Vietnam Journal of Agricultural Sciences

ISSN 2588-1299

VJAS 2022; 5(2): 1492-1388
https://doi.org/10.31817/vjas.2022.5.2.06

An Assessment of the Economic Efficiency of Swine Farms Applying BioSecurity Practices in Bac Ninh Province, Vietnam

Le Thanh Ha[1*], Lai Phuong Thao[1], Nguyen Xuan Hoa[2] & Do Quang Giam[1]

[1]Faculty of Accounting and Business Management, Vietnam University of Agriculture, Hanoi 131000, Vietnam
[2]Faculty of Natural Resource and Environment, Vietnam University of Agriculture, Hanoi 131000, Vietnam

Abstract

The research focused on evaluating the economic efficiency of swine farms applying biosecurity practices in Bac Ninh Province. Our study surveyed 143 pig farms in Bac Ninh province. The ordinal logit regression model was employed to estimate the factors affecting the level of biosecurity practices. Moreover, the semi-log regression model was used to examine the influence of some factors affecting the profitability of pig farms. The results showed that biosecurity practices had a significant impact on the economic efficiency of livestock farms by helping livestock farms increase their economic efficiency, reducing the mortality rate of animals, and reducing the rate of abandonment of farms. The factors affecting the level of biosecurity application on the farms included the gender, experience, and education of the farm owner, and the livestock scale. The results aslo expressed a negative relationship between the economic efficiency of the farm and seeding costs, electricity and water costs, feeding costs, labor costs, and veterinary medicine costs, and a positive relationship between the economic efficiency and selling price as well as between the livestock scale and biosecurity application. Finally, some appropriated solutions could be recommended for the improvement of the economic efficiency of swine farms applying biosecurity practices.

Keywords

Biosecurity, economic efficiency, pig farming

Introduction

Empirical studies have proven that biosecurity practices (BBP) on livestock farms bring many benefits to farmers such as protecting the environment, controlling the spread of infectious diseases, and protecting livestock from infectious diseases. The measurement of BBP on livestock farms can increase pig survivability for food

Received: September 21, 2021
Accepted: April 13, 2022

Correspondence to
lethanhha89@vnua.edu.vn

security and economic recovery (Asogwa *et al*., 2020). Previous studies on the current situation of biosecurity in livestock production in Vietnam showed that the level of BBP application is not very high. A survey on the average application of biosecurity at 110 private farms, including four VietGAHP farms and 46 farms with certificates of veterinary hygiene eligibility, showed that many farms had no awareness of BBP or BBP standards issued by the Ministry of Agriculture and Rural Development (MARD) in 2011. The average score of BBP for swine farms in Vietnam was about 53.5, far lower than the average required standard score of 65 (Cuc *et al*., 2020). Therefore, raising awareness about biosecurity and developing biosecurity practices in swine farms are very essential.

Bac Ninh province has a highly developed farming industry, and out of the 72 farms applying high technology, 49 farms are swine farms (68%) (Bac Ninh DARD, 2020). In 2019, African swine fever (ASF) affected a large area in the province, greatly impacting livestock production and farm economic efficiency. The occurrence of ASF caused many farms to begin applying BBP, and many farms had to abandon swine production and switch to other farming practices. However, the level of the application of BBP by farms is inconsistent, in which, many farms apply BBP at a low level, leading to low efficiency in disease prevention. Many empirical research papers have mentioned the positive effects of BBP on the control of ASF (Barot, 2017) and food safety (Huyen *et al*., 2018), but few researchers have studied the economic impacts of BBP on pig farms (Pham *et al*., 2017). Proving that adopting BBP leads to higher economic efficiency can enhance BBP application. This issue requires insight into understanding the economic efficiencies of farms with different levels of BBP applications. This is the foundation for convincing people to apply BBP and increase their ability to expand and perfect the BBP breeding model.

Given the mentioned problems, this study was conducted to evaluate the economic efficiencies of livestock production towards BBP in Bac Ninh province in order to find solutions for improving the economic efficiencies of livestock farms with BBP and encourage livestock production toward BBP.

Methodology

Research framework

Economic analysis is an essential tool to calculate the efficiency of production activities, but in agricultural production, most farmers only pay attention to productivity and pay little attention to economic efficiency. This can lead to incorrect decisions because the purpose of production is to bring about high economic efficiency, while high productivity does not always bring high economic efficiency (Do Van Xe, 2010). On the farm, economic efficiency can be calculated by the following criteria (Nguyen Van Song, 2006; Nguyen Quoc Nghi, 2017; Vo Thi Hai Hien, 2015):

(i) Production value/total costs: the higher the target, the higher the efficiency;

(ii) Production costs/production value: the smaller this indicator, the higher the efficiency;

(iii) Gross profit/variable costs: this indicator shows the efficiency of using variable costs; and

(iv) Net profit/total costs: this indicator shows the efficiency of using total costs.

Previous studies have shown the BBP impacts on economic efficiency. For livestock farms, a farmer's knowledge and livestock scale can affect the level of BBP. Farm awareness plays an important role in determining the level of BBP application on the farm. Large-scale farms are more likely to apply livestock standards related to BBP than those working on a smaller scale (Nguyen Ngoc Xuan & Nguyen Huu Ngoan, 2014b). The application of BBP can reduce the mortality rate of the herd and increase the growth rate, thus, improving the economic efficiency of the farm. Besides these, BBP can reduce the cost of feed, reduce veterinary costs, and increase the selling price of the product (Vo Thi Hai Hien, 2015). The application of BBP can help farms to optimize feeding costs and save labor costs (Nguyen Ngoc Xuan & Nguyen Huu Ngoan, 2014a). With references to previous studies, this study evaluated the factors affecting

the choice of the level of BBP application on the farm, including gender, academic level, breeding experience, knowledge of BBP, and scale of livestock.

