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Research Article

Improving Competitiveness Among Small-Scale Pig Farmers: Challenges, Innovations and Sustainable Practices in the Mekong Delta, Vietnam

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Abstract | Small-scale pig farmers face particular challenges of limited resources, fluctuating market demand and increasing competitiveness. This study aimed to assess the level of innovation, production efficiency and competitiveness of small-scale pig farms. The study was conducted in the Mekong Delta including 3 provinces of Tra Vinh, Ben Tre and Long An with the participation of 360 farmers selected for survey by random sampling method. Quantitative data analysis was performed, including descriptive statistics and multiple logistic regression (MLR) to evaluate the influence of innovations and production efficiency on farm competitiveness. The results showed that the majority of pig farms had an average level of innovation application (78.1%), specifically innovation in production capacity. In addition, the farm production efficiency of 61.7% was classified as effective. Furthermore, the competitiveness of the surveyed pig farms was mostly at the medium level (75.8%). Notably, increased innovation was positively correlated with competitiveness with 1 value of innovation increasing the farm's competitiveness value by 0.410 ($\beta = 0.410$; $p < 0.000$), suggesting that improvements in innovation practices can lead to market success. In contrast, the levels of productivity did not significantly influence competitiveness and hence could be a direction for further investigation. In conclusion, increasing innovation is a factor that contributes to enhancing the competitiveness of small-scale pig farming. Support programs, including training on innovation adoption and financial assistance, are essential to promote sustainable development in small-scale pig farming.

Keywords | Competitiveness, Innovation, Pig farming, Production efficiency, Sustainable development

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INTRODUCTION

The Mekong Delta is one of Vietnam's key agricultural regions, known for its intensive rice cultivation, aquaculture, and livestock farming. However, smallholder pig farmers in this area are often constrained by fragmented markets, inadequate infrastructure, and environmental challenges, such as waste management and disease outbreaks (Qui *et al.*, 2020; Qui *et al.*, 2021). These factors, combined with rising consumer expectations for pork

quality and safety, necessitate a deeper examination of how innovation adoption can enhance farm productivity and competitiveness. With approximately 80% of households engaged in small-scale pig farming, the sector has become an important source of income for many families, especially in rural areas (Huong *et al*., 2023). However, small-scale pig farmers face stiff competition from the rise of industrialized farming operations and larger agribusinesses with better access to technology and resources (Dhillon and Moncur, 2023) as well as rising production costs due to disease outbreaks that have had serious consequences on farmers' profits (Jouzi *et al*., 2017; Nguyen-Thi *et al*., 2021). This competitive environment forces small-scale farmers to adapt and innovate to maintain their market viability, as consumer preferences shift to quality and safety (Zhu *et al*., 2023). Along with the entry of international markets through the CPTPP and EVFTA, the price of imported pork will decrease compared to the price of local pork. In addition, farmers mainly sell pigs to collectors due to insufficient demand in the local market (Nga *et al*., 2021). In addition, due to the lack of written contracts with buyers, farmers have difficulty selling pigs, especially when collectors set low prices. This phenomenon often occurs in the domestic pork supply chain in Vietnam (Qui *et al*., 2020).

