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Factors influencing the adoption of innovation in beef cattle farming: A study in Peninsular Malaysia

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Abstract. Beef cattle plays a role as a protein source to the population of a country. However, the current demand for beef is greater than its supply making it a hot issue in food security. Moreover, the price of local beef per kilogram is higher than imported beef. The use of innovations such as artificial insemination, biosecurity and integration techniques is yet to be applied by beef cattle farmers although empirically proven to improve beef production. This situation has become more critical among beef producers in Malaysia. This study was conducted on 233 beef cattle farmers at four states of Peninsular Malaysia including Kedah, Kelantan, Selangor and Johor. Ordinal logistic regression was employed to analyse the influencing factors for adopting innovation in beef cattle farming. The result demonstrated that farmer-to-farmer extension, level of education, number of cattle, value of a business and access to information were statistically significant at 0.1, 0.01 and 0.05. However, age, experience and government extension showed an insignificant relationship with the adoption of innovation. Based on the findings, it can be concluded that farmers are still interested in adopting innovation; however, some limitations were found to drive them away from it. Hence, the collaboration among all parties is a must to ensure the success of this sector and achieve a self-sufficiency level for the Malaysian population.

1. Introduction

Malaysia is a resourceful country with various agricultural activities including beef cattle farming. This activity is essential as it is among the contributors of protein supply for the Malaysian population and becomes the raw sector emerged as the third contributor to the Gross Domestic Product (GDP) in 2017 after oil palm and other agricultural output [1]. However, problem arises when ruminant production in Malaysia had failed to achieve the self-sufficiency level (SSL) due to problems in breeding stock, high cost of feed and inefficient production of beef, mutton and milk [2].

In 2014, beef production was only 51,000 metric tonnes (MT) with the demand higher than 201,000 MT. Hence, the shortage of beef supply was about 150,000 MT [3], causing Malaysia to import beef from India, Australia and New Zealand. Besides, insufficient information regarding the latest technologies and weak networking among the players is the concern of Malaysia's cattle farming. Furthermore, the focus on advanced techniques and current technologies instead of enhancing the

adoption of basic and efficient farming methods including the integration technique has also become food security issues [4]. Integration is a resource-saving practice that minimises the cost of farming and earned higher profits [5]. This technique also may reduce erosion, increase the crop yields as the nutrients are recycling and providing the sufficient grazing area [6].

Abdullah, Ali and Noor [7] mentioned that innovation in cattle farming is to simplify and ease the farming process besides increasing the production. Several innovations in beef cattle farming have been widely introduced such as the artificial insemination, vaccination and biosecurity. Artificial insemination is recognised as one of the assisted reproduction technique. It involves a procedure by injecting bull semen into the cow's uterus to ensure high conception rate and producing a good crossbreed of calves [8] [9]. Meanwhile, vaccination and biosecurity are related to each other to maintain sanitation and healthy cattle. This practice may prevent from any infectious diseases and minimising the farm loses [10]. As previously mentioned, innovation does not rely on the technology itself. Cattle feed production from crop residues such as rice and corn straws has also been recognised as the alternative instead of forages and pellet. Studies conducted by Baba, Dagong, Sohrah and Utamy [11] show that most farmers have understood this practice to reduce the cost for the cattle feed.

Moreover, the adoption of compost used can improve the social status of a cattle farmer by generating more income from the cattle's waste. In a study at Caribbean Island by Paul, Sierra, Causeret, Guindé and Blazy [12], most crop farmers have known that the adoption of organic fertiliser is to overcome excessive use of chemical fertilisers in agriculture and reduce the pollution of water resources. This situation is similar to a study conducted by Wahyudi [13] on biogas technology adoption in Pati, Indonesia. However, the installation of a biogas digester involves a high cost. Hence, not all farmers could afford to employ this technology at their farm.

Based on the previous studies, several determinants have been identified as the influencing factors towards adopting innovation. Age, education and experience have become one of the vital variables in this study. Paul et al. [12] mentioned that these three variables were significantly influenced cattle farmers on adopting innovation. Furthermore, the farm factor such as income or value of a business, number of cattle and access to information play a vital role in innovation studies. Wahyudi [13] has found that income or value of a business is significant on the adoption of innovation among cattle farmers in Pati, Indonesia while the number of cattle also has a significant influence on adopting innovation in beef cattle farming [11] [13] [14]. Information access was also an essential factor to ensure the farmers tend to adopt innovation [12] [14]. Finally, institution factor such as the government extension service and farmer-to-farmer extension service are among the main actors to influence cattle farmers in adopting innovation [11] [12] [15]. Their role is vital to enhance the use of innovation and improve beef production in a country.

This study aims to examine the determinants of the adoption of innovation among beef cattle farmers in Peninsular Malaysia. Ordinal logistic regression was employed to identify the influencing factors including individual and institution factors.

2. Methodology

This part explains the data collection process and formulation of the research model on adopting innovation.