Factors affecting farm profitability included the selling price of pork at the farm gate, variable costs including feeding costs, breeding costs, veterinary medicine costs, labor costs, and tool costs, fixed asset depreciation, and the level of BBP application.

Data collection

Primary data

The study selected four research sites, namely Thuan Thanh, Gia Binh, Yen Phong, and Luong Tai districts. Of which, Thuan Thanh and Yen Phong were the two districts with the highest numbers of pigs in the province along with long histories and strong development of pig breeding. Gia Binh and Luong Tai belonged to the group of districts with fewer pig heads and many new farms engaged in swine production. For multivariate regression analysis, the minimum sample size needed was calculated using the formula: n = 50 + 8 * m; where: n is the number of samples to be investigated, and m is the number of independent factors (Tabachnick *et al*., 2007). Thus, the minimum number of survey samples was 130 samples. The study selected and interviewed 144 livestock farms from the list of pig farms (7,914 farms with over 10 pig-scale) in the districts provided by Bac Ninh's Department of Agriculture and Rural Development (Bac Ninh DARD) in 2018 to ensure the required minimum number of samples. Interviewed pig farms had a scale from at least 10 pigs because pig production at farms of this size was carried out on a large enough scale of production and had concentrated factors of production (Nguyen Manh Hung *et al*., 2021). The number of samples in each district was 36. The interviews were conducted in March 2021. After screening, the study collected 143 respondents because one farm refused to provide information fully.

A scoring method was used to assess the level of BBP application on the farms. In the BBP standards published by the Ministry of Agriculture and Rural Development (MARD), there are 37 criteria for BBP application (MARD, 2011):

Location: 3 rules;

Requirements for the barn: 11 rules;

Breeding: 3 rules;

Food and drink: 5 rules;

Care and nurturing: 2 rules;

Veterinary hygiene: 10 rules; and

Waste treatment and environmental protection: 3 rules.

We asked the farmers whether they applied each criterion. If the farmer's answer was "yes" meaning that they apply that criterion, the score would be "1", and otherwise the score would be "0". The total scores of BBP applications were analyzed using a combination of a linear scoring system and a categorical principal components analysis (Sarrazin *et al*., 2014). Based on consultations with swine production experts about the levels of applying BBP on farms, the scale of classified BBP application was divided into three levels:

(i) Low level of BBP application: scores from 1 to 16 points;

(ii) Medium level of BBP application: scores from 17 to 26 points; and

(iii) High level of BBP application: scores from 27 to 37 points.

The characteristics of the interviewed farms are shown in **Table 1**. There were 65 farms with a low level of BBP application, 61 farms with a medium level of BBP application, and 17 farms with a high level of BBP application.

In addition, the researchers conducted interviews with a number of experts on economics and BBP application on swine farms to collect information about the current status of economic efficiency of farms with BBP application in Bac Ninh province and the impacts of BBP application on economic efficiency.

Secondary data

The study used secondary data from livestock reports of the DARD in Bac Ninh province and the Department of Livestock in

Table 1. The characteristics of the interviewees

	Criteria	Number (n = 143)	Percentage (%)
Production organization	Outsourcing for a company	9	6.29
	Normal	134	93.70
BBP application	Low level of BBP application	65	45.45
	Medium level of BBP application	61	42.65
	High level of BBP application	17	11.88
Abandon	Abandoned farming	16	11.18
	Continued farming	127	88.81
Scale	Abandoned farming	16	11.18
	< 100 pigs	70	48.95
	100-1000 pigs	39	27.27
	> 1000 pigs	18	12.58

Vietnam. Other information was collected from published books, newspapers, magazines, scientific journals, directive documents of the government, and reports of specialized agencies under the MARD, which related to swine production towards BBP.

Data analysis

Accounting methods

Costs, prices, and production information were collected from the questionnaire used to interview the farmers. Then, accounting methods were applied in the calculation of the economic efficiency indicators of the farms. Costing methods were employed to calculate the fixed costs and variable costs (labor, breeding, feeding, electricity, and tool costs, etc.) for 100kg live pigs. Revenue and gross profit, and net profit were calculated to describe the economic performance of the farms. The indicators can be explained as follows:

Production costs were the total costs of a farm in relation to pig production, which included fixed costs and variable costs.

Variable costs were the corporate expenses that changed in proportion to how much a company produced or sold, including labor costs, breeding costs, feeding costs, electricity costs, and tool costs.

Production value was the total revenue of farms related to pig production.

Gross profit was calculated by subtracting the variable costs of sold goods from the revenue.

Net profit was calculated by subtracting the total costs of sold goods from the revenue.

Fixed costs were calculated by including the investment costs for basic construction on the farm, and investment costs in machinery and equipment, then allocated to the estimated number of usable years.

Production costs (production value) per 100kg were calculated by the total production costs (production value) per year divided by the total kilograms of production per year.

Kilogram production per year was calculated as the total number of sold pigs per year times the average kg per pig.