Along with that, the competitiveness of pig farmers is affected by many factors. In terms of sociological factors, factors that influence competitiveness have been noted to include farm size, education level, market access, and social networks. Research of (Vu *et al*., 2019) indicates that involvement in support groups or collaborative initiatives can offer significant insights, collective experiences, and resources, thereby enhancing the competitiveness of farms. Sociological studies have recorded the critical role of social capital and social networks in increasing competitive advantages for small-scale pig farmers. This is shown in (Khan *et al*., 2024; Kumari and Garg, 2023), when wanting to adopt innovations or improve farm productivity, capital is required. In addition, according to (Carayannis and Grigoroudis, 2016), the concepts of innovation, productivity, and competitiveness are closely related. The prevailing circumstances surrounding small-scale pig farming exhibit considerable variability in the implementation of technology and overall farming productivity. A substantial number of farmers continue to depend on conventional agricultural practices (Linh *et al*., 2022), frequently resulting in less than ideal production outcomes. In fact, there are more and more producers looking to incorporate new technologies into their fields, from automated feeding systems (Diaz *et al*., 2021) to improved farming methods (Krampe *et al*., 2024), with the view of increasing output and competitiveness. With such advanced technologies, farmers are able to realize remarkable productivity gains in terms of higher yields and better quality. However, small-scale swine producers can increase their productivity but fail to have a higher degree of market competitiveness due to a number of reasons such as market saturation problem, as opined by Savagar *et al*. (2024), price volatility, as evident by Qui *et al*. (2020), or inability to access quality markets. In addition, the adoption of innovative practices remains generally low among smallholder farmers, mainly due to financial constraints, lack of information, and inadequate training (Sharifuzzaman *et al*., 2024). To survive and succeed, farmers must find sustainable ways to improve their performance, as indicated by the increasing competition in the industry (Nybom *et al*., 2021). The combination of market orientation and multi-generational family involvement in management is a set of important, scarce, and difficult-to-replicate resources for a family farm. These resources can provide competitive advantages by facilitating the emergence of innovative ideas (Fuetsch, 2022).

Although previous studies have explored innovation and productivity in agricultural contexts (Qui *et al*., 2025), the relationship between innovation, production efficiency, and competitiveness remains under-researched, particularly in small-scale pig farming in Vietnam. This gap is critical in the Mekong Delta, where smallholders dominate the pig farming sector but face increasing competition from larger agribusinesses, fluctuating input costs, and limited access to modern technologies (Ndwandwe and Weng, 2018; Qui *et al*., 2021). Understanding how specific innovations influence farm competitiveness can provide valuable insights for improving the long-term sustainability of small-scale pig farming in the region. In addition to the above reasons, Vietnam's pig farming productivity is still low compared to other countries in the region and the world. On farms, Vietnamese farmers spend about 5.8 months to fatten pigs (Takahashi *et al*., 2020), leading to high production costs and reduced competitiveness. Therefore, we conducted this study to record information on production, innovation, and the impact of production efficiency and innovation on the competitiveness of pig farming.

MATERIALS AND METHODS

Research Place

The research was conducted in three districts of Mekong delta, Vietnam, namely Tra Vinh, Ben Tre and Long An province. This region is known for its agricultural practices, particularly in pig farming, which plays a crucial role in the livelihoods of smallholder farmers. The study focuses on small-scale pig farms, which are prevalent in this area, reflecting the typical farming structures found in rural Vietnam. Among the three provinces, the number of pigs in Tra Vinh, Ben Tre and Long An is 249.9, 335.6 and 95.6 thousand heads respectively (GSO, 2023) with this number of pigs, it can be representative for the assessment of the Mekong Delta. The location was selected due to its relevance to the broader research objectives of assessing

innovation, production efficiency, and competitiveness in small-scale pig farming. The research period spanned from January 2024 to May 2024, encompassing different operational conditions that could influence farming practices and outcomes.

Data Collection

A multi-stage random sampling method was employed to ensure representativeness across the three provinces. This study covered a total of 360 farmers. All participants provided informed consent before participating in the survey (the study was conducted according to the letter of assignment of 4971/UN1.P1/PT.01.01/2024). Farmers were chosen according to the following criteria: (1) a minimum of 3 years of experience in pig farming, (2) ownership of at least 10 pig units, and (3) operation of the farm for a minimum of 2 years. The respondents were selected according to the method outlined by (Levine and Stephan, 2010), which indicates that a minimum of 30 respondents is sufficient for survey sampling in cases of an unknown population. Consequently, the study recruited 30 respondents from each of the four chosen districts to gather data. The study was conducted specifically on small-scale pig farmers who have adopted at least one technological or management innovation in their farming operations. These innovations include, but are not limited to, automatic feeding and watering systems, waste treatment technologies such as biogas systems, and biosecurity measures aimed at preventing disease outbreaks. Farmers were selected based on their reported application of these technologies or practices during the survey process. The questionnaire utilized for this study was initially designed in English and subsequently translated into the local language, Vietnamese. The survey comprises three sections. Initially, the social profiles and productive attributes of farmers. Secondly, the farmers' opinion of agricultural advancements. Thirdly, the competitiveness of farms through farmers' self-assessment.