2.1. Data collection

This study was conducted in the Peninsular of Malaysia, which involved four regions namely northern, east-coast, central and southern region of Peninsular Malaysia. Based on data provided by the Department of Veterinary Services [16], the population of beef cattle farmers in Peninsular Malaysia is 41,305. However, the researcher managed to get only 233 beef cattle farmers to be involved in this study by employing multi-stage sampling technique.

Hair et al. [17] mentioned that the critical sample size is 200, while Roscoe [18] agreed that sample size ranging from 30 to 500 is appropriate for the quantitative study. Additionally, Israel [19] justified that an adequate sample size for regression analysis is between 200 to 500 units. Hence, 233

respondents were considered sufficient for this study. Stratified random sampling was chosen for the first stage to confirm that the sample would provide information within the group of beef cattle farmers. Next, simple random sampling was implemented onto the sample so that every respondent have an equal chance to be selected [20].

The questionnaire of this study comprised three sections. The first section was to identify the reasons for adopting innovations in beef cattle farming. The next two sections examine how the farmers gained information on the innovation, farm background and the socio-economic profile that may influence them to adopt innovation. This study has also faced several constraints in terms of time and finance. For instance, the implementation of Movement Control Order from March to May 2020 has caused the researcher to postpone the data collection process.

2.2. Factors for adoption

Diffusion of Innovation Theory by Rogers [21], Technology Acceptance Model by Davis [22] and Utility Theory were employed as the foundation of this study. The dependent variable selected was an ordinal variable explaining the adoption of innovation with 4-point Likert scale ranging from (1) strongly disagree, (2) disagree, (3) agree and; (4) strongly agree. All items were developed based on the established theory, previous literature and discussion with experts in this area.

The researcher has employed two categories of independent variables; the first was individual and farm factor. Age, education, experience, access to information, number of cattle and value of a business were the variables used under this category to measure the factors that influence the adoption of innovation. The second category included the institution factor, which involved the variables of government extension and farmer-to-farmer extension. These variables were commonly used as the determinant in the adoption of innovations studies [23].

Table 1. Description of the variables used for ordinal logistic regression.

Code	Variable	Description	Type of variable
Dependent variable			
Y	Adoption	Adoption of innovation in beef cattle farming	Ordinal (1 = low, 2 = medium, 3 = high)
Independent variables			
$\mathbf{X_1}$	Age	Age of farmer in the year	Ratio
$\mathbf{X_2}$	Education	Level of education of the farmer	Ordinal (1 = No formal education, 2 = Primary school, 3 = Secondary school, 4 = SPM/ MCE, 5 = Diploma/ STPM/ STAM, 6 = Bachelor degree, 7 = Master degree)
$\mathbf{X_3}$	Experience	Duration of beef cattle farming activity in the year	Ratio
$\mathbf{X_4}$	Government extension service	Extension service provided by the DVS	Nominal (1 = yes, 2 = no)
$\mathbf{X_5}$	Farmer-to-farmer	Extension service among the community of farmer	Nominal (1 = yes, 2 = no)
$\mathbf{X_6}$	Access to information	Information access among beef cattle farmers	Ordinal (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree)
$\mathbf{X_7}$	Number of cattle	Number of beef cattle units	Ratio
$\mathbf{X_8}$	Value of a business	The value of cattle holding	Ratio

2.3. Econometric model

Ordinal logistic regression was employed to examine the influencing factors on the adoption of innovation among beef cattle farmers in Peninsular Malaysia. The variables were measured using ratio, ordinal and nominal scale of measurement as explained in Table 1. This method was considered relevant and appropriate as the dependent variable was measured using the ordinal data. Hence, the model of this study was expressed as follows:

$\text{logit}\ (P(Y \leq j)) = \beta_{j0} + \beta_{j1}\chi_1 + \ldots + \beta_{jp}\chi_p$; $j = 1, \ldots, J-1$ and p predictors

$\text{logit}\ (P(Y \leq j)) = \beta_{j0} + \beta_1\chi_1 + \ldots + \beta_p\chi_p$; $\chi_{1\ldots,p}$ = independent variables

$= \beta_0 + \beta_1$AGE $+ \beta_2$EDUCATION $+ \beta_3$EXPERIENCE $+ \beta_4$GOVERNMENT EXTENSION SERVICE $+ \beta_5$FARMER-TO-FARMER $+ \beta_6$ACCESS TO INFORMATION $+ \beta_7$ NUMBER OF CATTLE $+ \beta_8$VALUE OF A BUSINESS

3. Results

3.1. Farmer characteristics and farm background

Table 2 below shows the findings from the socio-economic profile of the respondents. The mean of the farmer's age was 48.4 years old, whereas 36.1% of the farmers completed their secondary school with Malaysian Certificate of Examination (MCE) or *Sijil Pelajaran Malaysia* (SPM). The farmers' mean experience was 13 years in beef cattle farming, while the mean of farm distance to DVS was 12.4 kilometres (km), which is easy for the farmers to get assistance from the extension workers.

Table 2. Socio-economic profile of the respondents.

