ] Yes = 1; [ ] No = 0.

27a. If rent, how much you must pay per year? _____ (million/year)

27b. If rent, how long have you rented?: _____(year);

32. Equipments/machines used for pig production **(V22)**

Items	**unit**	**Amount**	**price (1000 đ)**	**Repairing cost (1000Vnd)**	**Potentian using year (year)**
Biogas system	M^2				
Water system					
Electricity system					
Feeding					

system					
Feed mixer					
Fan					
Water pump					
Others					

C2. Capital used for pig production

33. Current did you access to any formal source of credit for pig production **(V25)**?

[ ] Yes = 1; [ ] No=0. Reason. _____

34. If yes, please answer the following question: **(V21)**

Sources	Amount for purposes (Million VND):				Terms (years)	Interest rate (%/year)
	Improving infrastructures for pig production	Buying feeding	Buying breeding	Others (specify)		
1						
2						
3						

C3. Feeding method

35. Do you feeding mixed self prepare in pig production?

[ ] 1 = feeding self prepare from 100% own agricultural produced;

[ ] 2= Feeding mixed self prepare between own agicultural produced and commercial feed (Ratio own produced/commercial feed = ...%);

[ ] 3= Using 100% commercial feed.

36. **If feeding self prepare**, are you based on what source?

[ ] 1= based on experience; [ ] 2= based on guidance from extension worker;

[ ] 3= other (detail); _____

37. **If using 100% commercial feed, are you based on what source?**

[ ] 1= Based on experience; [ ] 2= base on media, extension worker; [ ] 3= asking other farmers; [ ] 4= other (detail):_____

D. Institutional access

38. Which **groups do you joint as listed below**? And what main kinds of information do you get from it? **(V27)**

Groups	Join?: 1=Yes; 0= No	The group you joint the most frequency mark X	Kinds of main **information** (can choose more than 1 choice): 1=yes, 0 =no;		
			information on husbandry technique;	market information (input and output price related to pig production);	3= other (detail)
Co-operatives					
Farmer association					
Women association					
livestock producer group					
Other (detail): ……					

39. Number of times you consuted by veterinary services during latest cycle **(V26)**? ..... Ti mes

[ ] Public veterian: _____ times

For vaccination service: _____ times

For disease consultation service: _____ times

For husbadry technique consultation:_____ times

Others: _____ time. (detail): .....

[ ] Private veterian: _____ times

For vaccination service:_____ times;

For disease consultation service:_____ times

For husbadry technique consultation: _____times

Others: _____time. (detail):.....

E. Perception and Adoption VietGAHP for pig production and concerns about VietGAHP

40. Have you ever heard about VietGAHP for pig production in general (especially, at household level)? **(V30)**

[ ] 1=not at all aware; Please, answer **from Question 51 to end**

[ ] 2= slightly aware; [ ] 3=somewhat aware; [ ] 4=moderately aware; [ ] 5=Extremely aware

if chose other than 1. Please answer from **Question 41 to end**

41. Where have you received VietGAHP for pig production information (multiple choice, tick x if yes)

[ ] Media communication; [ ] Other farmer

[ ] Organization (co-operatives, farmer association, groups of farmers, local authority)

[ ] others. Specify: _____

42. Are you a VietGAHP adopter or a VietGAHP former or conventional pig farmer?**(V23)**

[ ] 1= VietGAHP adopter.

[ ] 2= VietGAHP former. Reason for stop adopting. _____

[ ] 0= Conventional pig farmer. Reason._____

43. When did you apply VietGAHP in your pig production? _____

44. Do your pig production get a VietGAHP certificate?

1= yes

0=no. reason. _____

45. 2 Have you received any subsidy/intensive from govermance/organizations supporting for adopting VietGAHP? **(V28)**

If received, put X **(V28)**	Subsidies/Intensives
[ ]	Could get money subsidy for rebuild warehouse/buy equipments from govermance/organization
[ ]	Could get training on new technique improving production effeciency
[ ]	Could get training on marketing skills
[ ]	Could get some equipments/tools from governmance
[ ]	Others. Specify.....

46. In gerneral, Do you think it is important to apply VietGAHP for pig production at the current time? (choose **only 1 option**)

[ ] 5= Stronly agree. Reason. _____

[ ] 4= somewhat agree. Reason. _____

[ ] 3= Neutral. Reason. _____

[ ] 2= somewhat disagree. Reason._____

_____

[ ] 1= strongly disagree. Reason.