Data Analysis

Data were collected by officers with expertise in the veterinary field, ensuring the quality and consistency of the information. Data of pig farmers from three provinces were examined using SPSS v.26 software (IBM Corp., Armonk, NY, USA). Quantitative data analysis was conducted using descriptive statistics to examine farm characteristics and farmers' perceptions of innovation and competitiveness. Multiple logistic regression (MLR) was applied to assess the relationship between innovation, production efficiency, and farm competitiveness, with innovation and efficiency scores calculated based on a Likert scale. According to Sullivan and Artino (2013), Likert scale was used to assess the performance after an educational intervention. In this study, Likert scale will be used to estimate the perception of swine farmers on the competitiveness. The perception of farmers on innovation is assessed using four indicators including 14 statements, while the evaluation of agricultural competitiveness employs four pillars with 17 statements. The independent variables are displayed in Tables 1 and 2. The scale's internal consistency was evaluated using Cronbach's alpha, which indicates the effectiveness of a scale in assessing a notion. Cronbach's alpha ≥ 0.7 is considered to reflect good reliability of the scale (Tavakol and Dennick, 2011). Items that could not be measured by a single underlying latent variable were excluded from further analysis.

Table 1: Description of item used for innovation perception.

Code	Item	Response
I	Innovations	
IMK	Market innovation	1=strongly disagree 2=disagree 3= undecided 4=agree 5=strongly agree
IMK1	Pork from my farm is often more competitive than other farms.	
IMK2	My farm produces hog with lower price and higher quality of meat to the market.	
IMK3	My farm produces products that address customer needs.	
IMK4	My farm explores new market channel	
IPC	Process innovation	1=strongly disagree 2=disagree 3= undecided 4=agree 5=strongly agree
IPC1	My swine farm has flexible production management which can be changed efficiently.	
IPC2	My farm uses short supply chain and distribution network.	
IPC3	My farm invests in new techniques/ equipment to improve its activities	
IOZ	Organizational innovation	1=strongly disagree 2=disagree 3= undecided 4=agree 5=strongly agree
IOZ1	My farm has joined in group of farmers to stabilize the price.	
IOZ2	My farm has a relationship to middleman or market sellers.	
IOZ3	In my farm, labor/workers should have ability to innovate the farm	
IPD	Production innovation	1=strongly disagree 2=disagree 3= undecided 4=agree 5=strongly agree
IPD1	Swine from my farm are often considered as high quality (less fat) by customers.	
IPD2	In comparison to other farms, my swine farm has introduced more innovations in the past few years.	
IPD3	Breeds of my swine farm recently is significantly different from previous productions.	
IPD4	In comparison to other farms, my swine farm is successful	

Noted: The validity was from 0.174-0.770 which was more than r table in correlation table (N=360). The reliability was checked by Cronbach's alpha which was 0.798.

Table 2: Description items used for competitiveness pillars.

Code	Item	Level of evaluation
C	Competitiveness	
CS	Sustainability	1=very low 2=low 3=normal 4=high 5=very high
CS1	Level of Sustainability of swine production in supply natural resources	
CS2	Level of sustainability of swine production in supply of labor	
CS3	Level of sustainability of swine production in inputs supply	
CS4	Level of sustainability of swine production in supply with innovations	
CS5	Level of sustainability in swine production in fundings	
CS6	Level of sustainability of swine production in supply with production and health services	
CS7	Level of sustainability of swine production in marketing	
CA	Adaptability	1=very low 2=low 3=normal 4=high 5=very high
CA1	Level of Adaptability of swine production to natural environment	
CA2	Level of Adaptability of swine production to market environment	
CA3	Level of Adaptability of swine production to institutional environment	
CF	Financial endowment	1=very low 2=low 3=normal 4=high 5=very high
CF1	Profitability of own capital	
CF2	Liquidity	
CF3	Level of Financial autonomy	
CE	Economic efficiency	
CE1	Labor productivity in swine farm	
CE2	Land and swine productivity	
CE3	Income per swine.	
CE4	Profitability of swine farm	

Noted: The validity was from 0.245-0.767 which was more than r table in correlation table (N=360). The reliability was checked by Cronbach's alpha which was 0.893.