Socio-economic profile	Frequency (n=233)	Percentage (%)	Mean	SD
Age (years)			48.4	13.65
Years of experience in beef cattle farming (years)			13.17	11.38
Farm distance to DVS (kilometre)			12.4	9.8
Level of education				
No formal education	11	4.7		
Primary school	42	18.0		
Secondary school	59	25.3		
SPM/ MCE	84	36.1		
Diploma/ STPM/ STAM	26	11.2		
Bachelor Degree	10	4.3		
Master Degree	1	0.4		

3.2. The profitability and efficiency of beef cattle farming

The profitability of beef cattle farming activity is measured by calculating the total profit. Total profit will be positive if total revenue higher than total costs. Total revenue is calculated by multiplying the number of cattle sold in a year with the average price of the cow. On the other hand, total cost takes into account fixed costs and variable costs such as utilities, maintenance of the farm, feed and vaccine expenses. Table 3 shows the farm's profitability earned by these farmers before and after the adoption of innovation. The median for profit is RM 18,000 before adopting innovation while after the adoption of innovation, the profit earned has increased to RM 34,080.

Table 3. The profitability of cattle farms before and after adopting innovation.

Variable(s)	Frequency, n= 233		Median, RM	
	Before	After	Before	After
Profit, RM			18,000	34,080
≤ 10,000	70	32		
10,001 – 50,000	121	106		
50,001 – 100,000	22	40		
≥ 100,001	20	55		

3.3. Factors influence the adoption of innovation

Based on the result demonstrated in Table 4, it was found that education level (X2), farmer-to-farmer extension (X5), access to information (X6), number of cattle (X7) and value of a business (X8) were significant on the adoption of innovation in beef cattle farming. However, age (X1), experience (X3), and government extension service (X4) were not significant for adopting innovation among beef cattle farmers in Peninsular Malaysia.

Table 4. Ordinal logistic regression analysis.

Predictors	SE	*p*-value	Significance level
Age	0.016	0.523	NS
Education level	1.308	0.000	***
Experience	0.017	0.476	NS
Government extension	0.433	0.251	NS
Farmer-to-farmer	0.642	0.079	*
Information access	1.162	0.000	***
Number of cattle	1.252	0.012	**
Value of business	1.196	0.001	***

Pseudo R^2: Nagelkarke = 0.610

Notes: *p*-value ≤ 0.1*; *p*-value ≤ 0.05**; *p*-value ≤ 0.01***; not significant ^{NS}

4. Discussion

Farmers with high education levels are more ready to accept new knowledge and practices. However, the non-educated farmers are not prepared to accept any changes and prefer the traditional farming system [11] [13] [14] [15]. Adopting innovation in cattle farming needs high commitments and attitude to improve the existing farm activity. Baba et al. [11; 15] and Paul et al. [12] agreed that farmer-to-farmer extension influences the local farmers to employ the current innovation in cattle farming. The leader's knowledge about culture and local people's condition is important to gain trust from the farming community on the advanced practices [24].

Meanwhile, in another study, Paul et al. [12] agreed that access to information is significant towards adopting the compost use. Folefack [25] stated that information would be well disseminated when there is an effective collaboration among research centres and extension workers to assist the farming community. In a study done by Baba et al. [11], Wahyudi [13] and Rathod et al. [14] stated that the number of cattle reared had influenced farmers to adopt the alternative feed instead of forages and artificial insemination as an effort to obtain a good quality of cattle breed as well as the installation of biogas digester at their farm. Wahyudi [13] mentioned in his study that higher-income farmers are easily influenced towards adopting innovation. However, Kamarul Zaman [26] argued that income is not significant towards adopting innovation among paddy farmers in Peninsular Malaysia.

Furthermore, Baba et al. [11; 15], Wahyudi [13] and Rathod et al. [14] agreed in their studies that age is not significant towards adopting innovation. However, Folefack [25], Kassie et al. [27], Paul et al. [12] and Sotamenou and Parrot [28] observed contradicted findings where younger farmers were more open-minded and easy to receive any changes in farming practices compared to the older farmers who tend to reject the innovation. Meanwhile, Baba et al. [11] and Wahyudi [13] have also agreed that

experience does not influence farmers in adopting innovation as it is difficult for them to adopt the current technologies [29]. On the other hand, some scholars have found that government extension is not significant where most farmers disagreed that extension programs lead to a thriving farming activity [14][15]. During the data collection process, farmers mentioned that they needed assistance in adopting innovations such as producing the compost and making an alternative feed for cattle.

5. Conclusion

Results obtained from this study are applicable for identifying the strategies for beef cattle farmers to improve the production and contribute the ideas to the stakeholders including DVS, MARDI and beef cattle farmers. Moreover, more attention must be given on the areas that are less focused by the extension service. This effort ensures that all beef cattle farmers can receive the information and assistance provided by the extension service. The enhancement of the beef cattle sector in Malaysia can also prevent non-halal imported beef issues and ensure that the country's food security is guaranteed. Thus, relevant parties must also encourage private companies to promote their current innovation and collaborate with the farmers by contributing the funding, providing technical assistance and training. These could perhaps improve the existing policy regarding food security in Malaysia and increase the self-awareness among all stakeholders on adopting the innovation that can lead to the structural change in beef cattle activity.

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