Descriptive statistics

After collecting the data, descriptive statistics were processed using Excel software and synthesized by the use of statistical disaggregation, descriptive statistics, and comparative statistics. In addition, economic analysis was employed for the evaluation of the economic efficiency of swine production in relationship with BBP. The group method was utilized for finding the gap of economic efficiency of farms that applied a high level, medium level, and low level of BBP. The independent samples t-test was employed to analyze the difference between farms with different levels of BBP application.

Econometric methods

** Model for estimating the factors affecting the level of BBP application in swine farms (OLS01)*

The ordinal logistic model was used for the estimation of the influence of factors on the level of BBP application on the farms. The dependent variable was the level of BBP application (BBP). The estimator Y* was the variable that represented the probability of the level of BBP application. This variable can be explained by some independent variables x_1, x_2... x_n (K01-Gender, K02-Academic level, K03-Experience, K04- Knowledge about BBP) which were easy contextual indicators for the level of BBP application on swine farms. After screening to remove the data of the farms that had abandoned pig production or that had outsourced for company farms, the number of samples selected for inclusion in the model was 114 samples. The Y* estimation is as follows:

$y* = \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n + \varepsilon = x\beta + \varepsilon$ (OLS01)

$y* = \log[\frac{BBP}{1-BBP}]$

where ε is the error with the assumption of following the logistic distribution. The dependent variable is defined as follows:

BBP = 1 if $y* \leq \alpha_1$

BBP = 2 if $\alpha_1 < y* \leq \alpha_2$

BBP = 3 if $\alpha_2 < y*$

The cut-off point α is the index that is not known in advance and needs to be estimated. The probability for determining the dependent variable is explained as follows:

$P(BBP=1|x) = P(y* \leq \alpha_1|\ x) = P(\alpha_1 - \beta' x < \varepsilon\ |x)$

$P(BBP=2|x) = P(\alpha_1 < y* \leq \alpha_2|\ x) = P(\alpha_1 - \beta' x < \varepsilon \leq \alpha_2 - \beta' x|x)$

$P(BBP=3|x) = P(\alpha_2 < y*|\ x) = P(\ \varepsilon \leq \alpha_2 - \beta' x|x)$

** Model of factors determining the profitability of the farm (OLS02)*

Log-linear regression model (OLS), one kind of semi-logarithmic regression model, was used to evaluate the factors affecting the economic efficiency of livestock farms with BBP application. This was a suitable model to evaluate the percentage of profit shifting under the impacts of factors such as production costs, selling prices, breeding experience, and BBP application (Dowd *et al*., 2017). After removing the data of the farms that had abandoned pig production, the total number of samples selected for inclusion in the model was 114 samples. The regression function of OLS02 is expressed by the following formula:

$Ln(PROFIT_i) = \beta_0 + \beta_i Z_{ij} + u_i$(OLS02)

in which i(i = 1, 2, 3….n) is the order number of farm i, $PROFIT_i$ is the profit of a farm in a year, β_i is the estimated coefficients of variable number j^{th}, Z_j is the independent variable number j^{th} in the model, which represents the factors affecting the dependent variable (CP01, CP02, CP03, CP04, CP05, CP06, CP07, CP08, QM, and PR), and u_i is the random error of the model.

The explanatory variables were built in the model based on the overview of previous studies and were consistent with the consultations with livestock experts about new variables included in the model such as level of BBP application and farm-scale. The use of the scale variable was based on previous studies about economic efficiency of livestock production (Nguyen Van Song, 2006; Nguyen Quoc Nghi, 2017; ; Nguyen Ngoc Xuan & Nguyen Huu Ngoan, 2014b Vo Thi Hai Hien, 2015; Sarrazin *et al*., 2014). **Table 2** describes the explanatory variables included in the OLS01 and OLS02 models.

Results and Discussion

Status of pig farming in Bac Ninh province

Scale of swine farms

In the period from 2019 to 2020, Bac Ninh province had one of the largest scales of swine production in the country with over 20,000 pig heads, producing 45,000-80,000 pigs for sale per year for a total pork output of 43,000 to 60,000 tons per year (**Figure 1**). Due to the influence of African swine fever, in the period from 2019 to 2020, the number of pigs and the amount of pork production underwent a downward trend in

comparison to the period from 2017 to 2018. However, the proportion of BBP applications on livestock farms in the area had an upward tendency. This was reflected in the structure of the high technological applications on large farms which accounted for nearly 26.98% of the total number of pigs. In the period 2017-2020, 18 swine farms in the area were granted disease safety certificates, which represented the good activities of these farms in the prevention of livestock acquiring infectious diseases (Bac Ninh DARD, 2020).