The view of pig farmers about innovations and the competitiveness of pig farming is categorized into three levels, based on specific criteria. (1) High: A total value on the Likert scale ranges from 63 to 85 for competitiveness and from 52 to 70 for innovation. (2) Medium: total value on the Likert scale ranges from 40 to 62 for competitiveness and from 33 to 51 for innovation. (3): Low: The overall Likert scale values will range from 17 to 39 for competitiveness and from 14 to 32 for innovation. The productivity of pig farming, sometimes referred to as farm production efficiency, is determined by the output and input factors of the pig farm. Similarly, the research of (Zelenyuk, 2023) suggests that in economics, productivity is typically assessed by examining the ratio of outputs to inputs; however, this approach is not uniformly relevant. The notion of productivity is readily comprehensible when considering a singular output, y, generated from a singular input, x. This can be precisely expressed as the ratio of output to input. The computation can be executed at a specified time t using Equation 1:

$$Productivity = \frac{y_t}{x_t}$$

The index measuring productivity variations in simple contexts is defined as the ratio of single factor productivity over a designated period, reformulated as the ratio of the output index to the input index, as illustrated in Equation 2:

$$Productivity = \frac{Output}{Input}$$

Moreover, following the assessment of the pig farm's productivity using Equation 2, the study will convert this into production efficiency, with a ratio exceeding 1 denoting efficiency and a ratio of 1 or below indicating inefficiency. The MLR analysis was applied for this study. The formulation (Equation 3) will be:

$$Y_C = b_I X_I + b_P X_P + c$$

Where:
Y_C is the competitiveness level of the farm which is divided into 3 categories, low, medium and high level of competitiveness.
X_I is the perception of farmers towards innovations in farms.
X_P is the productivity of pig farming.
b refers to the parameter estimate for the innovation and production variable.
c refers to a constant.

RESULTS AND DISCUSSION

Production Analysis of Small Pig Farms in Mekong Delta, Vietnam

Table 3 and Figure 1 provides an overview of the production characteristics and financial information of pig farming, based on aggregated data from three provinces. The average rearing time for a litter of pigs remains at 5 months/litter. The number of piglets, sows, and pigs in farming households fluctuates greatly, indicating that the scale of farming is diverse but mostly small. On average, each farming household focuses on a certain pig unit, indicating the level of investment and production expansion. Regarding financial information, the price of live pigs, the cost of purchasing piglets, feed, and other costs such as veterinary medicine, electricity and water are relatively uneven

Table 3: Production characteristics and efficiency of small-scale pig farms.

Variables	Tra Vinh		Ben Tre		Long An		Total
	N	Mean±SD	N	Mean±SD	N	Mean±SD	
Production characteristics							
Raising time (months)							
Average (Mean±SD)	4.89±0.312		5.275±0.755		4.750±1.120		49.73±7.764
Min	4		3.5		3		
Max	5		6		7		
Piglet number (unit*)	16.75±4.488		51.32±83.42		20.42±45.35		29.49±56.89
Sow number	4.23±1.059		9.760±9.689		9.06±38.50		7.68±22.99
Hog number	16.93±3.559		88.85±170.1		87.9677.69		64.58±63.39
Swine unit	10.141±1.741		44.57±22.44		40.84±40.03		31.85±31.39
Financial information							
Hog price	5,150,083		5,251,725		5,297,433		5,233,080
Piglet expense	851,250		1,236,500		1,071,666		1,053,138
Feed expense	2,903,613		3,110,466		2,822,833		2,945,637
Veterinary expense	632,667		1,006,872		554,333		731,290
Water-Electricity expense	607,750		362,750		545,000		505,166

*one unit is equal to: > 25 kg is equal to 0.4 unit, < 25 kg is equal to 0.1 unit.