[ ] 0= not yet. Reason: _____

47. Based on your knowledge, **what does the level of** VietGAHP adopt for pig production at current? What do you assess the **necessities** of adopt VietGAHP? **(V23, V24)**_____

No.	Classified level	Practices	Did you apply each criterion? 1 = yes; 0 = no	Level of adoption at current? (V23, V24) (%)
I		**Location, building infrastructure and equipment**		
1.	B	Separating with residential area and with drinking water source		
2	A	Having enclosed wall/ enclosed fence, entranced gate into the pigsty and an antiseptic system at the entranced gate		
3	A	Having no standing water on the floor		
4	B	Without leaking and avoiding winds		
5	A	Having a system to collect and dispose solid and liquid waste		
6	B	Having exclusive tools and equipment for pig production		
II		**Breeding and breeding management**		

7	A	Having clear breeding sources and recording fully breeding sources		
8	A	Being fully vaccinated		
9	B	-Separating new bought breeds and having a record		
III		**Feeing and feeding management**		
10	A	Feeds have a clear origin (know shop address, Production address) and have a record		
11	B	-concentrated feed, compound feed, ingredients to make pig feedings have to ensure hygene, no moldy -agricultural products have to cook well before serving		
12	B	-concentrated feed have to a clear and suitable guidance for each type of pigs -compound feeds have to verify with a stamp -Mixed feeds have to have a mixed formulation		
13	B	-Be stored Feedings on shelves -To be packed in sealed bads -Have separate storing place, protect away		

		insects, rodents		
IV		**Water**		
14	B	-use drinking water sources for pig production -have enough water for pigs		
15	B	- Treated by a waste treatment system		
V		**Veterinary and veterinary hygene**		
16	A	-Disinfecting pigsty before raising pig 7 days and right after selling pigs. - -Disinfecting around pigsty area periodically		
17	B	- -Clean and collect daily solid and liquid waste		
18	B	-Change clothes, labor protection equipments when entering the pigsty area -Periodically disinfecting clothes, labor protection equipments		
19	A	-Disinfect shoes when check in and out the pigsty -Tools and Equipments must be disinfected before taking in and out of pigsty area		

20	A	Injected full vaccinations for required diseases and have to record fully		
21	B	All veterinary medicine, including antibiotics when buying and using have to follow a guidance by a veterinarian and record fully Have a separate store for veterinary medicine		
22	A	Do not use banned substances (banned antibiotics e.g.)		
23	A	Diseases happen households have to inform to a local authority and Keep record fully on diseases		
VI.		For Sale		
24	A	-after stoping veterinary medicine with a suitable time as described in the drug label. -Pigs are healthy, no sick		
25	A	Full raised recording are provided		
26	B	Fattening pig sold for meat must have a ear tag		
VII		**Environment**		

27	A	Death pigs must be collected and proposed regarding to the veterinary rules Recording fully information about death pigs		
28	B	Needles, plastic bags, plastic containers must be collected for separate treatment		
VIII		**Recording**		
29	A	Record exactly and fully based on the recording sample		

48. To what extent do you agree and disagree with the following concerns/challenges of VietGAHP for pig production facing now? **(V29)**

Concerns	Level of agree (5= strongly agree, 4=somewhat argee, 3=neutral; 2=somewhat disagree, 1=strongly disagree)	Ways to solve those concerns (for concerns have **4 and 5** in ranking?
VietGAHP practices are difficulty to apply and follow		
To get VietGAHP certificate is complex		
Output price of VietGAHP pig production is not different with that of conventional pig production in the market		
Applying VietGAHP practices require much intensive labours		
Lack of knowledge regarding to veterinary practices		
Traditional practice of locating pig production in residential area		

Not clear VietGAHP pork production marketing system		
Not have good breed center		
Limited in resources especially, land area and captial to build pigstties with separate sections		
No requirements from fattening pig buyers (e.g. profile of vacination and disease treatment, quanrantine certificate)		
Not understanding the purpose of compliance (e.g. keep sample of feed, record feed mixing formulas,...)		
Not have habit of recording in detail		
Others.Specify.....		

49. Do you have any plan to continue adopting or changing adopting plan in future? **(V32)**

[ ] 1= Continue/change to adopt Reason:_____

[ ] 2= Stop adopting; Reason. _____

[ ] 3= not sure yet. Reasson. _____

50. If you do not receive any subsidies/incentives from government, do you continue adopt VietGAHP in your pig production?

[ ] 1= Continue to adopt Reason: _____

[ ] 2= Stop adopting; Reason. _____

[ ] 3= not sure yet. Reasson. _____

51. The development trends in your scale pig production in future?

1=increasing scale; 2=decreasing scale; 3= constant

Reason:_____

52. In the conventional pig production, did you receive any incentive/support?

1=yes; 0=no

53. If yes; what kinds of support that you receiv

Type of support	Who support?
□ Capital	
□ Feed	
□ Breed	
□ Husbandy technique	
□ marketing	
□ equipment	
□others	

54. If you receive support for develop pig production? What kinds of support that you need?

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THANK YOU SO MUCH FOR YOUR INFORMATION!