Swine farm-scale structures

Swine farms were mainly small-scale operations, as the number of large-scale swine farms only accounted for a small proportion, but made a large contribution to the number of pig heads in Bac Ninh province (**Figure 2**). Of which, 36 swine farms had linkages with

Table 2. Variable descriptions

Codes	Names of variables	Descriptions	Min	Max	Mean	Standard Error
		OLS01				
K01	Gender	Gender of farm owner 0 = Male, 1 = Female	0.000	1,000	0.228	0.421
K02	Academic level	The academic level of farm owner Primary school Secondary school High school University	2.000	4.000	2.588	0.577
K03	Experience	Experience in livestock farming of farm owner 1-2 years 3-4 years 5-6 years About 6 years	1.000	4.000	2.263	0.625
K04	Knowledge about BBP	How well farm owner understands BBP? Does not know about BBP Knows about BBP Clear understanding about BBP	1.000	3.000	2.360	0.853
		OLS02				
BBP	Level of BBP applications	The level of BBP application on the farm Low level of BBP application Medium level of BBP application High level of BBP application	1.000	3.000	1.550	0.610
CP01	Fix asset depreciation	Fix asset depreciation calculated for 100 kg live pig (million VND)	0.019	0.233	0.083	0.031
CP02	Breeding cost	Breeding costs calculated for 100 kg live pig (million VND)	0.253	3.143	1.344	0.759
CP03	Electricity cost	Electrical costs calculated for 100 kg live pig (million VND)	0.021	0.240	0.069	0.033
CP05	Feeding cost	Feeding costs calculated for 100 kg live pig (million VND)	0.833	3.217	2.336	0.364
CP06	Tool cost	Tool costs calculated for 100 kg live pig (million VND)	0.012	0.103	0.052	0.018
CP07	Veterinary medicine	Veterinary medicine costs calculated for 100 kg live pig (million VND)	0.000	0.636	0.160	0.115
CP08	Labor cost	Labor costs (including both family and hired labor calculated for 100 kg live pig (million VND)	0.046	1.080	0.343	0.220
PR	Price	Average price for 3 nearest months asked from farmer per 1 kg live pig (thousand dong)	58.000	86.000	68.512	5.928
QM	Scale	Livestock scale (100 pigs)	0.100	20.000	1.752	2.942
PROFIT	Profit	Total profit of swine farm per year (million VND)	12762.910	1128.620	1931.890	12762.910

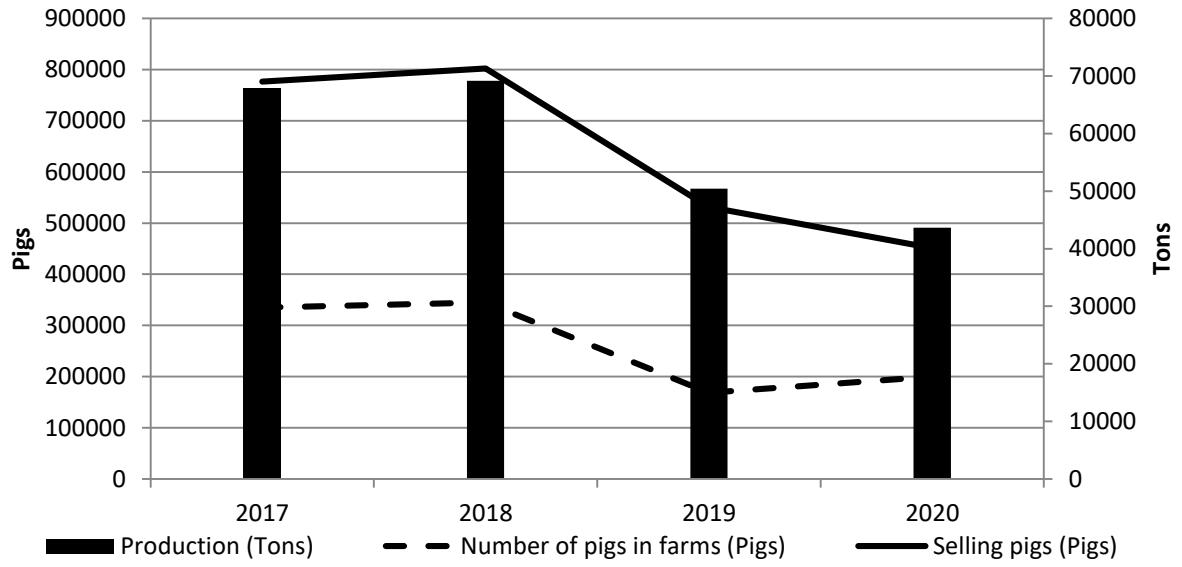


Figure 1. Livestock scale in Bac Ninh province
Source: Department of Livestock (2020)

companies in swine production and selling, applying closed cage breeding, and applying waste treatment with tarpaulin-covered Biogas tanks, 20 farms had linkages in the form of outsourcing swine production with large companies such as DABACO and CP, and 16 swine farms had linkages with companies in the form of contracts for product selling.

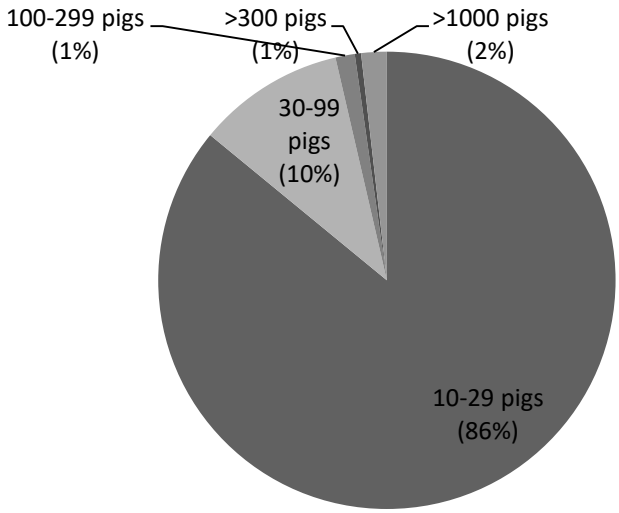
Current status of swine production with biosecurity practice in Bac Ninh province