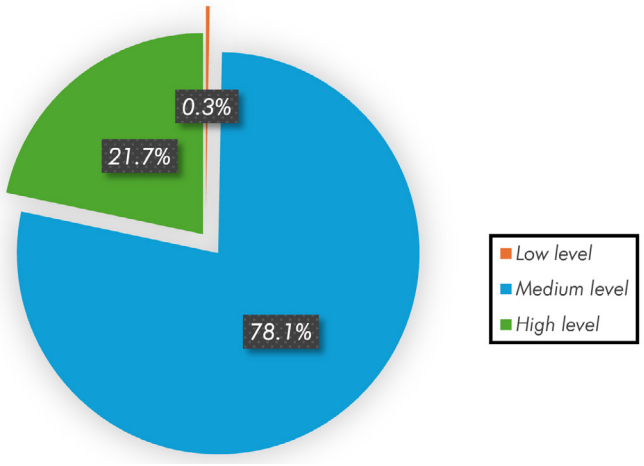

Figure 1: Production efficiency in small-scale pig farms.

among households, indicating the difference in the market prices of input and output of the production process in the Mekong Delta. In particular, feed costs account for the majority of total costs, reflecting the important role of this factor in the economic efficiency of farming households. According to this analysis, it is relatively clear that there was a moderate increase in productivity of farms. According to (GSO, 2024), pig output, pork product output and pig farm productivity had registered a high level during the six months of 2024. Particularly, there was an indication that the prices of pigs increased over the corresponding period. Moreover, the pig prices increased by VND 10,000-11,000 per kilogram. The enhancement of pig herd production can be analyzed through the lenses of rearing duration and breeding stock quality. In comparison to the research conducted by Takahashi *et al.* (2020), the elevated expenses associated with pig rearing, attributed to prolonged raising periods, are also somewhat linked to livestock productivity. It was observed that the average raising duration of a litter of pigs has diminished from 5.8 months in the study of Takahashi *et al.* (2020) to over 5 months in this study. According to this study, the awareness of farmers in regard to innovation on farms and competitiveness of the farms is moderately above average. This may partly explain the role farmers give to innovations in their operations and partly show the relationship between innovations, productivity and competitiveness.

Perception of Farmers Towards Innovation and Competitiveness of Small Pig Farmers in Mekong Delta

Table 4 provides an overview of farmers' perceptions of innovation in smallholder pig farms. The majority of farmers reported notable improvements, particularly in product quality, reflecting increased customer satisfaction, and the application of innovations in pig breeds, supply chain efficiencies, and distribution networks. They also believe that their farms are flexible in their production processes, having implemented specific techniques such as the adoption of automatic feeding systems, improved biosecurity measures, and waste management technologies, despite the financial constraints. Notably, farmers believe that their pork products are competitive in meeting customer needs. The ability to exploit new market channels is also highly valued, indicating a proactive approach to expanding consumption markets. In addition, a large proportion of farmers recognize their workers' innovative contributions, particularly in

optimizing feeding practices, improving livestock health monitoring, and maintaining sustainability-oriented practices, reflecting a willingness to innovate and adapt in the production environment.

Table 4: Perception of farmers on innovations in small-scale pig farms.

Indicators	Degrees of agreement				
	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
IPD1	3.1	1.9	17.2	77.5	0.3
IPD2	2.8	6.4	24.2	66.4	0.3
IPD3	2.8	0.3	11.4	83.9	1.7
IPD4	-	2.8	22.2	73.3	1.7
IPC1	-	3.1	20	73.1	3.9
IPC2	2.8	-	11.7	81.7	3.9
IPC3	2.8	6.4	30.6	59.2	1.1
IMK1	-	13.1	38.9	44.7	3.3
IMK2	1.9	23.3	36.1	35.3	3.3
IMK3	-	9.4	27.8	60.8	1.9
IMK4	-	1.7	8.3	88.1	1.9
IOZ1	0.3	10.3	37.8	48.6	3.1
IOZ2	-	12.5	29.2	56.7	1.7
IOZ3	-	4.4	14.7	80.6	0.3

Table 5: Perception of farmers on the competitiveness of their farm.

Indicators	Degrees of agreement				
	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
CE1	4.7	19.7	14.2	60.3	1.1
CE2	2.2	45	17.5	34.2	1.1
CE3	3.1	47.8	17.8	28.3	3.1
CE4	2.5	49.4	16.7	28.9	2.5
CF1	3.1	50.3	18.1	28.1	0.6
CF2	0.6	8.1	15.8	71.9	3.6
CF3	2.2	48.6	20	26.1	3.1
CA1	0.6	8.3	45	45.3	0.8
CA2	0.3	7.5	47.5	43.6	1.1
CA3	-	6.9	52.2	38.9	1.9
CS1	-	12.2	42.8	43.9	1.1
CS2	-	20.8	24.7	53.1	1.4
CS3	-	5	22.8	70.3	1.9
CS4	-	11.1	36.7	51.9	0.3
CS5	0.6	17.5	36.7	43.3	1.9
CS6	0.3	20.3	33.6	44.4	1.4
CS7	0.6	23.9	33.3	40.3	1.9

Table 5 reflects farmers' perceptions of factors related to efficiency and sustainability in pig farming. The majority of farmers agreed that labor productivity was relatively high due to task-specific innovations such as automated watering and feeding systems, though challenges related to long-term labor sustainability remain, with nearly 60% agreeing or strongly agreeing. Meanwhile, the relationship between land and pig productivity had a lower level of agreement, with nearly 45% disagreeing or disagreeing. Regarding income per pig, consensus was relatively low, indicating concerns about farm profitability. Similarly, farm profitability and capital profitability did not receive strong consensus, with many farmers expressing neutrality or disagreement. Among financial factors, liquidity was highly valued with more than 71% agreeing, indicating that farmers have confidence in their farm's financial management ability. However, financial autonomy was met with mixed opinions. Regarding the adaptability of pig production to natural environmental, market and institutional factors, farmers showed high levels of agreement. Regarding sustainability in production, despite perceived labor productivity, concerns about long-term resource and labor sustainability persist, reflecting ongoing challenges related to soil depletion, feed costs, and workforce retention, but there was a higher consensus on the use of production services and veterinary services. Factors such as maintaining the supply of raw materials and the ability to adapt to innovation were also positively viewed by farmers, indicating an optimistic outlook for sustainability in the pig industry.

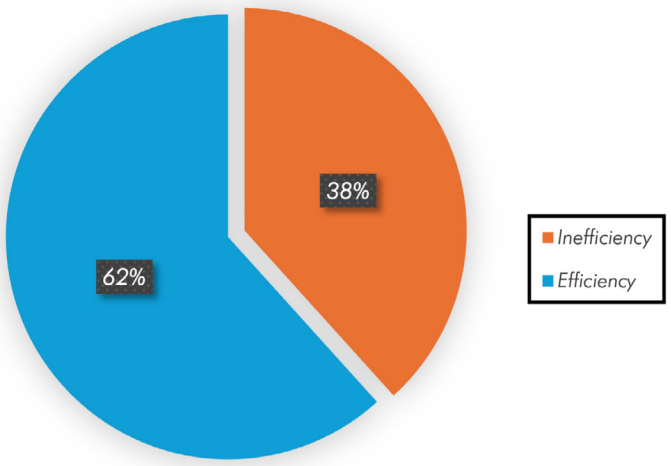

Figure 2: Innovation levels of small-scale pig farms.

The Table 3 and 4 was sumerized in the Figures 2 and 3 which show that the majority of farms operate at a medium level of innovation, indicating that they have adopted some improvements in production processes, but have not yet reached their optimal potential. In addition, production performance has a large proportion of farms identified as efficient, indicating improvements in techniques and output optimization. The competitiveness of the farms is also at an average level, with a significant proportion having