Swine production with biosecurity practices on farms

Most of the surveyed farms in Bac Ninh province had Farms applying a medium level of BBP applications accounted for nearly 35.66% of the total number of farms surveyed, and the proportion of farms applying a high level of BBP application accounted for only about 11.89%. A large number of the farms applied veterinary hygiene treatments for preventing the spread of diseases. Most of the farms with a medium or high level of BBP application utilized closed barn production. Farms with a high degree of BBP application applied closed cage farming and livestock waste treatment procedures as well as controlled the herd on the exit and entry points to the livestock farms. Farms with a low level of BBP application had higher rates of mortality than those with a medium or high level of BBP application. The rate of farms abandoning pig production was also higher on farms with a low level of BBP application than in the other two farm groups. Especially, farms that had a high level of BBP application had a 0% abandonment rate. Many farmers gave up pig production because of the influence of African swine fever, which led to a large number of pigs being infected and culled; consequently, the revenue of farms reduced sharply. BBP could help farmers reduce the rate of infected pigs and protect livestock from diseases effectively.been shifting to BBP applications. However, in this process, the application of BBP standards on farms was at different levels. A significant proportion of farms were farms with a low level of BBP applications (approximately 52.45% of the total surveyed farms) (**Table 3)**.

Swine farm-scale

The percentage of large-scale farms with over 1,000 pigs applying a high level of BBP was higher than that of smaller-scale farms. **Table 4** shows that a small proportion of livestock farms



Source: Department of Livestock (2020)

Figure 2. Swine farm-scale structure in Bac Ninh province

Table 3. Current status of swine production with biosecurity practices in swine farms in Bac Ninh province

Criteria	BBP application		Abandon		Mortality rate
	Num.	Percentage (%)	Num.	Percentage (%)	Percentage (%)
Low level of BBP application	75	52.45	10	13.33	0.026
Medium level of BBP application	51	35.66	6	11.76	0.014
High level of BBP application	17	11.89	0	0	0.011
Total	143	100.00	16	11.18	

with a scale of under 100 pigs applied a high level of BBP. For small-scale farms, there currently are disadvantages to applying a high level of BBP because: (1) it is difficult to apply the regulation of arranging isolated breeding areas because of the lack of cages, (2) there is a lack of connections with traders and companies to export pigs at the same time, (3) there is a lack of capital to import piglets at the same time, (4) there is limited policy accessibility, and (5) there is less understanding about BBP. For livestock farms with 100 to 1000 pigs, BBP was mainly applied at a medium level. The in-depth survey of farms indicated that small-scale farmers often believed that "the small-scale of farming makes it very difficult to apply BBP standards due to little capital, investment, and technical staff to support and control livestock". Then, "such criteria related to livestock waste treatment systems and isolating farms from the area where people live, are difficult to apply in fact".

Product selling

Table 5 shows survey data on live pig sales channels of farms.Most of the farms sold pigs to traders and companies, in which the selling price to companies was relatively higher than that of traders. In particular, in Bac Ninh province, there were many models of linkages between enterprises and farms such as linkages for output consumption and linkages for outsourcing swine production. For farms applying a low or medium level of BBP, it was very difficult to link production and consumption with the companies, so they mainly sold their products to traders.

The selling price of live pigs is presented in **Table 6**. At the time of the survey, the selling price of live pigs was quite high compared to the previous years, as the live-pig price at the farm gates ranged from 58 to 86 thousand VND per kg. The selling price for the companies was higher than the selling price for traders, but lower

Table 4. Actual situation of BBP application on farms in Bac Ninh province

Unit: %

Level of BBP application / Farm-scale	Low level	Medium level	High level	Total
Abandon pig production	6.99	4.20	0.00	11.19
< 100 pigs	38.46	10.49	0.00	48.95
100-1000 pigs	0.00	23.78	3.50	27.27
> 1000 pigs	0.00	4.20	8.39	12.59
Total (n = 143)	45.45	42.66	11.89	100.00

Table 5. Structure of main sales channels of live pigs

Unit: %

No.	Channels	Local slaughterers	Slaughter-houses	Traders	Companies	Total
1	Farms with a low level of BBP application	2.01	0.00	4.64	0.00	6.65
2	Farms with a medium level of BBP application	2.00	1.53	27.79	4.64	35.95
3	Farms with a high level of BBP application	0.58	0.12	10.21	46.49	57.40
4	Average (n = 143)	4.58	1.65	42.64	51.13	100.00

than the price for local slaughterers and slaughterhouses. However, the number of pigs that can be sold for local slaughterers each time was quite small, whereas traders and companies could purchase a large number of pigs. Consequently, a large proportion of live pigs still had to be sold to traders and companies. Farms with a high level of BBP application were able to sell at higher prices than farms with a lower level of BBP application in all selling channels, especially the company channel. However, the farmers interviewed stated that "the selling price for the company is not much higher than that of the trader, but the selling procedure is more complicated".