difficulty maintaining their market position. This underscores the critical need for targeted policies and investments aimed at promoting technological adoption, capacity-building initiatives, and knowledge-sharing networks to enhance the competitiveness and sustainability of small-scale pig farms, thereby fostering long-term resilience in livestock sector. This study indicates that farmers' perceptions of innovations on their farms and the competitiveness of their farms are moderately high. This may partially indicate that farmers recognize the significance of innovations in their operations and the correlation between innovations, productivity, and competitiveness. (Nguyen *et al.*, 2023) shown that financial challenges influenced agricultural development. Bai *et al.* (2019) recorded that animal husbandry was intricately connected to domestic policy, which directly impacted the growth of pig populations and the efficiency of pig farming. Technologies continuously evolve and adapt across many locations and time periods, influenced by local conditions and supported by social learning and advancement (Glover *et al.*, 2019). In this ongoing transition, farm trials and farmer field schools act as a nexus for the convergence of social and technical innovation dynamics. According to Smith *et al.* (2021b), the current reporting approaches are inadequate to capture the temporal dynamics of a process or novel effects. Technologies continuously evolve and adapt across many locations and time periods, influenced by local conditions and supported by social learning and advancement (Glover *et al.*, 2019). Throughout this ongoing change, farm trials and farmer field schools function as a nexus for the convergence of social and technical innovation dynamics. Smith *et al.* (2021b) assert that the existing reporting methods are insufficient for accurately capturing dynamic processes and unforeseen consequences. This analysis indicates that farm productivity was moderately elevated.

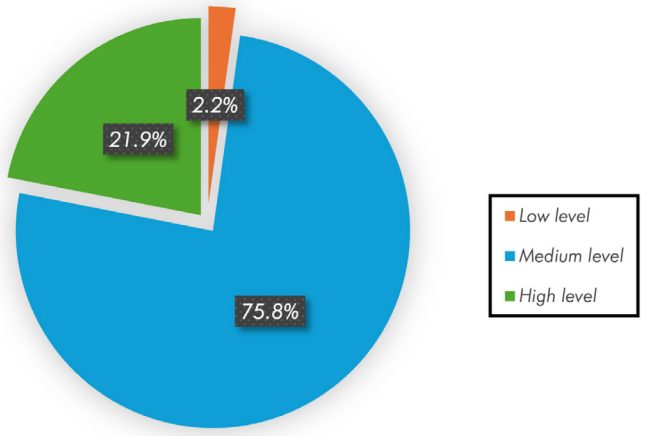

Figure 3: Competitiveness levels of small-scale pig farms.

Effects of Productivity and Innovation on Competitiveness at Small Farms in Mekong Delta, Vietnam

Figure 4 shows the results of the regression analysis showing that innovation has a positive impact on farm competitiveness ($p < 0.001$). For every unit increase in innovation, competitiveness increases by approximately 0.410 times, assuming that all other factors in the model remain constant. Besides, the interaction between innovation and production efficiency did not yield statistically significant results in this study. This may suggest that innovation alone, rather than in combination with efficiency improvements, plays a more pivotal role in determining competitiveness. Future research could further explore whether certain types of innovation, such as biosecurity enhancements or supply chain improvements, are more effective when combined with increased productivity. The equation of current study could be written as follow:

$$Y = 1.994 + (0.410 \times innovation)$$

The current research establishes that innovation enhances competitiveness while productivity has no impact. Technological advancement is crucial in pro-actively improving on challenges that affect small scale pig farms in effort to improve competitiveness. Gottschall and Woods (2020), illustrate that in small family enterprises, the family plays a crucial role in fostering innovative activities. Innovation can improve the efficiency and effectiveness of the production, processing, sale, and distribution of agricultural goods (Smith *et al.*, 2021a). The results for innovation and competitiveness indicate that knowledge-technology output and creative output have a significant positive effect on competitiveness. The studies of (Doğan, 2016) show that there is 0.0045 unit improvement in competitiveness for 1 unit increase in the knowledge-technology production and 0.0046 unit improvement in competitiveness for 1 unit enhancement in the creative output. Chursin *et al.* (2017) assert that innovation is fundamental to competitiveness.

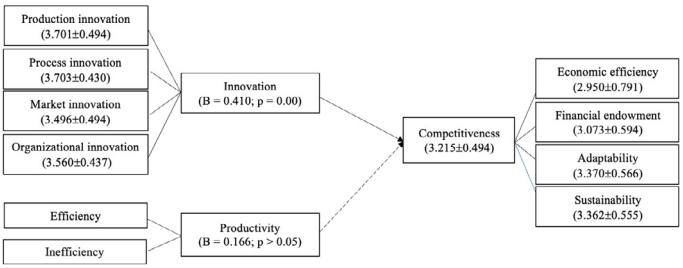

Figure 4: The effect of innovations and productivity on the competitiveness of small-scale pig farm ($R^2 = 0.112$, $F = 22.404$, sig. = 0.000).