The factors affecting the level of BBP application in swine farms

Table 7 showed the results of the model fitness test. The Chi-square ratio was 58.464, being statistically significant at 1% level, and the Nagelkerke Q-square was 48.5%, meaning that the model was suitable to estimate the factors affecting the level of BBP application on the farms. The estimated coefficient of the gender variable was -1.450 at the 5% significance level, which showed that the odds of a male applying a high level of BBP was 4.2 times that of a female household head. The probability of a female applying a higher level of BBP was 23.5% that of a male. The academic level had a positive effect on the level of BBP application at the 10% significance level, showing that if a farmer's academic level increased by one level, the probability of the farmer applying a higher level of BBP would increase by 2.09 times. Our study agrees with the research by Asogwa *et al*. (2020) who reported that farmer education was one of the important determinations for BBP application. The estimated coefficient of the experience variable was 1.454 and was statistically significant at 1%, meaning that a farmer's livestock experience had a positive impact on the level of BBP application. A previous study reported that the level of BBP application was negative with both "age" and "experience" of farm owners, suggesting that it was easier for younger farmers to accept BBP applications (Laanen *et al.*, 2013). However, in Bac Ninh, farm owners with good experience

Table 6. Average price of live pigs at the farm gate

Unit: 1,000 VND/kg

No.	Level of BBP application	Local slaughters	Slaughter-houses	Traders	Companies	Average
1	Low level of BBP application (n = 58)	74.19	-	66.50	-	68.82
2	Medium level of BBP application (n = 49)	72.82	70.28	66.88	70.29	67.80
3	High level of BBP application (n = 7)	75.99	72.00	71.35	71.69	71.68
4	Average (n = 19.972)	73,82	70.40	67.91	71.57	70.09

Table 7. Estimated results of factors affecting the level of BBP application of the farms

Code		Variables	OLS01			
			Estimated coefficient	Standard Error	P-value	Margin effect
Thresholds	[BBP = 1]		7.638	1.804	<0.001	
	[BBP = 2]		12.055	2.223	<0.001	
Location	K01	Gender	**-1.450	0.569	0.011	0.235
	K02	Academic level	*0.741	0.382	0.052	2.098
	K03	Experience	***1.454	0.427	0,001	4.280
	K04	Knowledge about BBP	***0.873	0.302	0.004	2.394
	QM	Farm scale	***0.466	0.102	<0.001	1.594
	Chi-Square = 58.464***					
	Nagelkerke R-square = 48.5%					
	n=114					

*Note: *, **, and *** denote the significance levels of 10%, 5%, and 1%.*

Source: SPSS (2021)

could have good knowledge about how to apply BBP on their farms in a reasonable way and understand how useful BBP is for swine farms in terms of biosecurity and health control for pigs, and its benefit of preventing ASF. If the breeding experience increased by two years, the probability of being in a higher level of BBP application would be expected to increase by 4.28 times. Knowledge also had a positive effect on BBP application at the 1% level of significance. The probability of a high level of BBP application, farmers with a "clear understanding about BBP", was 2.39 times that of farmers who "know about BBP". The positive estimator of the livestock scale also showed the positive impact of livestock size on the level of biosecurity application. If the livestock scale increased to 100 animals, it would be expected to increase the probability of applying a higher level of BBP application by 1.59 times. This result is consistent with previous studies that have shown that the score of BBP application is positively associated with livestock size (Laanen *et al*., 2013; Nguyen Ngoc Xuan & Nguyen Huu Ngoan, 2014a). It can be revealed that BBP application is generally better implemented on large-scale swine farms.

Economic efficiency of farms

Economic efficiency of farms with BBP

The indicators of economic efficiency of farms, including production costs/production value, raw profit/variable costs, and net profit/total costs, are presented in **Table 8**. The results of the independent samples t-test showed that farms with a low or medium level of BBP application had statistically significant differences about breeding costs, electricity costs, feeding costs, and veterinary costs. While the medium and high levels of BBP application had statistically significant differences about feeding costs and labor costs. In general, the application of BBP brought about more

Table 8. Economic efficiency of livestock farms in the direction of biosecurity in Bac Ninh province calculated for 100 kg of live pigs

No.	Criteria	Unit	Level of BBP application				T-Test (I vs II)		T-Test (II vs III)	
			(I) (n = 58)	(II) (n = 49)	(III) (n = 7)	Average (n = 114)	F	P-Value	F	P-Value
1	Fixed asset depreciation (1)	Million VND	0.081	0.085	0.084	0.083	2.211	0.140	1.788	0.187
2	Breeding costs (2)	Million VND	1.310	1.316	1.823	1.344	**4.893	0.029	0.029	0.864
3	Electricity costs (3)	Million VND	0.064	0.076	0.063	0.069	**21.383	<0.001	1.332	0.253
4	Feeding costs (4)	Million VND	2.346	2.314	2.413	2.336	***16.645	<0.001	*3.283	0.076
5	Tool costs (5)	Million VND	0.051	0.054	0.054	0.052	*2.889	0.092	2.556	0.116
6	Veterinary medicine costs (6)	Million VND	0.136	0.18	0.204	0.16	***7.827	0.006	1.029	0.315
7	Labor costs (7)	Million VND	0.442	0.254	0.135	0.343	1.018	0.315	*5.246	0.026
8	Other costs (8)	Million VND	0.016	0.017	0.017	0.017	2.211	0.140	1.788	0.187
9	Production value (9)	Million VND	6.701	6.661	7.234	6.717	1.988	0.161	0.009	0.926
10	Variable costs (10) = (2)+(3)+(4)+(5)+(6)+(7)+(8)	Million VND	4.366	4.211	4,709	4.321	***10.386	0.002	0.607	0.439
11	Gross profit (11) = (9)- (10)	Million VND	2.335	2.45	2.525	2.335	**4.172	0.044	0.883	0.352
12	Total costs (12) = (10)+(1)	Million VND	4.447	4.297	4.794	4.404	***10.569	0.002	0.544	0.464
13	Net profit (13) = (9)-(12)	Million VND	2.254	2.365	2.441	2.313	**4.230	0.042	0.862	0.357
14	Costs/Production value (12)/(9)	Times	0.664	0.645	0.663	0.656	***8.431	0.004	1.788	0.187
15	Gross profit/Variable costs (11)/(10)	Times	0.535	0.582	0.536	0.54	***11.159	0.001	0.729	0.397
16	Net profit/Total costs (13)/(12)	Times	0.507	0.55	0.509	0.525	***10.971	0.001	0.724	0.399

Note: (I) low-level of BBP application, (II) medium-level of BBP application, (III) high-level of BBP application.

economic efficiency to farms. The profit of farms applying a high level of BBP, 2.441 million VND per 100kg of live pigs, was higher than that of farms with a low or medium level of BBP application. The survey data showed that farms applying a high or medium level of BBP had lower rates of costs/production value than farms applying a low level of BBP. Meanwhile, the farms with a high level of BBP application had a higher gross profit/variable costs and net profit/total costs than farms with a low level of BBP application. However, comparing the farms with a medium level of BBP application and the farms with a high level of BBP application, the former group had a better economic performance than the later. The main reason was that for the farms with a high level BBP application, it was very important to comply with the "same-in-same-out" rule, meaning taking the breeding stock in and taking the live pigs out for selling at the same time, so most farms had to buy piglets from outside suppliers. This made their costs of breeding pigs much higher than those of the farms with a medium level of BBP application. Many farms with a medium level of BBP application could produce part of or all of their breeding pigs by themselves, then their breeding costs were much lower than buying breeding pigs from breeding agencies. Especially during the survey period, the price of breeding pigs from the agencies increased to about 2-3 million VND/breeding pig, which was much higher than the breeding costs produced by the farms themselves.

Factors affecting the economic efficiency of pig farms applying BBP

The testing results of the reliability of the model in **Table 9** show that the OLS02 model was statistically significant at the 1% level with an R square of 90.9%, meaning that the variables in the model could explain 90.9% of the changes in farm profitability. This showed that the model was suitable for estimating the influence of the factors on farm profitability.

The estimation results of the OLS02 model revealed the factors affecting the total costs impacting the profit of the farm. The estimated coefficients of the variables, including the level of BBP application, costs of seeds, electricity, and water, cost of feed, labor costs, and selling price were statistically significant at the 1% significance level. This suggests that applying BBP had a positive impact on profits, and if the level of BBP application increased by one level, profits would increase by approximately 65.53%. If the selling price increased to one thousand VND, the profit would be expected to increase by $e^{0.039} \approx 1.039$ times. The estimated coefficients of the cost of breeding stock, electricity and water costs, and feeding costs were negative, meaning that there was a negative relationship between costs and profitability. These results are consistent with previously published research which also revealed that BBP can help in reducing the amount of antimicrobials used and improve the production of swine farms (Laanen *et al*., 2013; Nguyen Ngoc Xuan & Nguyen Huu Ngoan, 2014b). The estimated coefficient of the livestock scale variable was 0.185 at the 1% significance level, showing that the livestock scale had a positive effect on the profitability of the farm, and if the livestock scale increased by 100 pigs, the profit would be expected to increase by approximately 20%.

Conclusions and Implications

Our survey of farms on their level of BBP application and economic efficiency of livestock production with BBP showed that BBP had a significant impact on the economic efficiency of livestock farms and helped livestock farms increase their economic efficiency. The estimating factors affecting the level of BBP application showed that the factors affecting the level of biosecurity application of the farm depended on the gender, livestock experience, and academic level of the farm owner, and the farm-scale. In addition, it was found that the factors that had negative effects on the factors that had negative effects on the economic efficiency of the farm included the level of BBP application, seeding costs, electricity costs, feeding costs, labor costs, and veterinary

Table 9. Model estimation results of the factors determining the profitability of the farms

Code	Variables	OLS02			
		Estimated coefficient	Standard Error	P-value	Margin effect
Constant		***5.244	0.574	<0.001	
BBP	Level of BBP application	***0.504	0.096	<0.001	1.655
CP01	Fixed asset depreciation	-4.315	5.287	0.416	0.013
CP02	Breeding costs	***-0.492	0.056	<0.001	0.611
CP03	Electricity costs	***-6.397	1.572	<0.001	0.002
CP05	Feeding costs	***-0.365	0.121	0.003	0.694
CP06	Tool costs	3.958	9.359	0.673	52.353
CP07	Veterinary medicine costs	0.492	0.393	0.214	1.636
CP08	Labor costs	***-2.588	0.286	<0.001	0.075
PR	Price	***0.039	0.007	<0.001	1.040
QM	Scale	***0.185	0.017	<0.001	1.203
Model testing		R- Square = 90.9% n = 114 Dependent variable Ln(PROFIT)			

*Note: *, **, *** denote the significance levels of 10%, 5%, and 1%,*
Source: SPSS (2021)

medicine costs. The positive relationship between economic efficiency and selling price, and between livestock-scale and level of BBP application were also explored through the OLS model.