The findings of this study support the research conducted by (Abd Aziz and Samad, 2016), which demonstrated that innovation has a significant and positive effect on the competitiveness of small and medium-sized enterprises in Malaysia's food industry. The findings also align with global trends observed in studies from other developing countries, where innovation adoption has been shown to

improve farm competitiveness (Abd Aziz and Samad, 2016; Wakgari *et al*., 2024). However, barriers to innovation adoption remain significant for small-scale farmers in the Mekong Delta, including financial constraints, lack of technical knowledge, and limited market access. Addressing these barriers through targeted support programs, such as cooperative models, and extension services, could enhance the effectiveness of innovation adoption and promote long-term sustainability in the pig farming sector (Qui *et al*., 2020). Wakgari *et al*. (2024) pointed out that organizational innovation has a positive impact on competitiveness. Applications on feeding systems, thermal and health control, and waste disposal facilitates creates easy means for farmers to address some complex human labour activities (Diaz *et al*., 2021; Neethirajan, 2021). This lowers costs of operations while at the same time provides standard and accurate care to the animals hence enhanced growth rates for the livestock. This is crucial in supporting competitive markets price since technology application in the management improve productivity without compromising resource use in farm management (Oladapo *et al*., 2023). Also, it improves health management and biosecurity common factors as part in farming of pigs (Alarcón *et al*., 2021). Higher levels of production mean increased production efficiency, and lower production costs, particularly veterinary services as well as losses due to diseases. This in turn improves the competitive edge of a farm since the amount of produce, qualities of pigs, and hence the priced offered to the market are improved.

Nonetheless, the productivity or production efficiency of pigs does not consistently impact the competitiveness of small-scale pig farms. A primary reason is that competitiveness frequently relies more on market positioning and access than on production efficiency alone. A farm may attain high productivity regarding pig production or feed conversion ratios; however, without sufficient market access, distribution channels (Qui *et al*., 2021), or the capacity to sell at advantageous prices, this efficiency fails to enhance competitiveness, as particularly indicated in the study by Savagar *et al*. (2024). There is also the risk that farmers struggle getting consistent and reliable buyers or there are forced to lower the price because the market is saturation, or regions are situated far from areas of high demand. Also, production efficiency commonly confines itself to some production parameters like feed conversion, growth rate, and mortality. While these elements are critical for cost reduction (Maes *et al*., 2020), they might not capture competitive pressures from the outside. Companies may optimally farm pigs but they may not be able to market the products differently. Competitiveness includes branding and value enhancement together with satisfaction with customers on aspects such as quality meats and organic farming, all of which are not directly associated with productivity. Equally important, competitiveness is influenced by other factors such as credit and policy, which again may present limitations in this study.

CONCLUSIONS AND RECOMMENDATIONS

The study indicated that farmers exhibited a strong perception of innovations and their farms, contributing positively to farm competitiveness; however, production efficiency was not fully optimized. The study also showed that innovation leads to a significant enhancement in pig farm competitiveness; however, an increase in production efficiency does not always result in similar effects. To address this, policies should prioritize supporting smallholders in adopting key innovations, such as automated feeding systems, biogas digesters, and disease prevention technologies. Financial assistance, training programs, and cooperative models can further facilitate the transition towards more competitive and sustainable pig farming in the Mekong Delta.

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AUTHOR'S CONTRIBUTIONS

Budi Guntoro and Ahmad Romadhoni: Conceptualization, Methodology, Validation, Supervision; Nguyen Thuy Linh, Nguyen Van Vui, Nguyen Thi Anh Thu: Investigation, Supervision, Reviewing and Editing; Nguyen Hoang Qui, Chau Cong Dang and Noemi C. Liangco: Investigation, Writing and Editing. All authors have read and agreed with the final manuscript.

Disclosure Statement

This manuscript includes the assistance of AI tools for grammar refinement. All data analysis, interpretation, and conceptual insights were conducted by the authors.

Conflict of Interest

The author declare no conflict of interest.

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