From the research results, BBP application can increase the economic efficiency of swine farms, and the promotion of BBP application is a current issue for the development of swine production in Bac Ninh province. For the wide implementation of BBP applications on swine farms in Bac Ninh, some proposed solutions are as follows: (i) encourage male participation in swine production; (ii) enhance the farmers' knowledge about BBP by training farmers about BBP applications so that farms can actively apply biosecurity in swine production, improve economic efficiency, and increase profits for pig farms; (iii) encourage both young people with high education and experienced farmers to participate in swine production with BBP; (iv) provide support for farms to allow them to enhance their scale of swine product through assistance of capital, land, and livestock technology; and (v) organize workshops for the purpose of sharing livestock caring experience so that farm owners can increase their experience, which can encourage their participation in BBP applications. Other recommendations can be suggested to improve swine farm economic efficiency such as: (i) increase the support of good-quality, low-cost pig breeds for livestock farms, especially large-scale farms, that apply a high level of BBP in order to increase the economic efficiency of the farms; (ii) increase the selling price of live pigs for pig farms applying a high level of BBP; and (iii) reduce the supply price of animal feed for high BBP application farms to reduce the livestock costs and increase the economic efficiency.

References

Asogwa V. C., Ona. O. & Monday G. N. (2020). Biosecurity measures required for increasing pig survivability for food security and economic recovery in Abia state. Journal of Agricultural Education Teachers Association of Nigeria. 4(1): 169-177.

Bac Ninh DARD (2020). Report on livestock production in Bac Ninh province and a list of high-tech livestock farms in Bac Ninh province. Bac Ninh province. 20 pages (in Vietnamese).

Barot M. (2017). Biosecurity and disease control perceptions and practices of Vietnamese smallholder pig farmers (Doctoral dissertation, University of Sydney).

Cuc N. T. K., Dinh N. C. D., Quyen N. T. L. & Tuan H. M. (2020). Biosecurity Level Practices in Pig and Poultry Production in Vietnam. Advances in Animal and Veterinary Sciences. 8(10): 1068-1074.

Department of Livestock (2020). Statistics on the number of livestock farms in 2019. Retrieved from http://channuoivietnam.com/thong-ke-chan-nuoi/ on July 10, 2021 (in Vietnamese).

Dowd T., Landefeld P. & Moore A. (2017). Profit shifting of U.S. multinationals, Journal of Public Economics. 148: 1-13.

Do Van Xe (2010). Analyze the economic efficiency of the agricultural farming model: Case study of Cai Lay district - Tien Giang. Journal of Science Can Tho University. 13: 113-119 (in Vietnamese).

Nguyen Manh Hung, Pham Tien Thanh & Pham Bao Duong (2021). Overview of Credit for Farm Development. Vietnam Journal of Agriculture Science. 19(9): 1261-1269 (in Vietnamese).

Nguyen Quoc Nghi (2017). Comparison of financial efficiency between ecological and traditional livestock: A case study of livestock farms in Phong Dien district, Can Tho city. Journal of Science Can Tho University. 5(D): 80-86 (in Vietnamese).

Nguyen Ngoc Xuan & Nguyen Huu Ngoan (2014a). Economic efficiency of swine production is concentrated in the direction of good agricultural practice (VIETGAP). Journal of Science and Development. 12(6): 906-912 (in Vietnamese).

Nguyen Ngoc Xuan & Nguyen Huu Ngoan (2014b). Analysis of factors affecting the applicability of pig raising standards in the direction of VIETGAP good agricultural practice in Hanoi city. Journal of Science and Development. 12(5): 779-786 (in Vietnamese).

Huyen N. T. T., Nga, N. T. D., Hung, P. V., Lapar, L. A., Trung, N. X., Unger, F., & Pho, N. V. (2018). Farming Practices in Smallholder Pig Production in Vietnam: Implications for Food Safety. Journal of Economics, Management & Agricultural Development. 4(2390-2021-407): 1-14.

Laanen M., Persoons D., Ribbens S., de Jong E., Callens B., Strubbe M., Maes D. & Dewulf J. (2013). Relationship between biosecurity and production/antimicrobial treatment characteristics in pig herds. The Veterinary Journal. 198(2): 508-512.

MARD (2011). Regulations on biosecurity in swine farms. Issued together with Circular No. 04/2010/TT-BNNPTNT on biosafety pig farm conditions.

Pham H. T. T., Antoine-Moussiaux N., Grosbois V., Moula N., Truong B. D., Phan T. D., Vu T. D., Trinh T. Q., Vu C. C., Rukkwamsuk T. & Peyre M. (2017). Financial impacts of priority swine diseases to pig farmers in Red River and Mekong River Delta, Vietnam. Transboundary and Emerging Diseases. 64(4): 1168-1177.

Sarrazin S., Cay A. B., Laureyns J. & Dewulf J. (2014). A survey on biosecurity and management practices in selected Belgian cattle farms, Preventive Veterinary Medicine. 117(1): 129-139.

Nguyen Van Song (2006). Economic efficiency in dairy farming in the Red River Delta region. Journal of Economic and Development. 114: 370-375 (in Vietnamese).

Tabachnick B. G., Fidell L. S. & Ullman J. B. (2007). Using multivariate. Pearson Boston, MA. statistics. 5: 481-498.

Vo Thi Hai Hien (2015). Solutions to develop duck farming towards biosecurity in My Duc district, Hanoi city. Graduate thesis. Forestry University. Hanoi City: 100 pages.